Grant Agreement: 785125

Call identifier: H2020-EE-2017-CSA-PPI

Project full title: STEP-IN - Using Living Labs to roll out Sustainable Strategies for Energy Poor Individuals

# STEP-IN

## D1.4 – Lessons Learned, Final Results and Knowledgebase

Deliverable lead beneficiary: LIST

Authors: Rod McCall, Neil Simcock, Stefan Bouzarovski, Dimitris Damigos, Zoltan Kmetty, Ulrich Leopold, Sukriti Bhattacharya

| Internal Technical Auditor | Name (Beneficiary short name) | Date of approval |
|---|---|---|
| Task leader | Rod McCall (LIST) | 01.09.2021 |
| WP leader | Rod McCall (LIST) | 01.09.2021 |
| PAST Team | Valérie Mellier (ARTTIC) | 01.09.2021 |
| WP Leader | Rod McCall (LIST) | 01.09.2021 |

Abstract: This deliverable provides an overview of the methodology and the results obtained from the STEP-IN Living Labs. It also provides a set of recommendations and future challenges.

Due date (according to DoA): 31/03/2021

Actual submission date: 31.03.2021 Revised Version Submitted: 02.09.2021

Publication date: 02.09.2021

Project start date: 01.06.2018 Project duration: 34 months

**This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 785125. This deliverable solely reflects the STEP-IN Consortium's views, and the European Commission and the European Agency for Small and Medium-sized Enterprises are not responsible for any use that may be made of the information it contains.**

**Dissemination Level**: PU Public

# Table of Contents

# Table of Figures

# Table of Tables

# Glossary

| Abbreviation / acronym | Description |
|---|---|
| Citizen/Consumer | The term is used interchangeably throughout the document for individuals. |
| EEPI | European Energy Poverty Index |
| EPOV | European Energy Poverty Observatory |
| EU-SILC | European Union Statistics on Income and Living Conditions |
| GWh | Gigawatt Hours |
| kWh | Kilowatt Hours |
| LL | Living Lab |
| WG | Working Group |

# 1 Executive Summary

This deliverable summarizes the methodology, and the results used within the STEP-IN living labs. The STEP-IN living labs operated in three countries (UK, Greece and Hungary) with the aim of alleviating energy poverty. Besides helping specific groups of people, the living labs comprised large-scale energy advice information programmes. These programmes included the distribution of leaflets, use of social media and the use of traditional media.

The STEP-IN Living labs work alongside existing programmes, schemes and stakeholders. The living labs used a standard methodology which could be adapted in terms of methods and advice for the local circumstances. Key aspects of the living labs included face-to-face approaches such as focus groups, energy cafes, and visits by home energy advisors. Non-face-to-face (remote) approaches included ICT tools, telephone help, and videoconferencing. Many of the remote services came about because of the Covid-19 pandemic, while they had their benefits, face-to-face approaches remain the most effective. As a by-product of this there is discussion which may prove useful for those aiming to tackle energy poverty post-Covid-19 and who to rule out programmes during a pandemic.

This deliverable provides an assessment of the methodologies and the results. It discusses key aspects and provides recommendations for organisations wishing to roll out similar programmes. A key aspect is that the living lab methodologies are co-created and reflect lessons learned as they operate. This approach allows for them to respond to the needs of the vulnerable citizens involved.

Key take home messages are that while relatively low-cost and easy-to-use interventions are successful. However, in the longer-term policy makers at EU, national and regional level must view energy poor citizens as a unique market segment. The need to reduce carbon emissions must consider this group of citizens who are already under-consuming. In some cases, connecting them to a safe and stable energy supply is more important than asking for energy reductions.

# 2 Introduction

> *"Living Labs (LLs) are defined as user-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings."*[1]

The STEP-IN living labs operated in three countries across Europe (Greece, UK and Hungary) with the objective of tacking energy poverty. The living labs engaged directly with the citizens involved and not only provided them with assistance, but also allowed the citizens and other stakeholders to have an input into the methodology and their operations. This co-creation approach ensured that the advice, referral programs and assistance offered were adapted to the local context. However, the project also adopted an overall methodology which is designed to be rolled out in many countries and adapted as required. The living labs operated before and during the Covid-19 pandemic, which had an impact on their operation and the results. This means that the findings can be used to assist in tackling energy poverty post-pandemic and to allow for an assessment of how effective remote (mainly online) approaches are in such contexts. Outside of pandemic situations the methodology can be applied and has been shown to bring positive results to those involved.

This deliverable outlines our experiences in the rollout and operation and the three living labs and across the three iterations. The document therefore focusses on the application of the methodology and the results obtained. From methodological perspective key themes emerge: the need for a clear benchmarking and evaluation process, using appropriate data collection techniques, providing relevant advice, involvement of local stakeholders, and a thorough reflexive and co-creative approach. While STEP-IN operated in specific localities, the approach is designed to be flexible enough to fit local needs. For example, referrals are made to specific local and national programmes, while the advice provided can be adapted for that specific locality. Also, the demographics in each of the STEP-IN living lab locations were quite different, which further strengthens the argument that the overall approach employed is both usable and relevant across locations. Overall STEP-IN worked directly with over XX citizens in the three living labs. In addition, more than 13,000 people received some form of advice from STEP-IN and in Greece the information leaflet was distributed nationally to 331 municipalities.

From a results perspective STEP-IN had a positive impact on the lives of many citizens, with perhaps one of the most striking findings being the reconnection of some people in Hungary to the electricity grid. Other large-scale measures such as referring people to heating maintenance programmes, or small-scale upgrade schemes will have long lasting impacts on their lives. Across all living labs some direct and indirect rebound effects occurred, while these are concerning, it is due to the fact that the consumers involved were under-consuming. In many cases the rebound effects may be beneficial on their lives e.g. raising comfort levels or allowing them to spend money on other daily essentials. The measures taken by citizens who took part in the living labs will provide long term energy efficiency benefits while also leading to a reduction in $CO_2$ emissions. The benefits of STEP-IN were shared by those who attended the living labs and those who only received information. Therefore, in the longer term STEP-IN should have brought a positive impact on the lives of many people.

STEP-IN leveraged the existing ecosystem at local, national level in each of the living lab areas that it operated within. This was achieved either through partners such as GMCA, E.ON and MALTAI operating on the ground and/or through working with supporting organisations such as Groundwork or programmes such as LEAP. This not only strengthened the results but also allowed for the experiences of these organisations to shape the development of the living labs. It also means that post project the citizens in the locations will in many cases still have support. It also means that the best practices developed during STEP-IN have already been shared with those who are most likely to implement similar schemes in future.

---

[1] European Network of Living Labs (ENOLL). A definition of a Living Lab. https://enoll.org/about-us/ (accessed 13-3-2019)

The following deliverable provides an overview of STEP-IN and selected related projects, reports on the methodological aspects, and provides results from each living lab coupled. It presents findings in a way which should aid in gaining an overall picture of the methodology and results from the project. It then explores the sustainability of the project methodology and results and provides a summary of the lessons learned and policy impacts.

# 3 An Overview of STEP-IN

The initial aim of the H2020 call from which this project came was to reduce the overall energy consumption of energy vulnerable citizens. While we may view this outcome as beneficial, e.g. reduction in energy consumption should reduce bills also lowering $CO_2$ emissions, it became clear during the project that ethically this is problematic. For example, many energy vulnerable people already cut back on energy supply in order to pay the bills and some do not have a safe and stable energy supply. Therefore, the aim should be to improve their quality of life. This objective could involve sometimes increasing their consumption and/or bringing them into the mainstream energy supply network. This challenge of reducing energy consumption was further exacerbated by the COVID-19 pandemic, which often resulted in people being at home during the day; - thus potentially increasing consumption. Therefore, taking these two challenges into account, it is worth revisiting the eight specific objectives which were set in the project (see Table 1).

| | |
|---|---|
| Obj. 1 | Positive Impact on Citizens. |
| Obj. 2 | Assessment and Benchmarking. |
| Obj. 3 | Supporting Best Practices. |
| Obj. 4 | Engaging with the Energy Poverty Community. |
| Obj. 5 | Define Future Policies, Strategies and Research Areas. |
| Obj. 6 | Support Clearly Defined Target Groups of Citizens. |
| Obj. 7 | Reduce Environmental Impacts. |
| Obj. 8 | Identifying viable financial schemes at local, national and European scale. |

***Table 1 List of STEP-IN Project Objectives***

| | |
|---|---|
| **R1** | Foster measurable behaviour changes among citizens, which will encourage greater energy efficiency while not sacrificing comfort. |
| **R2** | A methodology to support the analysis of and rolling out of solutions to help alleviate energy poverty. |
| **R3** | Execution, and proof of concept, of the global methodology in three Living Labs in diverse geographical European locations. Each LL will be operated by relevant local organisations with assistance from the STEP-IN consortium. This will result in direct engagement with citizens. There will be a strong emphasis on measuring real impact on citizens and recording best practice. |
| **R4** | A set of reports on best practice focusing on long-term and short-term solutions regarding energy behaviour and their energy saving capacity, relevant for the EU member states. |
| **R5** | A set of ICT tools at individual and community level that aim at alleviating energy poverty. |
| **R6** | Provide governance, policy and research recommendations/roadmaps. |
| **R7** | A knowledge base and community platform to encourage knowledge sharing between a range of stakeholders. |

***Table 2 List of Expected Results from STEP-IN***

In addition to the overall objectives of the project, STEP-IN aims to provide seven key outputs, or results, which are outlined in Table 2. As noted earlier, a key concern which is reflected in one result is balancing reducing energy consumption while improving overall quality of life and comfort levels.

Results R2 and R3 relate to the methodology and operation of the living labs. The STEP-IN living labs provided a menu of options ranging from visits by energy advisors through to the operation of remote services during the Covid-19 pandemic. In addition, the citizens took part in energy cafes (public meetings) and may also have taken part in focus groups. Behind the scenes, energy awareness was often improved not just for those taking part but also the wider public through public information campaigns. In Greece, for example, RAE has distributed the leaflet to all 13 Regional and 331 Municipal Authorities. The approach used was also iterative and in common with living labs methodologies was subject to change and modification based on the feedback from those taking part. We also adapted the advice itself for local contexts, ranging from connection to an energy supplier through to encouraging people to maintain their boilers.

## 3.1 Related Projects

### 3.1.1 ENPOR

Website: [www.enpor.eu](http://www.enpor.eu)

Project ENPOR works to address energy poverty involving nine European countries (DE, UK, EL, HR, IT, AT, EE, NL, BE). ENPOR will examine in-depth energy poverty policies for the private rented sectors (PRS) across the EU, monitor the dimensions of energy poverty in the PRS, support tailored policies, and provide guidelines for other countries. ENPOR targets the PRS, precisely dealing with the following two issues:

1. Identifying and quantifying energy-poor households in the PRS; and
2. The delivery of energy efficiency measures to those households is difficult because of structural problems like information deficits, split incentives, etc.

### 3.1.2 EnergyMEASURES

Website: [www.energymeasures.eu](http://www.energymeasures.eu)

Project EnergyMEASURES works to address energy poverty in seven European countries (BE, BG, IE, MK, NL, PL, UK). The project contributes to reducing participants' vulnerability to energy poverty while at the same time cutting household energy consumption and associated GHG emissions. EnergyMEASURES introduces two complementary and synergistic strands of work:

1. The first strand will involve working with energy-poor households to improve their energy efficiency through a combination of low-cost measures and changes in their energy-related behaviours and practices.
2. The second strand will include working with municipalities, energy authorities, housing associations, and other relevant actors to assess how current multi-level institutional contexts affect efforts to mitigate energy vulnerability in the participating countries.

### 3.1.3 SocialWatt

Website: [www.socialwatt.eu](http://www.socialwatt.eu)

Project SocialWatt works to address energy poverty involving eleven European countries (ES, FR, EL HR, AT, LV, IT, BE, NL, IE, RO). Project SocialWatt aims to support obligated parties under Article 7 of the Energy Efficiency Directive to develop, adapt, test, and spread innovative energy poverty schemes across Europe. SocialWatt will contribute to the following three main pillars:

1. SocialWatt decision support tools identify energy poverty among their clients, elaborate Energy Poverty Action Plans after having evaluated and selected energy poverty schemes, and monitor and assess the overall procedure.
2. Bridging the gap between energy companies and social services by promoting collaboration and implementing knowledge transfer and capacity-building activities.
3. Implementing and replicating innovative schemes to ease energy poverty across Europe.

### 3.1.4 POWERPOOR

Website: www.powerpoor.eu

Project POWERPOOR works to address energy poverty involving ten European countries (DE, LU, LV, EL, HR, EE, PT, ES, BG, BE, HU).

POWERPOOR develops support programs (schemes) for the energy-poor citizens. The programs especially encourage alternative financing schemes such as establishing energy communities (cooperatives) and, crowdfunding, etc. Global and EU initiatives, such as the EU Energy Poverty Observatory and the (EU and Global) Covenant of Mayors on Energy and Climate, will disseminate the project results. Synergies will be pursued accordingly. The Energy Supporters / Mentors will support (over 22,000) energy-poor households to plan and implement energy efficiency interventions and participate in joint energy initiatives. Energy poor citizens will be engaged through various planned activities, such as Info Days, Local Energy Poverty Offices, and ICT-driven tools (Energy Poverty Mitigation Toolkit).

### 3.1.5 STEP

Website: www.stepenergy.eu

Project STEP works to address energy poverty involving nine European countries by (LT, SK, BG, PO, LV, CZ, PT, CY, UK). There are 11 organisations taking part in the STEP project. Nine of them are established consumer organisations that provide advice to consumers at the national level. The other two organisations are a European umbrella network of consumer organisations (BEUC) and a UK-based trade association from across the industrial, commercial, and public sectors working on energy efficiency and decentralised energy (ADE Research). STEP facilitates behavioural change by providing trusted and tailored advice directly to consumers in or at risk of energy poverty and implementing low-cost energy efficiency solutions in energy-poor households. It creates a collaboration between consumer organisations and frontline workers. The latter is already used to advising vulnerable people on things like financial or health issues. STEP will contribute to the following three main pillars:

1. To develop well-functioning and well-trained national networks of advisors from consumer and frontline organizations who are in direct contact with consumers in or at risk of energy poverty;
2. To improve living conditions of consumers in or at risk of energy poverty through behaviour change and implementation of no- or low-cost energy efficiency measures;
3. To create schemes contributing to the alleviation of energy poverty, promote their replication and draw policy recommendations.

Thirteen policy recommendations directed to tackling energy poverty at the national and European level were published on 3rd February 2020.

(https://www.stepenergy.eu/wp-content/uploads/2020/08/Policy_Recommendations_1st_set_D6.3_final.pdf)

### 3.1.6 ComAct

Website: www.comact-project.eu

Project ComAct works to address energy poverty in the Central and Eastern European (CEE) region and the former Soviet Union republics (CIS region). The project aims to make high-impact/high-cost energy-efficient improvements in multi-family apartment buildings that are affordable and manageable for energy-poor communities.

ComAct focuses on these two regions to identify the underlying causes and develop alternative approaches to reduce energy poverty levels. It aims to create the necessary assistance conditions for lifting the people involved out of energy poverty.

### 3.1.7 EmpowerMed

Website: www.empowermed.eu

Project EmpowerMed works to address energy poverty involving six European countries (ES, FR, HR, AL, DE, IT). Project EmpowerMed works to address energy poverty in the Mediterranean countries by empowering women to act against energy poverty. Project results and outcomes will be disseminated among the target groups to ensure a broad reach out at local, national, and EU levels. EmpowerMed will collect and validate gender-disaggregated data related to energy poverty to better understand women's roles in addressing energy poverty. EmpowerMed Mainly focuses on:

1. Implementing a set of practical energy efficiency and RES measures tailored to empower households in energy poverty and focused explicitly on women and health.
2. Assessing their efficiency and impacts to formulate policy recommendations, and
3. Promoting policy solutions among key actors to stimulate action against energy poverty at the local and EU levels.

EmpowerMed project has started an energy audit of the target group in the Municipality of Vlora. (https://www.empowermed.eu/empowermed-project-has-started-the-process-of-energy-audit-of-the-target-group-in-the-municipality-of-vlora/). The "Right to energy forum 2020," which took place in December 2020, presents how EmpowerMed connects energy poverty, health, gender, and summer challenges of energy poverty, together with its 9 European partners. (https://www.empowermed.eu/save-the-date-empowermed-at-right-to-energy-forum-2020/). IREC and UAB, two of our EmpowerMed partners, participated in the Annual IEEE Canada Power and Energy Conference on November 9-10, 2020. (https://www.empowermed.eu/save-the-date-smart-meters-tackling-energy-poverty-mitigation/)

### 3.1.8 SAVES 2

Website: saves.nus.org.uk

Erasmus Students' Network, European Students' Union, and the Student Hotel/Class of 2020 form part of the project's Communications and Networking Advisory board, in addition to the smart meter, roll out organisations in the respective countries - Smart Energy GB (UK), Sustainable Energy Authority of Ireland (Ireland), ESO (Lithuania), Hedno (Greece) and Energy Policy Group (Romania). SAVES 2 builds on the success of the EU Intelligent Energy Europe-funded SAVES project (2014-2017), which expanded the Student Switch Off (SSO) campaign to Cyprus, Sweden, Lithuania, and Greece. SAVES2 supports students in minimizing their carbon footprint in their accommodation, promoting energy efficiency, and promoting good sustainability habits that last beyond their education time. Project SAVES2 catalyses sustainable energy behaviours among over 219,000 university students in seven countries to reduce their fuel poverty exposure. It incorporates two strands that engage with students living in university accommodation and private-rented sectors. It provides ongoing advice and support to students via energy-efficiency and bill management training, peer-to-peer advice sharing via video blogs, and regular e-mail and social media communications. SAVE2 reaches 38,000 students living in dormitories each academic year (114,000 students over 42 months), with the SSO campaign inspires them to adopt sustainable energy behaviours at a key stage of their lives. Save quantifiable amounts of energy in student dormitories (9 GWh). It reaches over 100,000 students when they look at moving into the private rented sector to encourage them to make housing choices that minimise their exposure to fuel poverty. It also reaches over 100,000 students when they move into, and live in, the private rented sector.

### 3.1.9 DecentLivingEnergy

Website: www.decentlivingenergy.org

Project DecentLivingEnergy is hosted by Internationales Institut Fuer Angewandte System Analyse, Austria. The purpose of the project DecentLivingEnergy is to understand the confusion of how poverty eradication contributes to climate change. The project identifies the knowledge gaps related to the material basis of poverty and the relationship between energy and human development. The project aims to bridge gaps between global justice, economics, energy systems analysis, and industrial ecology and applying this knowledge to projections of anthropogenic greenhouse gases. The project aims to develop a body of knowledge that quantifies the energy needs and related climate change impacts for providing decent living standards to all. This research identified different opportunities to shift developing societies towards low carbon pathways and substantiate countries claims for carbon space for

The research addressed three questions:

1. What goods and services, and with what characteristics, characterize decent living standards?
2. What are the energy resource requirements and related climate change impacts of decent living goods and services, and how do they vary by country?
3. How do the constituents of decent living, and their energy needs, evolve as countries develop?

To solve the above questions, the project estimates bottom-up the energy embodied in the material underpinnings of decent living standards for India, Brazil, and South Africa. (https://www.nature.com/articles/s41560-019-0497-9)

## 3.2 Links to other Project Deliverables and Outputs

This deliverable draws heavily on the assessment and benchmarking and results of the living labs and ICT Tools. For more detailed information relating to each living lab, please refer to the deliverables from work package 2,3,4 and 5. Each follows the same number sequence, for example D2.1, D3.1 and D4.1, refer the assessment and benchmarking phases while D2,2, D3.2 and D4.2 relate to round 1. Rounds 2,3 while D2.3, D3.3 and D4.3 cover the rounds 2 and 3 of the living labs. The initial methodology which is intended as a menu of options for each living lab and a summary of the locations involved in can be found in D1.1.

# 4 Living Labs Methodology

## 4.1 What Are Living Labs?

Living labs have grown in popularity in recent years and have tackled several societal issues ranging from crime, energy use, food consumption, and urban planning (Vicini, 2012; University of Maribor, 2017; LILAN, 2009). Unlike traditional laboratory-based approaches where the experimental design and hypothesis are developed in advance for a study. Living Labs exist primarily to provide a material benefit to those involved (e.g., citizens, policymakers, researchers). This is supported by allowing those taking part (e.g., citizens) to help design and implement how the Living Lab functions.

STEP-IN uses a methodology for analysing and tackling energy poverty through three Living Labs situated in a mountainous region in Greece, a rural area in Hungary and an urban area in the United Kingdom with low-quality housing. Each site has a unique set of challenges ranging from energy sources to the socioeconomic status of those taking part as they involve citizens that are hard to reach. This diversity allows STEP-IN to develop and evaluate a range of customizable approaches for each location generalizable enough to be adopted by stakeholders at other sites (including those outsides of STEP-IN). Living Labs are not experiments, but a way for citizens and other stakeholders to develop interventions that best fit their needs. STEP-IN achieves this through home Energy Advisor visits, energy cafes, surveys, and focus groups. Through living labs, STEP-IN believes that the vulnerable members of society who are most affected by energy poverty will benefit from the results and be able (along with other stakeholders) to devise new insights and solutions that best fit their needs.

The GRASPINNO project (University of Maribor, 2017) provided an approach known as VISOR - abbreviated after five aspects: Values, Influence, Sustainability, Openness, and Realism. These five aspects offer a concise way to summarise STEP-IN's core features concerning Living Labs. While GRASPINNO concentrated on higher-level elements such as values and influence, LILAN (LILAN, 2009) pointed to specific attributes within each Living Lab from a methodological perspective.

Individual STEP-IN Living Lab comprised the following five components- recruitment, benchmarking, home energy advisor visit, impact monitoring, ICT tools and information campaigns.

**A full description of the STEP-IN Living Labs methodology can be found in D1.2.**

## 4.2 The STEP-IN Methodology

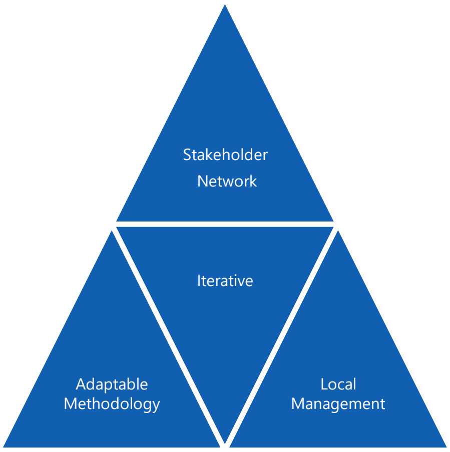


*Figure 1: The Four Key Elements of The Living Lab Methodology*

The STEP-IN living labs comprised four key elements. These are that they are iterative, involve a stakeholder network, utilise an adaptable methodology and are locally managed (Figure 1). It can be thought of as existing on two levels, an underlying but adaptable methodology with an emphasis on receiving feedback and adapting the approach based on the needs of the citizens involved.

A summary of the STEP-IN methodology during each round and the results can be found in this section. However, a full description of the overall methodology can be found in STEP-IN deliverable D1.2.

### 4.2.1 Iterative and Local Approach

The STEP-IN methodology was designed specifically to benefit the citizens involved, rather than acting as an academic research exercise. In order to support this, the living labs consisted of three rounds which each operated in the UK, Hungary and Greece. We designed the labs to operate for a period of up to six months and later rounds incorporated changes either as a result of the feedback from citizens, our own assessments or indeed those brought on due to the Covid-19 pandemic. This approach allowed for the STEP-IN methodology to be modified during each round and between each round.

While an overall approach was used, we decided that the demographics and social challenges in each location would necessitate customisations. This meant that the way the advice was given and often the advice itself varied. For example, in Hungary the advice would often tilt towards suggesting that people connect themselves to the energy grid, while in Greece it was often used to encourage people to undertake small maintenance measures. In contrast, in the UK consumers were often advised to save money via switching energy providers. These are not exhaustive examples, but they represent the variety of advice provided.

*Figure 2 STEP-UP Consisted of Three Rounds of Living Labs in the UK, Hungary, and Greece*

## 4.2.2 Organisational Structure on Different Levels

Each living lab was coordinated by a lead partner in that country, UK (UMAN), Hungary (ARIOSZ) and Greece (NTUA). Each Lab, while implementing their own version of the overall methodology, operated independently, and had authority to manage operations in the way which best fitted their locality. Furthermore, STEP-IN recognised that the involvement of organisations who were trusted by the citizens in each location was critical to success. In some cases, this local involvement was by the project partners themselves, e.g. MALTAI and GMCA, and In addition, it often involved third party organisations such as Groundwork. This local support also ensured the project put emphasis on the citizens involved. This was backed up by an extensive stakeholder network at local, regional, national and EU level. This approach meant that STEP-IN formed an addition to what was being offered in each of the areas, thus meaning that many aspects can perhaps be operated after the project. National Energy providers and regulators were often also involved, for example E.ON Hungary and the Greek National regulator RAE. This management approach meant that if problems occurred in one lab, they would have no or minimal impact on the other living labs.

## 4.2.3 Components of Each Living Lab

The STEP-IN living labs contained several components which operated at different points (see Table 3). For example, early work often focussed on recruitment, benchmarking, and market segmentation. These set the basis of the lab's operations and allowed an approach which focussed on the needs of local citizens. Following on from that various elements connected directly with the local people involved, for example energy cafes, advisor visits and the provision of local advice centres. A range of ICT tools were used to collect data from the advisors and consumers–this varied per location. In addition, we provided an online knowledge base. Temperature and humidity sensors were used in some locations. Surveys and other data collection techniques were used to assess the effectiveness of the STEP-IN interventions. Besides our own methods, E. ON provided aggregated energy data in Hungary for the area in which the lab took place. Where the citizens consented, information from pre-paid meters was also collected.

| | Description |
|---|---|
| Recruitment | Encouraging people to take part in STEP-IN via the campaigns outlined later, referrals via local organisations etc. |
| Benchmarking | An assessment of the current situation for energy vulnerability in each area. |
| Market Segmentation | Within each area, the particular groups of citizens involved along with their particular housing situation and other demographic issues were identified. |
| Information Campaigns | Information leaflets, use of social media and appearances on traditional media. |
| Information Centres | Provision of service where people can drop in in order to receive advice and possibly be referred to STEP-IN. |
| Focus Groups | Citizens along with members of the STEP-IN project and relevant organisations were involved in identifying and suggesting possible. |
| Energy cafes | A public open advice forum, here citizens can visit and get overall and specific advice relevant to them. |
| Energy Advisor Visits | Citizens who agreed were visited several times by a home energy advisor. |
| Installation of Equipment | Installation of temperature and humidity sensors. |
| ICT Tools | A range of tools to assist consumers, advisors, and the public. Ranging from data collection tools through to a knowledge base. |
| Surveys | A range of surveys were conducted across each living lab, these included those relating to the benchmarking aspects, through to assessing impact and also how the citizens involved felt towards the operation of the lab. |
| Dissemination Actions | A range of dissemination actions were undertaken to assist consumers, advisors and policy makers ranging from summer schools, organisation and/or participation in conferences, TV and radio interviews, scientific publications, etc. |

***Table 3 The Components of the Living Lab***

The following sections (4.3, 4.4, 4.5) summarize the methodologies used within each round of the living labs. As seen, we adapted the methodologies and advice provided to fit the situation identified at each location.

## 4.3 Round One

| | UK | Greece | Hungary |
|---|---|---|---|
| Focus Groups | 2 | 1 | 1 |
| Energy cafés | 3 | 1 | 2 |
| Home visits | 150 | 180 | 93 |
| Installation of equipment | 20 | 30 | - |
| Social Survey | N/A<br>Pre-existing data was used. | 1 (to a representative sample of 300 households) | 1 (to a representative sample of 305 households) |

*Table 4 The Methodologies Employed During Round One of the Living Labs*

Table 4 provides a summary of the methodological aspects conducted during round one of each living lab.

### 4.3.1 Manchester – United Kingdom

In the first iteration, the Manchester Living Lab was centred on the Local Energy Advice Partnership Programme (LEAP), provided by a private company Agility Eco, alongside several partner organisations, funded by energy suppliers as part of the UK Government's Warm Home Discount Industry Initiatives fund. The programme is implemented in close collaboration with Local Authorities and Housing Associations. It is open to eligible people on a variety of grounds, such as health, income, social exclusion and housing. Various bodies are able to refer people into LEAP – these include local councils, housing associations, local community groups and private companies. As a whole, LEAP is Greater Manchester's the principal policy in the domain of energy poverty mitigation.

LEAP: applyforleap.org.uk/how-leap-works

KYP: www.kyp.org.uk

We did not carry out a social survey with primary data, because highly detailed, disaggregated and thorough information was available from the UK census, local authorities, and English fuel poverty statistics.

Home ***energy advisor*** ('Green Doctor') visits were the central methodological element of the Living Lab's first iteration. The advice was provided as part of the LEAP home visit, which offers guidance and support on a range of issues. This includes both behaviour change measures and approaches to energy saving via energy efficiency investment, as well as housing and appliance stock improvements. In the main, the advisor visits focused on the targeted households' everyday energy consumption and saving strategies. It should be noted that, in the first iteration of the Manchester Living Lab, the STEP-IN project added several supplementary questions and checks connected to the home assessor visit. This included temperature measurements, examinations of energy and spending cutbacks beyond heating, and self-reported information on household health circumstances. The demographic profile of the households – age profile, number of people, gender, occupation – was also surveyed.

After a period of several months, towards the end of the iteration, each household participating in the Lab was invited to participate in a second, follow-up energy advisor visit. This was used to assess the effectiveness of the initial visit in improving comfort levels and reducing energy poverty. Extensive quantitative and qualitative data were collected during both the initial and follow-up visit.

The first advisor-led questionnaire survey was answered by 154 households in GM – containing approximately 300 people – between 26th April 2019 and 30th June 2019. Due to non-responses on some questions, this generated 150 complete household profiles that could be analysed across all questions asked – these households included 290 people. The same 154 households were contacted once again for the second advisor-led visit and questionnaire, which took place between the 25th of July 2019 and the 20th of September 2019. A total of 84 households agreed to be interviewed once again in the follow-up questionnaires – resulting in a response rate of 55%.

In addition to the advisor visits, three ***energy cafés*** were held in the first iteration of the Living Lab: a central Manchester café in March 2019, and two in inner-city Rochdale in June 2019. The latter two were organised together with the Kashmir Youth Project (KYP), a local community organisation. KYP focuses on enhancing community development and opportunity in the Rochdale area via the provision of a range of services and activities and a strong focus on training, education, and advice services. The cafés focused on information provision at citizens vulnerable to energy poverty – specifically, local community residents in the Rochdale area. Given KYP's focus and history of working with Muslim residents in Rochdale, the cafés also had a particular focus on this section of the community. The events were organised following the principles of a 'world café' style format, with relevant experts positioned at tables or stalls. Attendees had the opportunity to visit the stalls and were offered advice on a number of points. They could discuss and ask questions relating to energy issues. Evaluation questionnaires were distributed at the end of the cafés. A total of 155 people attended the cafés.

During the first stage of the Lab, ***temperature, humidity, and electricity consumption monitors*** were also installed on the residential premises of 20 households.

***Focus groups*** were held during at the start (10th September 2018) and towards the middle of the Lab (28th January 2019). University academic experts, local authority officials, residents, practitioners and private company representatives were in attendance. The focus groups discussed the methodological architecture of the Lab and its operational aspects. They highlighted key expected outputs and challenges ahead.

There were also multiple ***dissemination activities*** with relevant stakeholders to exchange knowledge, influence policy as well as identify and promote best practices beyond the confines of the Lab.

### 4.3.2 Metsovo – Greece

The partners directly involved in the mountainous Living Lab (LL) in Metsovo, Greece, 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 in the area, RAE that provides impactful suggestions for national policy measures for vulnerable consumers, and LIST which develops software and other tools. In addition, a number of local stakeholders have been invited 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.

The first iteration of the mountainous LL took place between March and September 2019 and included among other activities a baseline survey, information campaigns, training of Home Energy Advisors, organisation of one energy café, recruitment of 50 households (in 30 of them, monitoring equipment was installed to measure electricity consumption and indoor temperature and humidity) and operation of an Information Centre.

The ***baseline survey*** aimed to establish a benchmark for energy needs and cost and energy-related behaviour in the area of Metsovo that would also help for assessing the impact of STEP-IN. In order to cover a wide range of issues, e.g. living and housing conditions, housing infrastructure, heating systems, energy expenses, income, and other socio-demographics, the baseline survey used both secondary and primary data gathered by means of a social survey to a representative sample of 300 households.

In the first iteration of the LL one ***energy café*** was held place in the facilities of the Metsovion Interdisciplinary Research Centre (MIRC) of NTUA on Wednesday March 13th, 2019. The energy café involved different stakeholders, i.e. Metsovo's citizens, policymakers, representatives of the local authorities and representatives of the local trade stakeholders. To maximise the engagement of citizens facing energy-related problems and, on the other hand, to avoid any issues of stigmatisation, the energy café invitation and the related poster were strictly focused on - and limited to - energy savings and cost reduction issues. Three short and simple presentations were given from researchers of NTUA and RAE, covering the following topics:

- Understanding of electricity bills and aspects to which citizens should pay attention when switching electricity provider;
- Easy, low-cost methods for reducing thermal energy expenses;
- Collective actions for reducing energy costs, with emphasis on energy communities/ collectives.

A total of 40 people attended the café.

***Energy advisor visits*** were the central methodological element of the LL during the first round. The visits were paid by three trained energy advisors. The households were divided in two groups. The first group involved houses where monitoring equipment were installed, besides the visits and advices 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. During the first visit, information related to the buildings' energy efficiency, current energy costs, heating energy sources, heating system's condition, etc. was collected using questionnaires. A number of supplementary questions were asked (including self-reported temperature estimates, energy spending, etc.). The demographic profile of the households was also surveyed. In the second visit, the energy advisors installed the monitoring equipment in 30 out of 50 households. In some houses, the Advisors used an infrared camera to spot the "weak" points and areas of the building shell and an exhaust-gas analyser to measure the characteristics of exhaust gases from the heating systems. During the third visit (or the second for those households without monitoring equipment), the Energy Advisors provided advice based on the information and the measurements that they received from the first visit and the monitoring equipment, respectively. The last visit aimed at the final assessment and the results achieved in relation to the effects and the appropriateness of the measures and actions applied for reducing energy costs.

The analysis of the results was carried out in three distinct levels of assessment:

(a) Initial assessment, i.e. analysis of the information gathered during the first.
(b) Monitoring assessment, i.e. the calculations conducted using data 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 live, etc.

Based on the initial and evaluation questionnaires (100 in total) and the monitoring data, the following findings were obtained:

- The average indoor temperature in the houses monitored was below 20°C up to April 20th (the outdoor temperature in the same period ranged between 5°C and 10°C). 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.
- Based on the measured temperature, the total heating energy consumption of the households amounts to 951,679 $kWh_{th}$, which is lower than the total required thermal energy (i.e. 988,367 $kWh_{th}$) to keep the houses at comfort levels. In some houses (around 15%), there is over-

spending of thermal energy. The average annual electricity consumption is around 3,800 $kWh_{el}$, about 20% lower than Greece's average. The households that use electric hot water boilers consume, on average, approximately 1,900 $kWh_{el}$ more electricity per year than households without electric boilers.

During the V1 of the LL operation a number of ***dissemination actions*** took place beyond 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 as well as some preliminary results appeared in a widely online energy portal in Greece (https://energypress.gr/news/step-seminario-gia-tin-energeiaki-ftoheia-geniki-syneleysi). Moreover, one paper was published in an international scientific journal (Papada et al., 2019. https://doi.org/10.1080/15567249.2019.1634162) and a presentation was made in a scientific conference, which was held in Metsovo and helped further towards the acquaintance of the local society with the project. In addition, the project was also presented at the 2019 Thessaloniki International Exhibition. As far as the social media are concerned, the Greek Facebook page of the mountainous LL had 452 unique users and attracted 760 unique people. Further, the number of times any content from the page entered a person's screen was 3,261.

### 4.3.3 Nyírbátor – Hungary

The Hungarian Living Lab is in the eastern part of Hungary, close to Nyíregyháza, in the district of Nyírbátor and its neighbourhood. Around 50,000 people live in this area in over twenty settlements. Most of the settlements are villages; there are only 5 cities. Nyírbátor is the biggest with a population of 12,000 people.

To assess the initial situation in this area, we conducted a survey using a detailed questionnaire about energy usage, energy needs, energy literacy, and other aspects of energy vulnerability. The fieldwork started in mid-January and finished in mid-February. The sample size was 305. We used this survey to segment the target group and to explore the needs of local citizens. Based on the survey, more than half of the citizens suffer from some kind of energy-related problem. Over 80% of the average energy expense is the cost of heating, so if we would like to reduce the energy usage, we have to focus primarily on heating, recognizing that electricity is just a secondary target. The two dominant fuel types are gas and firewood for heating. Based on the expenditures, heating with firewood is more expensive than gas. Because of government subsidies and price policy, the gas price had not increased in the last 6 years. With firewood, the situation is worse. Just in the last year, the price of firewood increased by over 10%. At times, there is a deficit of wood, because large biomass energy power plants buy up the stock. It is also much harder to control the room temperature and the overall consumption using a fireplace or a tile stove compared with central gas heating.

Our home advisors were trained social workers, but they didn't have any special knowledge of energy-related advice work. So before starting the LL cycle, we held a training for them. E. ON developed a training material for this purpose. This training material covers a wide range of topics, from safe energy access, through arrear handling and a better understanding of energy bills. We based this training material on the experience of a previously successful programme in Tatabánya, Hungary. Tigáz (gas supplier in the area) extended this training material with information on heating and gas usage. Máltai added elements of available financial schemes for refurbishment actions. In March 2019, local energy advisors (3 in the first round) were trained using the developed training material. Only those energy advisors could take part in the project who went through our training process.

**We held two energy cafes during the first Living Lab cycle**. We organized the first café on the 12th of April 2019. 15 people took part (including stakeholders and STEP-IN partners). STEP-IN members presented the project to the audience; then roundtables were set-up with different topics: discussion on energy saving, tips and tricks, energy bills and arrear handling, heating system, refurbishment schemes, subsidies, and the rights of protected consumers. We organized the second energy café on the 25th of June 2019. 21 people took part (with stakeholders and STEP-IN partners). We added some additional elements to the content of the café. We presented the potential benefits of the programme, and we also introduced how we use the questionnaire data to give insightful tips to the households. The two Energy Cafes helped us to increase the local visibility of the project and helped us to understand better the needs of the citizens.

**Home visits** were the core part of the service that we offer in this area. The Energy Advisors trained by experts carried home visits out. Home visits started with a brief presentation of the programme and the service that STEP-IN offered. Advisors explained how we processed the data that we collected and assured the participants that we will record only personal information to track the programme development, and this information stored separately from other data. The participants then had to sign a consent form. The counselling work started with an establishment survey. Based on the questionnaire, we generated a Personal Advice Sheet (PEAS). In this small report, we gave an overview of the general energy usage of the household; we compared the electricity usage of the household with similar households, and we also disaggregated the electricity consumption on appliance level. At the end of the report, we also gave personalized advice to the household. Our algorithm can recommend possible actions, which could lead to energy reduction. If the household has regular bulbs, we calculated the pay-off period of changing to energy efficient bulbs. If a household had old appliances, we presented the possible energy reduction (and money savings) with new EE appliances. But we also gave tips about heating and arrear handling if they identified these as issues in the questionnaire.

One of the most striking results we had, was that 33% of the first-round participant households had no electricity access at the time of the home visits. These households did not have a formal contract with the utility, or the contract was cancelled because of large arrears. In their cases, our HEAs had limited options. To solve this problem, we needed a complex solution where local governments worked together with the utilities and the NGOs. We put special emphasis on this issue in the following living lab rounds. We calculated an Energy Poverty index by using hard and soft indicators. Based on that typology, 21% of the households had low energy vulnerability risk. 13% of the households had to pay high energy bills compared with their income situation, but the EVI value was not high in their case, which means they could avoid some negative consequences of energy vulnerability like low thermal comfort or arrears. 19% of the households had high energy vulnerability indices without the problem of a high energy burden. There was 12% who were at risk for both aspects. They were the most vulnerable households regarding energy vulnerability, alongside that of the 33% of respondents who had no electricity access.

The impact assessment surveys typically conducted 9-12 months after the first household's visits. We started the impact assessment on June 2020. We wanted to include the 2019/2020 winter period in order to measure the change of heating consumption. The first wave of COVID-19 hit Hungary in March 2020, and it had a serious impact on the energy consumption of the households. 30% of the first LL round households took part in the impact assessment.

**After finishing the first Living Lab cycle, we held a focus group discussion at Nyírbátor**, on the 17th of October 2019. The main discussion developed around possible engagement strategies. Overall, the focus group meeting reached its objectives. We could improve our engagement strategy with new information we received.

**The STEP-IN service was widely advertised and promoted to local people and relevant stakeholders, using a variety of channels.** We advertised the project through local media. Before the first LL, the project leader of Maltai, Gábor Major, gave an interview to the local TV. One of our home energy advisors (Bea Pálóczi) was also interviewed by the local TV, after the first Energy Cafe. Besides the mass media, we also established our social media presence on Facebook. All the STEP-IN events were advertised on this page. Relevant information about energy related questions were also regularly shared on the page. Maltai's office in Nyírbátor served as the Information Centre of the project. Dedicated time slots were available for citizens to meet the HEAs and discuss any energy-related questions. HEAs used this office to organize the home visits, record the information obtained from the home visits' questionnaire, and hold the follow-up meetings with participants.

## 4.4 Round Two

| | UK | Greece | Hungary |
|---|---|---|---|
| Focus Group | 2 | | - |
| Telephone interview | - | 50 | - |
| Home visits | 218 | 130 | 292 |
| Energy cafés | 2 | 1 | 2 |
| Installation of equipment | 20 | 30 | - |

***Table 5 The Methodologies Employed During Round Two of the Living Labs***

Table 5 provides a summary of the methodological aspects conducted during round two of each living lab.

### 4.4.1 Manchester – United Kingdom

The second Living Lab round started on the 6th of September 2019 with a focus group to reflect on the findings of the first iteration, any methodological challenges, and the evolving energy poverty situation in the Greater Manchester area. Changing public policy priorities across Manchester and the UK, and lessons learned from the first iteration caused the modification of some approaches previously used, particularly regarding energy monitors, energy advice and energy cafés. The most significant step was the introduction of direct energy consumption readings during the advisor visits, and the modification of follow-up surveys to evaluate the effects of the Lab. There were also significant changes to the IT approach used, and the manner in which energy, humidity and temperature monitors were used. All of these activities were in line with the Living Lab's overall goal of improving people's quality of life by addressing energy use and broader social exclusion issues among vulnerable consumers.

In the second iteration, the Living Lab continued to involve ***energy advisor visits*** arranged via LEAP. The referral channels, eligibility criteria and mechanics of advice remained roughly the same as in the first round. Once again, there was a first visit involving an energy advisor and covering advice and questions on a range of energy efficiency, financial, housing, health, social welfare, institutional support and energy supply issues. Some of this was provided as standard by LEAP, while the STEP-IN team added a range of supplementary questions to obtain a better picture of the challenges faced by fuel poor households in particular (as they were shown to comprise a very large part of the sample in the first iteration of the Lab). An evaluation visit followed the initial visit to survey the effects of the programme. We collected extensive qualitative and quantitative data during both visits, as in the first iteration. Importantly, we gathered data on actual energy consumption in addition to monetary savings because of the visits. This allowed us to compare financial savings in energy bills to changes in energy consumption itself (see results in section 4). Also, ICT tools were modified to allow for a smoother integration of the Living Lab questions (especially questions regarding the demographic characteristics of the households and the nature of advice received).

The initial Green Doctor visits took place between the 4th of October 2019 and the 27th of February 2020, while the follow-ups were held between the 24th of February 2020 and the 13th of March 2020. Given the unfolding of the UK's pandemic in 2020, Green Doctor visits in the second round of the Living Lab were not affected by any pandemic-related restrictions. A total of 218 households received advice – exceeding the initial target of 150 households. Out of these 150 were approached for a follow-up evaluation visit and 117 responded, representing a much higher response rate compared to the first round – 78%. This can be attributed to improved communication methods and approaches adopted after the experience from the first iteration (changes to communication strategies were discussed and agreed at focus groups).

***We organised energy cafés targeting the communities of Tameside and Wythenshawe*** in a similar way to the first round in order to explore and discuss social participation, advice, behaviour and inclusion issues around domestic energy use and inequality. The energy cafés provided a range of advice: awareness raising around issues relating to energy bills and thermal comfort; switching energy suppliers; available support services that may help with the management of energy costs (including participation in the STEP-IN project via a Home Energy Advisor visit), and household measures that can be taken to reduce energy costs and improve comfort (e.g. through more informed purchase decisions, behavioural change, physical measures such as energy-efficient appliances, refurbishment schemes,.). As before, a 'world café' style format was followed – energy experts were positioned at several tables, each focused on a specific set of advice; attendees of the event then visited and moved between the various tables, receiving the respective advice, along with the opportunity to discuss and ask questions relating to energy issues. A member of the research team remained near the exit and recruited attendees to complete the evaluation questionnaire as people left. The events took an intentionally informal style to ensure a relaxed atmosphere in which attendees feel comfortable asking questions.

The cafés were run by members of the STEP-IN team. Evaluation questionnaires were distributed at the end, to gather data on: (1) attendees' perceptions of the café, and what they found to be useful; (2) aspects they believe could be improved, in terms of information provision and communication; (3) changes in their knowledge and awareness of energy-costs, and energy-efficient technologies and behaviours; (4) whether there are any behavioural changes they plan to make as a result of what they learnt at the café, in terms of energy efficiency and behavioural measures. This information provided data analysed by UMAN for scientific purposes, as well as feeding into the design of future energy cafés. We also utilised the cafés to recruit households for STEP-IN Home Energy Advisor visits. A total of 105 people attended the cafés. A third café was also planned for mid-March 2020 but had to be cancelled due to the pandemic.

Two ***focus groups*** were held during the Living Lab, on the 6th of September 2019 and the 7th of November 2019. The focus groups involved all the relevant stakeholders relevant to the Living Lab: academics, researchers, practitioners, advocates, citizens and organisational representatives. They helped alter and improve the methods used by the Living Lab in its first iteration. There was much discussion of the challenges encountered by Living Lab participants and the urban area as a whole. Each focus group involved 8 participants.

Energy, humidity and temperature ***monitors*** were distributed across 20 households. Even if the fire safety and data compatibility issues encountered during the first iteration of the Lab were overcome following discussions and actions decided at the focus group, an additional problem emerged: none of the monitors could be recovered from the 10 households that they were distributed to. Nevertheless, data was collected from the temperature and humidity monitors. We also collected 10 ***energy diaries***, which, however, did not yield scientifically rigorous results. The qualitative insights from the diaries indicated that the surveyed households were facing severe financial, resource and time pressures and would be unlikely to complete the diaries consistently without remuneration (which was not foreseen in the initial project design and would have presented ethical issues). Nevertheless, the design of the diaries was judged positively by focus group participants.

As before, the Lab team undertook multiple ***dissemination activities*** with a wide range of stakeholders. This allowed for the exchange of knowledge and policy impacts. It also helped identify and promote best practices beyond the confines of the Lab.

As before the Lab team undertook multiple ***dissemination activities*** with a wide range of stakeholders. This allowed for the exchange knowledge and policy impacts. It also helped identify and promote best practices beyond the confines of the Lab.

As a whole, the second Living Lab iteration allowed for multiple refinements and improvements to the data collection process and consumer engagement methodology, thanks to lessons learned from the previous round. This includes improvements to the advisor visits (types of data collected, engagement mechanisms), IT approaches, deployment of energy, humidity and temperature monitors, energy café design, and energy diaries. The round involved a higher-than-expected number of participants supported by focus groups.

### 4.4.2 Metsovo – Greece

The V2 round of the mountainous LL started in November 2019 and ended in June 2020. Focusing on the findings and lessons learned from the V1 round, we made certain methodological adaptations, particularly regarding the energy café and the energy advisors' actions during the home visits. Further, energy diaries were distributed across the households and significant changes to the IT tools used by the LL were made. All these actions were in line with the LL's goal of improving people's quality of life and reducing energy consumption and spending among local households. Finally, the activities of the LL were suspended for two-and-a-half months due to pandemic-related restrictions and were modified to adapt to the new situation.

We held the **second energy café** on Saturday, January 25th, 2020. Taking into consideration the comments of the participants in the first event (i.e. to move closer to centre of Metsovo), the second energy café was hosted at the Metsovo City Hall. The main theme of the event was the presentation of the results of the first round of the LL. The energy café involved different stakeholders, i.e. Metsovo's citizens, policymakers, representatives of the local authorities and representatives of the local trade stakeholders (i.e. Metsovo Trade Association) and was attended by about 40 residents. 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. During the event, the heating and electricity needs of the households of Metsovo were analysed, based on the measurements collected by the temperature, humidity and electricity consumption sensors. Then, 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, and 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 they will implement energy-saving measures based on what they heard at the event.

As far as the ***energy advisor visits*** were concerned, 50 new households were recruited, divided into two groups similar to the V1 round (i.e. with and without monitoring equipment installed). Based on the approach developed during the V1 round, the Energy Advisors would visit the thirty households, where equipment was installed, four times and the rest twenty households three times. Due to the coronavirus outbreak, the final visit was not conducted, and the evaluation questionnaire was filled out remotely. In the first visit, the Advisors installed the monitoring equipment and used questionnaires to collect information regarding 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.). It should be pointe d out that these questionnaires were filled out during a second visit to the households with monitoring equipment, this was to avoid staying long in people's homes. Again, the Advisors used an infrared camera to spot the “weak” points and areas of the building shell (thermal bridges, badly insulated walls, etc.), and an exhaust-gas analyser to measure the characteristics of exhaust gases from the heating systems. Based on the experience gained from the first round, twelve oil-fired burners were checked. In the second round, only three burners had to be maintained. This is a promising sign, meaning considering that during the first round of the LL, almost half of the burners checked were out of specification. This point was discussed during the energy café and promoted through leaflets and social media posts and seemed to resonate with many people. The energy advisors provided the households where monitoring equipment was installed with energy diaries and asked them to keep a daily record on the usage of the heating system and electrical appliances. They collected less than half of them. For these households, it was easier to provide more accurate and tailored-made advice concerning simple and easy ways to reduce their energy expenses and/or improve their households comfort level. In general, energy diaries did not seem to work well in the mountainous LL, as people were not committed to keeping the diaries.

Again, the analysis of the results was carried out in three distinct levels of assessment (i.e. initial, monitoring and evaluation). Based on the initial and evaluation questionnaires (100 in total) and the monitoring data, the following findings were obtained:

- 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. 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.
- Based on the measured temperature and the engineering models, the total heating energy consumption of the households 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. In some houses, there is over-spending of thermal energy. 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. 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.

As before, a number of ***dissemination actions*** took place beyond local scale. More specifically, the project and results up to this point were appeared once more in a widely online energy portal in Greece and a presentation was given at the Conference of the “Twinning Project for Service Quality and Smart Metering in Georgia”. As far as the social media are concerned, the Greek Facebook page of the mountainous LL had 446 unique users (i.e. Daily Page Engaged Users), while it attracted 1,829 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 2,567.

### 4.4.3 Nyírbátor – Hungary

The second Living Lab round started with an Energy Cafe at Nyírbátor in September 2019. We started the home visits in November 2019 and finished them in June 2020. Based on the first-round results we adapted a new engagement strategy. The local embeddedness of Máltai in Nyírbátor was not so strong. Thus, it was really challenging for the HEAs to raise public interest there. The opposite was true in Nyírpilis - where Máltai had a strong ongoing presence through the Children's Chance program. The operation of the program and the continued presence of Máltai social workers created an environment of trust where local engagement was much easier. Therefore, we decided to focus those settlements were Maltai has strong presence, or where we can find strong local actors who could help us reaching the community. This is especially true in small settlements, where the trust is lower towards people outside from the community. The new engagement model went much better, more people participated in round 2 than in round 1. We also made some minor modifications in the questionnaire we used for home assessment. We updated the questions about heating and gas consumption to mirror better the habits of participated household. We used the same Personal Advice Sheet (PEAS) as in round 1, but we integrated this feature to the STEP-IN tool developed by LIST. This made it easier for our HEA's to give quick response on household actual needs.

**Two energy cafes were organized in round 2.** The annual expo "Nyírbátor city days" was held in Nyírbátor on September 20-22, 2019. The STEP-IN project was represented at the event by local partners Ariosz, Maltai and E.ON. Citizens who were interested had the opportunity to learn about the services they offer and could also complete a small energy quiz. Ariosz, Maltai and E.ON started discussions with more than 40 people and organised new home energy visits. The event was a great opportunity to raise awareness towards the STEP-IN project and to discuss energy related questions with people who are otherwise difficult to reach. Building on local events or programmes such as this is a very successful engagement strategy for the project. We hold the 4'th. Energy Café, at Nyírpilis, on March, 9th, 2020. The main topic of the event was the safe access to energy sources as well as possible ways to reduce heating costs. Through this event, we were able to reach a lot of new potential participant of ongoing home visits. 27 local people participated in the EC. This was the last face-to-face event before the COVID-19 lockdown.

In the second LL period, we carried out **292 home visits**. We started the second LL round in November 2019 and finished it in June 2020. The original plan was to finish the second LL round earlier, but due to COVID restrictions we had to suspend the work for around 2 months. We followed the same strategy in the home visits as in round 1. In the first visit, we asked the households to fill out an assessment survey. This helped the HEA's to identify the main problems and risks and to map the baseline situation of the household. The PEAS add an overview of the energy consumption of the household and gave them useful advices. Our advisors then tried to put together a work plan on how the situation of the household could be improved. This work plan had different elements and it mirrored the needs and opportunities of the current household. Sometimes, we suggested refurbishment actions, in other households we tried to provide arrear management support. 10% of the second-round participant households had no electricity access at the time of the home visits. That was a lower number than round 1, but it was still a lot of households. 35% of the households said that they did not have any problem with their dwelling, but there was almost the same number of households which marked 3 or more of the problems below. The most common problem (45%) was that there is condensation on the windows and walls during winter. A lower but significant number of participants (31%) said that there was dampness on the walls or floors, and 29% said their dwelling is **not** comfortably cool during summer. 26% noticed mold in their home, 25% said that they were in arrears with the energy bills over the last two years, and another 23% said their house is **not** comfortably warm during winter. Leaking roofs presented as a problem in 19% of the households. 14% of the respondents said that their power supply had been cut off due to arrears over the last 24 months. There were fewer energy vulnerable people in the second LL round, 51% of the households have low energy vulnerability risk. 17% of the households have to pay high energy bills compared with their income situation, but the EVI value is not high in them. 12% of the households have high energy vulnerability indices without the problem of high energy burden. Moreover, there is 10% who are at risk for both aspects. These are the most vulnerable households regarding energy vulnerability, alongside with that 10% respondent who had no electricity access.

Most of the second LL round **impact assessment** were carried out in between November 2020 and January 2021. 78 households took part in the impact assessment, this is 37% of the second LL round participating households.

We developed an **energy diary** and distributed it in 10 households. The results were the same as in the UK Living Lab, we did not get any useful data from the diaries, participants didn't fill it in a proper way. It was too much time and effort for them, and because they did not get any remuneration for that, they were not motivated enough. Despite the diaries itself could not produce any useful data, the participants felt it helped them to raise awareness, so the diaries were not entirely useless on a project level.

In parallel with STEP-IN the Emerging Settlements program[2] has been launched in Hungary. In the framework of the Emerging Settlements program strong emphasis has been put on **support for setting up formal connection to the electricity grid**. One of the most striking results of the first LL was that more than 30% of the participated household didn't have formal electricity access. STEP-IN worked jointly with the Emerging Settlement Program to solve this issue. ESP provided the financial support and STEP-IN provided the professional advisory layer. During the second LL round 10 households managed to reconnect to the grid. Almost all of the families engaged in energy advisory and claiming support for reconnecting used to have formal electricity supply (so the network is present) but have been disconnected to various reasons. We have received a high number of support claims for limited funds, thus we had to set up eligibility and priority rules to decide who could be involved in the reconnection scheme in the first round. Support decisions were made by a multiparty committee. Criteria covered the number of children, financial situation and indebtedness of the family, electricity arrears, ownership situation and technical condition of the house. The preparation phase took months, including getting a deeper understanding of the situation of the families, preparation of documents, technical condition survey of houses and negotiation with the electricity provider company. As a requirement of the grant agreement, all of the new electricity connections were installed with prepaid meters, which helps to raise awareness of the actual consumption and prevents the accumulation of arrears and disconnection.

A number of **dissemination actions** took place. We presented our project at a Conference about Energy Poverty hosted by the Hungarian Academy of Science, we organised a meeting with the experts of Regional Centre for Energy Policy Research (REKK) and we also organized a winter school in Budapest and Nyírbátor.

---

[2] The Emerging Settlements program is a national social inclusion program which was launched in 2019 and will cover 300 settlements in 10 years. It provides complex development measures for segrerated areas and areas at risk of segregation.

## 4.5 Round Three

| | UK | Greece | Hungary |
|---|---|---|---|
| Focus Group | 5 | 1 | 1 |
| Telephone interviews | 196 | app. 210 | 292 |
| Home visits | | | |
| Online energy cafés | 5 | 1 | |
| F2F energy cafés | | | 3 |
| Online round tables | | 1 | |
| Web conference | | 1 | |
| Social survey | 1 (to a sample of 102 households) | 1 (to a representative sample of 303 households) | |

*Table 6 The Methodologies Employed During Round Three of the Living Labs*

Table 6 provides a summary of the methodological aspects conducted during round thee of each living lab. Round three was heavily impacted by the Covid-19 pandemic. As can be seen across all three living labs, no home visits took place.

### 4.5.1 Manchester – United Kingdom

The third iteration of the Living Lab took place during 2020, and as such was undertaken in the midst of the global COVID-19 pandemic. Notably, the Greater Manchester Urban Area was affected by different forms of pandemic-related restrictions for the most part of 2020 and extending into 2021.

The very first actions to curb the spread of COVID-19 were implemented on the 12th of March 2020, when the UK Government suspended various sporting and cultural events, along with local elections. On the 16th of March 2020, the Government advised all people in the UK against 'non-essential' travel and contact with others. The advice was particularly directed at pregnant women, people over 70 and those with certain health conditions; they were asked to self-isolate within days.

On the 23rd of March 2020 the UK government announced the first lockdown, imposing a 'stay at home' order, titled 'Stay Home, Protect the NHS, Save Lives'. This banned all non-essential travel and closed most gathering places. People with symptoms, and their households, were told to self-isolate, while those with certain illnesses were told to shield themselves. People were told to keep apart in public and police were given the power to enforce the measures. Emergency powers were granted to the national Government under the auspices of the Coronavirus Act 2020. The lockdown was eased on the 10th of May 2020 – followed by the opening of most facilities - and groups of six were allowed to meet outside on the 28th of May 2020. Children returned to schools on the 1st of June 2020. The coronavirus alert level was subsequently reduced, but face coverings become mandatory in shops on the 24th of July 2020.

Following a rise in the basic reproduction number in September, parts of the North West (including Greater Manchester), West Yorkshire and the Midlands faced severe new restrictions in response to major increases in cases. This was toughened further on the 20th of October, after the establishment of a three-tier system of local alert levels for England. On the 2nd of December, England's national lockdown came to an end, being replaced by a strengthened three-tier system. On the 4th of January 2021, the UK's Prime Minister announced a third national lockdown for England, resulting in schools shut to most pupils and people urged to stay at home to prevent the NHS being overwhelmed by surging coronavirus infections. Restrictions started to be eased from March 2021, with schools reopening from the 8th of March 2021.

The third and last round of the Manchester Living Lab was undertaken entirely during the COVID-19 crisis and the restrictions described above. As such, it necessitated a further level of socio-technical experimentation in urban public engagement and energy interventions, as well the deep modification of previously applied methodologies. The Lab was, in effect, the first of its kind to provide energy advice to vulnerable citizens through remote methods during a pandemic. Nevertheless, the Living Lab continued to function in line with its original aims (established before COVID-19) to identify and promote ways in which vulnerable consumers can improve their quality of life. Its primary purpose – developing and expanded on the experience gained during the previous Lab iterations – still held.

In the third iteration, the Living Lab adapted its methods to an online working format, so as to ensure compliance with COVID-19 restrictions. Instead of physical energy advisor visits, the Lab set up a phone-based energy consultation service. The service was independent of the LEAP scheme that had been previously tagged on to the Living Lab (because LEAP itself was temporarily suspended at the start of the third Living Lab iteration). Still, citizens could self-refer or be referred to the service via communication channels previously used for LEAP. Phone advice was provided in the course of a one-hour conversation. A number of questions were asked by the advisors (answers were subsequently recorded), in addition to advice given (also recorded). A wealth of qualitative evidence about energy poverty issues faced by callers was also collected. In 16 instances, advisors dropped off energy saving equipment and devices at customers' doors.

***Online energy advice*** was provided between the 21st of May and the 14th of September 2020, when coronavirus restrictions were relatively lighter in Greater Manchester. A total of 197 consultations were held; the same households were approached several months later and, remarkably, despite the difficult conditions, 102 provided follow-up evaluation data on the effectiveness of the advice and any consecutive measures taken. This represents a response rate of 51.8%.

***Energy cafés*** were organised so as to provide information on: 1) the factors that influence perceptions of energy advice during the pandemic context (particularly in terms of the nature of the information being communicated and perceptions of the source of information); as well as 2) the determinants of socio-technical and behavioural interventions to address energy poverty. The Living Lab organised a total of 5 online energy cafés in the form of web chats with specialised advisors, on the 8th, 12th and 15th of October 2020, and the 7th and 10th of December 2020. However, there was very limited attendance in spite of the extensive advertising through multiple local channels undertaken by the Living Lab team. This can be attributed to the severe difficulties imposed by the pandemic on vulnerable people throughout the Greater Manchester urban area.

Five ***online focus groups*** were held during the Living Lab, on the 10th of June 2020, 20th of July 2020, 6th October 2020, 27th November 2020 and 25th February 2021. As before, the focus groups principally involved expert, citizen and practitioner discussions and modifications of the methods used by the Living Lab, as well as the ongoing challenges that it faced. Each focus group included 6 participants. Energy diaries, as well as energy, temperature and humidity monitors, were not distributed due to lockdown restrictions.

***Dissemination activities*** continued to take place with a wide range of stakeholders, but exclusively online. We still managed to exchange knowledge and exert policy impacts, while identifying and promoting best practices.

Based on the results from the third Living Lab iteration, novel and original analyses about energy advice in COVID-19 conditions, in the context of previous iterations of the Lab, were undertaken following the completion of the Lab.

### 4.5.2 Metsovo – Greece

The V3 round of the mountainous LL started in mid-June 2020 and ended in late December 2020 (although the monitoring equipment stayed at the houses till the end of January 2021). Nevertheless, 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 remotely by the households that participated in the V3 round activities and the second social survey. 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 V2. 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 V3 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, the conference was co-organised with RAE as Web Conference on November 19, 2020 instead of a live event. With over 220 people attending, the conference was a great success especially considering the COVID-19 situation (approximately 100 attendees were expected).
11. The link for the app is: https://mirc.ntua.gr/step-in-app/
12. The app provides the user the ability to calculate the heating and electricity cost to meet the needs of her/his home. In addition, by changing the parameters (e.g. type of window frames, existence of thermal insulation, type of heating fuel, etc.) the app allows the user to explore possibilities of saving energy costs.
13. The app involves three steps. In the first step, the user gives some basic information about her/his home. In the second step, the user fills in some details concerning the characteristics of the building.
14. In the last and final step, the used provides information about the heating and electricity systems. Once all the fields have been filled in, the calculation button is activated and the user receives the results (energy consumption for heating and electricity purposes in kWh and energy cost in Euros per year).
15. The user can also go back to the data tabs, change the options, and perform new calculations. With this process, the results tab gives the new energy consumption and cost as well as the difference with the previous calculation. As mentioned, this function allows the user to explore possibilities of saving energy costs.

As mentioned, the third **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 is mentioned, however, that participants' involvement in the online event was not the same as in the face-to-face events.

In the last round of the LL, 50 new households were recruited, in addition to the 30 households of the V2 round that kept the monitoring equipment. All the ***energy advisor visits*** were conducted remotely via phone, online platforms or email. The analysis of the results was conducted separately for the new and "old" (i.e. households with monitoring equipment from the V2 round). As far as the V3 households are concerned, the analysis was based solely on the initial and evaluation questionnaires (100 in total). Concerning the "old" households", the analysis was carried out using monitoring data and questionnaires with the aim 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.). In order to support not only the households that participated in the last round but also the rest of the households in the area of the LL and beyond, the following awareness and information material was prepared:

- An online app 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 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 that includes information and advice on energy efficiency and consumption, refurbishment schemes, subsidy programmes, energy labelling schemes, etc.

Based on self-reported estimates, the following findings were obtained for the V3 households:

- Among those who have thermostats (either analogue or digital), 2.6% reported that they set the thermostat below 18ºC, 23.7% said that the thermostat is set between 18ºC and 20ºC, and the rest (i.e. 73.7%) claimed that they set the thermostat to over 20ºC. As regards the stated indoor temperature, about 93% of the households stated an average temperature over 18ºC during the winter period. Specifically, 41% stated an average temperature in their home more than 20ºC, 52% an average temperature between 18ºC and 20ºC, and the rest an average temperature below 18ºC.
- 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, the size of the house and the insulation of external walls. Nevertheless, the difference in the means proves to be statistically significant only for the size of the house. 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 vary to the size of the house and the size of the household. In both cases, the differences in the electricity cost between the groups of house and household sizes are statistically significant.

Concerning the impact of the COVID-19 pandemic and the restrictions adopted 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 5 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.

As regards the ***dissemination actions***, the project and its results appeared widely in an online energy portal in Greece. Further, three scientific papers have been published in international peer-reviewed scientific journals, one presentation was made in the 5th HAEE Energy Transition Symposium "Global and Local Perspectives" and seven presentations were made at the 1st National Energy Poverty Web Conference. Further, the energy advice booklet was distributed by RAE to all 13 Regional and 331 Municipal Authorities, the Ministry of Environment and Energy and the "Centre for Renewable Energy Sources and Saving – CRES". So far, the booklet has been posted on the website of more than 20 Regional and Municipal Authorities. 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). Also, a quick Google search for the title of the national energy poverty conference returns over 10,000 results. In addition, around ten interviews at radio stations and the TV about the energy poverty conference were given. Finally, the Greek Facebook page of the mountainous LL had 50 unique users (i.e. Daily Page Engaged Users), while it attracted 563 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 904.

### 4.5.3 Nyírbátor – Hungary

**The COVID-19 pandemic** started around March 2020, in Hungary. In the first months, the case number was quite low, as the Hungarian government successfully implemented many restrictions to prevent the outbreak of the first wave. Schools and shops were closed, and people have been asked to stay at home. Around June the life went back to a normal, most of the restrictions were lifted. The second wave started around end of August and reached its peak around November. Primary schools were not closed during the second wave just the secondary schools, but a curfew has been introduced between 8pm and 6am from November. The third LL round home visits started at September. We have finished the home visits in November. In the start of the third round, we organized a Focus Group meeting to discuss the possible adaptation strategies under the Covid pandemic. We decided to move forward with "minimal contact" face to face home visits. We also kept the f2f format of energy cafes, but we asked the participants to wear masks, and we asked them to keep distance from each other. All of the home advisors agreed that online and telephone format is not suitable for our target group. But when the Covid case numbers started to increase in November, we decided to shut the face-to-face meetings. As we already reached at that point the planned number of home visits that didn't have any negative impact on the project objectives. But the impact assessment surveys were conducted through phone, or our advisors left the questionnaire at the household and collected it later. We add a special COVID block to the questionnaire in order to measure the impact of COVID-19 pandemic to our service

**We organized three Energy Cafes in the third Living Lab round**. The 5th Energy Café was at Nyirkáta, on September, 10th, 2020. Around 40 participated in the Energy Cafe and more than half of the participants signed up for home energy visits within the scope of our STEP-IN project. The main topic of the event was "*Safe and formal access to energy sources and basics of energy awareness*". This energy Cafe was a really good „ice-breaker" in this settlement, it raised trust, and it supported our field work activities. We organized the next EC in Nyírbéltek – with the same objectives. 10 people participated, most of them live in the segregated part of the settlement. This event helped us to start discussion with the local Roma community. The last EC was held in Nyírbátor in November, with 11 participants. There was a lively discussion around heating problems. Indeed, firewood is the main heating source in most of households there and proper storage of the firewood could increase its effectiveness by 30-50%. We discussed possible community solutions which could support pensioners in this issue.

In the third LL round we add a new settlement to the program: Nyírbéltek. Nyírbéltek is a special settlement regarding available data sources. E.ON deployed **two aggregator measurement points** there which allows us to continuously monitor the aggregated electricity usage of these districts. Around 100-150 households live in each district. The 15 minutes granular electricity consumption data is available here from 2018. We primary used this data to estimate the impact of COVID-19 on electricity consumption. E.ON also deployed **pole-meters**[3] in Nyírbéltek. A Pole-meter is a special electricity meter type. In this case the meters are not within the house, but they are fixed to the electricity pole. This meter type has one very important feature. It records the electricity usage every 15 minutes, so it works like a smart-meter. This data makes it possible to create smart-meter based electricity reports. We add this report type as a new element of our service in Nyírbéltek. We continued to support the **reconnection of households**. We managed to reconnect 4 households within the cycle of this lab.

As a new project element, we were able to organize an **Energy Adventure program for children**. Our Energy Advisors visited the primary school in Nyírpilis in our Hungarian Living Lab and had a live conversation with the pupils (age 10-14) about #energy usage habits. Almost 40 students participated in our lecture which was one of the events of the Sustainability Week in the school. It was a pleasure for us to chat with these smart kids about energy and we thank all of them as well as the school staff for such a great discussion. Low energy literacy is a key factor when it comes to inefficient energy use. If we can educate the young generation on how to use energy properly, we can achieve long-term effects, and we have achieved a small step within the STEP-IN project.

In the third LL period, **292 home visits** were carried out between September and November 2020. As mentioned before, two new settlements were joined the project, Nyírkáta and Nyírbéltek. 8% of the third-round participant households had no electricity access at the time of the home visits. According to the calculated EP index 36% of the visited households belonged to the low-risk category. 23% had

---

[3] https://www.youtube.com/watch?v=AdOXbNg_W6w – E.ON experts present the pole meter technique (Hungarian)

to pay high energy bills compared their financial position. 19% of the households were in high energy vulnerability risk, and another 14% were in risk of both former aspects. Third LL round **impact assessment** was carried out in in January 2021. 106 households took part in the impact assessment, this is 37% of the third LL round participating households (same ratio as in round 2).

In order to map the **COVID impacts**, we add a COVID block to the impact assessment questionnaire. This question block was identical with the ones we used in the other LL's (Metsovo, Manchester). 46% of the participants said that they stayed more time at home. The average increase was around 3 hours. Participants experienced many negative consequences of the restrictions and it affected the basic needs of these households. 54% of the households had difficulties to afford adequate food. Childcare was another issue, 46% had difficulties in managing the kids. On top of that 32% had difficulties managing care for other members of the household. We found one additional negative consequence of COVID. Heating with rubbish was more common than before. 37% reported that they sometimes use rubbish for heating. This number was 10% lower in the initial home visit questionnaires.

As regards the dissemination actions, we primary used our Facebook channel to communicate directly with the local community. We shared their many tips and suggestions about possible energy reduction methods. We created a new flyer about the dangers of electricity. We experienced many safety problems during the home visits, so this flyer proved to be very useful in round 3. We hold an oral presentation in the "Right to Fair Energy Access" Conference organized by Adiconsum. We also organized a webinar in March for colleagues and experts to present the main findings of the Hungarian Living Lab.

## 4.6 ICT tools

An important part of the Living Labs was their user-centred innovative concept, where ordinary people, scientists, stakeholders, and policy makers who work in the same geographical area, are actively involved in real life communities and settings. Through a mutually beneficial collaboration, the Living Labs allowed for an interactive communication amongst actors to find solutions, ranging from new products, processes, services to local, regional, national strategies, policies and legislation, to the specific needs and aspirations of local contexts, cultures, and creativity potentials.

ICT tools played a central role in supporting all living labs (see Figure 3) to collect information and provide advice. They were specifically designed to support each Living Lab locally in data collection, automated analysis and advice tools, to find reliable solutions for consumers and energy poor households. In addition, it was important to develop generic ICT tools, which are easily transferrable and interoperable to allow data integration and analysis. All Living Labs adopted a three-stage methodological approach where ICT tools should encourage the tackling of energy poverty issues at an individual and community level. Data were gathered by energy advisors and stored locally after written consumer consent at each living lab and anonymised to guarantee data privacy. The energy advisers of each Living Lab assisted in providing advice to vulnerable consumers on understanding and improving energy consumption behaviour and to lower costs and consumption where possible.

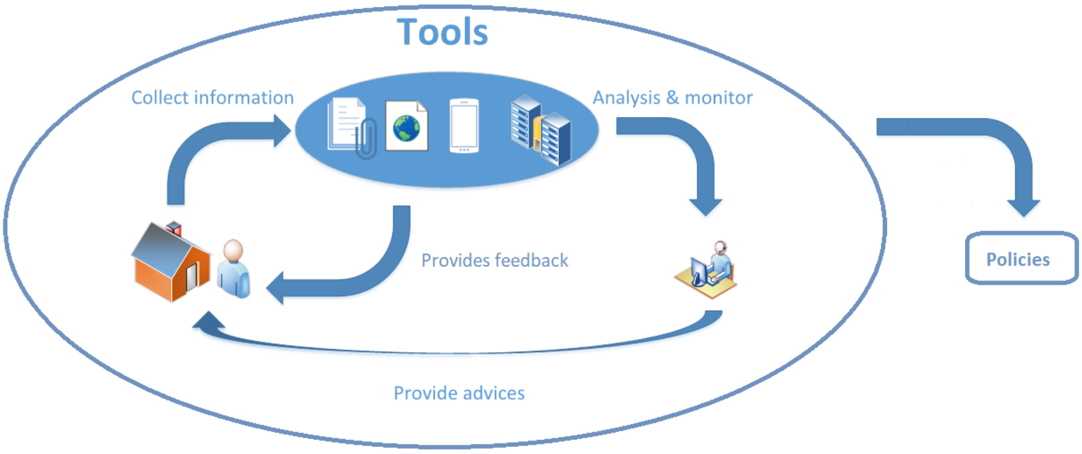


*Figure 3: Role of ICT tools in STEP-IN*

### 4.6.1 Specifications, Design and Implementation

Before the start of the three Living Lab cycles (V1-V3), an inventory of requirements was performed in 4 workshops, 3 workshops with each Living Lab individually and 1 joint workshop with all Living Labs to decide on the final requirements and to design the ICT tool architecture. Each Living Lab cycle V1, V2 and V3 was supported by ICT tools, tested, evaluated and, if necessary, refined based on the feedback obtained from the participants. All the partners collaborated in translating the requirements into system specifications to make the proposed ICT tools effective and to support sustainable energy advice to vulnerable consumers.

Validation of the ICT tools helped to evaluate the impact, and to identify improvements and their usefulness of the said tools for vulnerable consumers. Data gathered from the different Development, Implementation and Testing stages during the 3 living lab phases V1, V2 and V3, were analysed and improved for each cycle.

STEP-IN leveraged from existing ICT tools, such as the iGuess® software framework developed by LIST which served as the main frontend and backend, as well as additional tools such as the LEAP app in Manchester used in the UK LEAP programme for energy advice to consumers. The STEP-IN platform was then created to integrate energy data coming from home sensors, mobile devices and PCs and allows for analysis and advice or support tools for energy vulnerable people and energy poverty risk avoidance in the Living Labs. The created tools focus on supporting four main groups: researchers, energy advisors, consumers, and policy makers.

#### ICT tools requirements analysis

The living lab workshops resulted in the general requirements for the ICT tools. Below is a brief description of list of key features which were implemented at different points during STEP-IN, i.e. V1, V2 and V3. Table 7 lists the most important Key Features for the ICT tools and platform.

| # | Feature | Description |
|---|---|---|
| 1 | Credentials | Login/logout for multiple user profiles: local researchers, local energy advisors, consumers, LIST researchers. Public can access general advice information without login. |
| 2 | Dashboard | A dashboard letting users access quickly specific parts of the tools |
| 3 | Home setup | Interactive floor map that can be drawn directly in the tool, where the user can define the room set up, assign a function and temperature values, the windows and door location, and heating system locations. |
| 4 | Questionnaires | Questionnaire to be filled by the adviser with the input from the consumer visited. Questions were defined by each Living Lab. |
| 5 | Feedback | Allow to get some feedback from consumers and advisors about the app or the methodology used in general and from consumers about energy advices themselves. |
| 6 | Result analysis | Display the result of analysis computed by researchers or Energy advisors. |
| 7 | Researcher analysis tools | Survey data as summary, statistics overview graphics, Detailed maps, Floor plan mapping, Energy poverty risk |
| 8 | Energy adviser analysis tools | Time series graphs for individual household data, floor plan mapping, heat map or neighbourhood/district maps, comparison chart to average of all other households, e.g. boxplot for all households and point datum for the individual household concerned in the comparison |
| 9 | Scenarios | Allow to evaluate alternative scenarios for energy consumption and costs |
| 10 | Knowledge base | Some general advices that may be common to all consumers, e.g. avoid/reduce heating while windows are opened. General guidelines, to be assessed without login in a knowledge web page. |
| 11 | Personalized advices display | Advice dedicated to an individual consumer, based on the consumers observed data and on the analysis, results made by the living lab researchers. |
| 12 | Visualisation of results | Some charts (bar plots, time series graphs, etc.), easy to understand, showing more comprehensive results in an easy way for energy advisors, consumers, and policy makers |
| 14 | Benchmarking | A way to display consumer data in relation to average or alternative consumption profiles or displaying the evolution between first cycle and last cycle of analysis. |
| 15 | Reporting | An easy way to export the data as PDF to be printed on paper or shown in electronic format so the consumer can keep a trace of it. |
| 16 | Raw data access | To be able to do any kind of analysis, the researchers have the need to access the raw data easily, to use it directly or on external tools. Data are going towill be exported as CSV. |
| 17 | Upload Data | Data to be uploaded:<br>Energy advisor (household survey, sensor data, smart meters), household plan, researchers to upload results |

*Table 7 Key Features for the ICT tool platform*

### 4.6.2 The STEP-IN ICT tool platform

The STEP-IN ICT tool platform was implemented according to the specifications and design, respecting GDPR. The platform is deployed in each LL and connects to a data analysis engine to enable effective analysis of energy consumption patterns. Multiple types of device (smart phones, tablets, PCs) are able to connect to the platform and its user interface to interact with it to send, gather and display information from it (e.g. questionnaires, diaries, sensors data, charts).

#### Platform features

We describe here the list of features and functionalities available for versions V1 and V2 which were finally implemented into the STEP-IN platform during the three Living Lab rounds V1, V2, V3:

**Advice / Reports** - STEP-IN web platform provides access to general information and advice about energy consumption. There are two defined types of advice:

(a) General advice suitable for all consumers, called the public. We created a page called Knowledge Base containing a set of documents (PDF files) containing general advice suitable for all Living Labs but also some specific ones fitting the needs of individual living labs. Here an advisor or a consumer can find basic advice, general energy consumption graphs and general information displayed on a map.

(b) Personal advice and reports consisting of advice for a specific user (customer). Here the energy advisor can get charts based on a consumer's consumption data at specified dates regarding a selected variable. It also allows to run an analysis of consumer data (energy consumption and/or questionnaire based) which produces a pdf report containing information and advices specific to the consumer.

**Contact report** - The platform offers to schedule and track contacts between advisors and consumers in a form, the advisor can fill in the following contact details:

(a) the schedule of the contact.
(b) the type of contact (e.g. phone call, an email, or home visit).;
(c) the topic discussed.
(d) the result of the contact.
(e) the tasks raised during the contact.

This report is stored and linked to the anonymised consumer ID and can be consulted later on demand.

**Home setup** - Advisors and consumers can use this to create a map of a consumer's home. It allows users to draw rooms, doors, windows, heaters, sensors. They can add a label (e.g. living room) and temperature to the rooms. This map is stored in the database, server side and can be created and modified at any time.

**Import/export data** - The platform allows registered users to upload data, which consists of energy consumption and a questionnaire. These data are uploaded as CSV files and then stored in an SQLite database. Registered users can also export the data they have previously uploaded. Only data specific to the current selected user can be downloaded. Consumers are only able to download their own data which in CSV format.

**Multiple languages** - To improve the website accessibility across consumers, it is translated into the languages used at the Living labs: English, Hungarian and Greek. You can switch language of a page at any moment by simply clicking on the corresponding flag in the navigation bar of the website.

**Multiple user roles** - Multiple user roles of the platform have been targeted during the development:

(a) People can connect to the platform because they are curious about it or want to get general information about energy consumption (public).
(b) Consumers may want to get feedback or information about energy consumption.

(c) Researchers who want to model energy consumption.
(d) Advisors who must analyse consumer data to provide feedback.
(e) The super administrator who must take care about the platform.

Thus, a user can register, log in and log out on the platform. An Access Control List was implemented to define access level to certain features and data. All credentials are encrypted before being stored in the database.

On the dashboard page there is a specific table used to display and select consumers. This table contains the list of consumers the current logged in user can see. For instance, a default a consumer can only see himself whereas an admin (an advisor or researcher) or the super admin can see all consumers. A search field is provided so that it is easy to find specific consumers data, this is important as there are potentially many consumers.

**Questionnaires** - The platform provides the possibility to import and/or fill questionnaires. These forms are displayed directly on the website using a questionnaire definition described in a JSON file and stored on the server side. Each user can access a pre-defined list of questionnaires and fill them in. This is stored server-side and can be gathered or modified at any time by simply retrieving the form again. Advisors can set the list of available questionnaires for each user, but by default, all users have access to all questionnaires.

Gathering information through questionnaires is a big part of the advisors' work, as it can be the only way to gather consumer data (not all consumers have smart meters at home) and at each cycle of the living lab, these questionnaires can be improved or totally changed. We added an interface called questionnaire builder in order to help advisors building these questionnaires quickly. It consists of:

(a) a tree on the left allowing to follow the list of elements in the questionnaire,
(b) some questionnaire item fields on the right used to design the current item, and
(c) a small preview of the full current questionnaire at the bottom, used to see what has been built so far.

## Web platform

The web platform is composed of the back-end (the server) and front-end (the user interface) shown in Figure 4. The platform can be found at https://step-in.list.lu.

### Back-end

The back-end was developed in JavaScript using nodejs. It is linked to an SQLite database where the data (e.g. questionnaires, sensor data, some consumers data) are stored. This approach was used so that in the future, external computation engines will be able to be connected to the platform and make use of the information stored in the database. This is planned for future versions of the platform, although it is possible now for data to be exported and used.

### Front-end

The front-end is basically the UI displayed on user devices (which can be a tablet, a phone or a computer). It has been developed in HTML, CSS and JavaScript using the angularjs framework. The content which is displayed comes from the data and algorithms within the back-end components.

The User Interface is split in multiple parts (see Figure 4): a navigation bar allows the user to go to the dashboard, about and contact or login/register pages. Once the users have registered, it also displays their login and location.

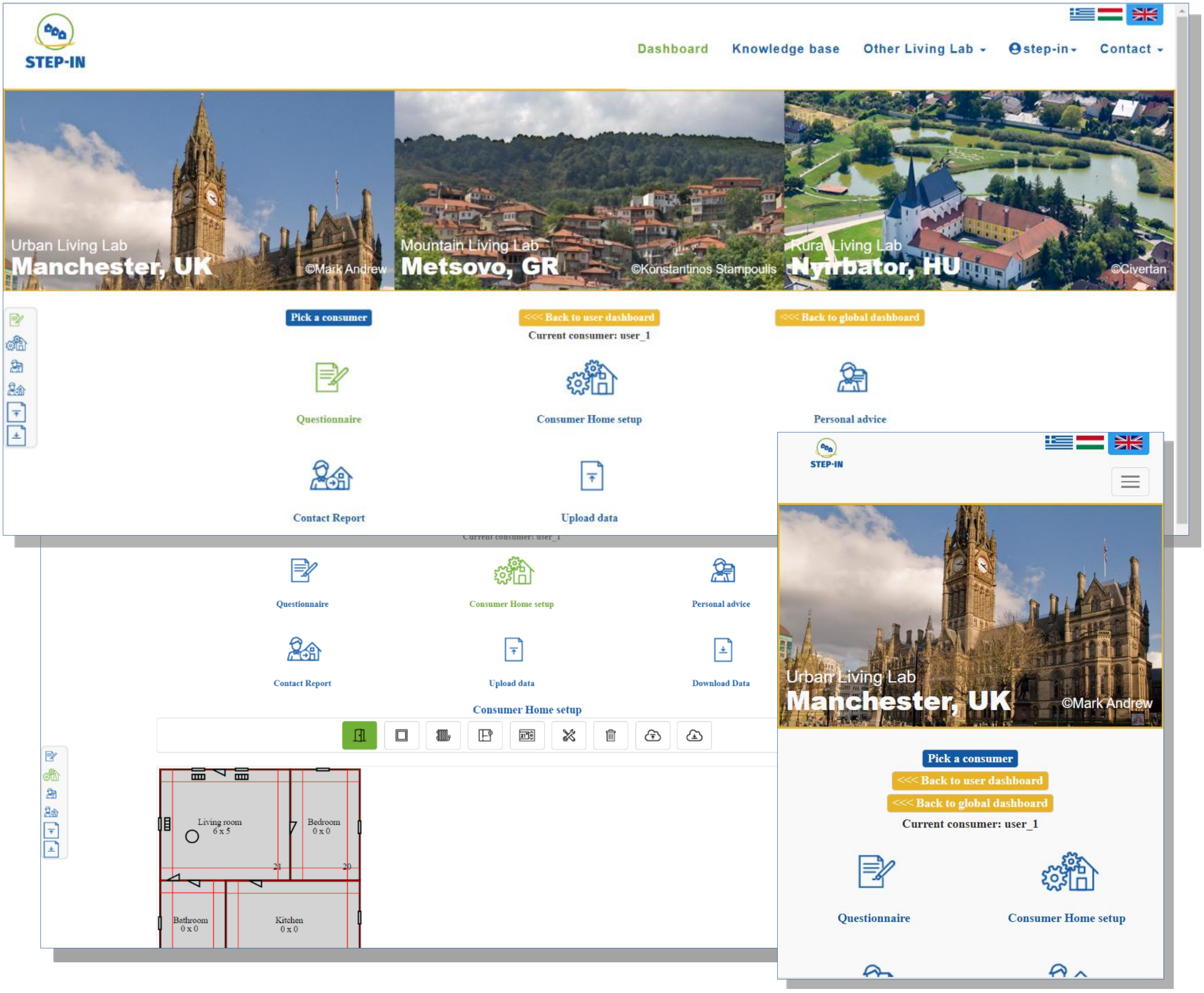


*Figure 4 The STEP-IN platform user interface. Top: Start Page. Bottom left: Home setup. Bottom right: Display on mobile device.*

The main content is displayed on the dashboard page, which is reachable only if the user is registered and logged in.

### 4.6.3 Deployment and data management

Each Living Lab site (Metsovo at first iteration, Greater Manchester and Nyírbátor district started at the second iteration) will installed a local version of the ICT tools, see Figure 5 for a complete schema. Therefore, each Living lab was responsible for their local data and the administration of their systems. Only anonymised and aggregated data (with no identifiable information) were shared between living lab sites, LIST and the wider public where appropriate.

The analysis tools, the data storage service and the server used to provide the web application in each living lab location were deployed locally. Raw data were only accessible locally: there are specific raw data exchange only between the computation engines and the web server in each specific living lab.

The LEAP mobile app from the Greater Manchester Living Lab can connect through data uploads to the platform as CSV formats. But data download from the LEAP app was not easy to achieve due to the closed commercial software environment of the LEAP application.

As the STEP-IN platform is web based, each living lab was able to access its specific data or send it to its specific storage for all user profiles. The web app is usable on any kind of platform able to browse the web. Most importantly is the use through tablets for home advisors and consumers, tablet and desktop computer for advisors and consumers in energy cafés and researchers.

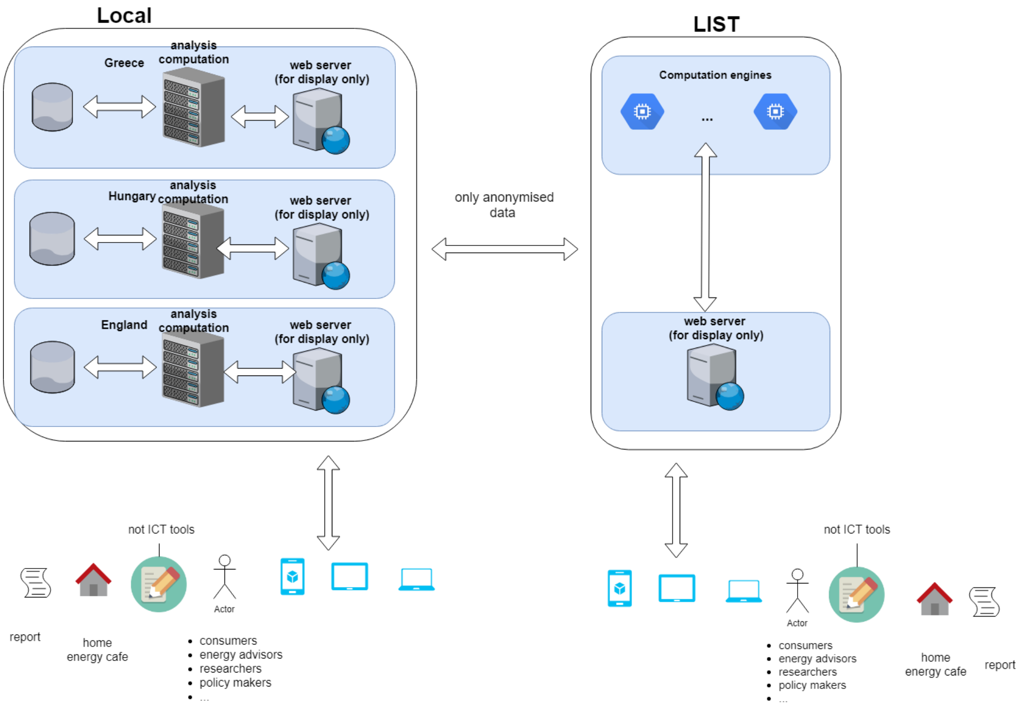


*Figure 5 Architecture design of the distributed ICT tools platform.*

### 4.6.4 Data protection

In order to preserve privacy and reduce the risk of any data protection policies being broken, each living lab was responsible for the storage and use of the data at their location. Furthermore, no identifiable data was neither exchanged between living labs nor with LIST. To further protect users, data were only referred to an anonymous ID, not being able to trace back data to a physical person. This ensures that, when data is exchanged, it is not possible to identify who provided the data.

### 4.6.5 Reuse of existing tools and methods

The platform reused a few existing elements from previous work from LIST and LEAP in Manchester. For instance, the credentials system, the general layout of the page, the map system and the libraries used for the prototype were the same that were used in the LIST developed web-based iGuess platform. Compute engines used as a service were implemented in an interoperable way and on the same basis as used in iGuess.

The same was true for the LEAP app which was actually a fully established app for energy advice targeting the LEAP programme in the UK with which already all energy advisors were familiar with. This required less additional training of energy advisors in Manchester compared to energy advisors in Metsovo or Nyírbátor.

### 4.6.6 Non-ICT tools

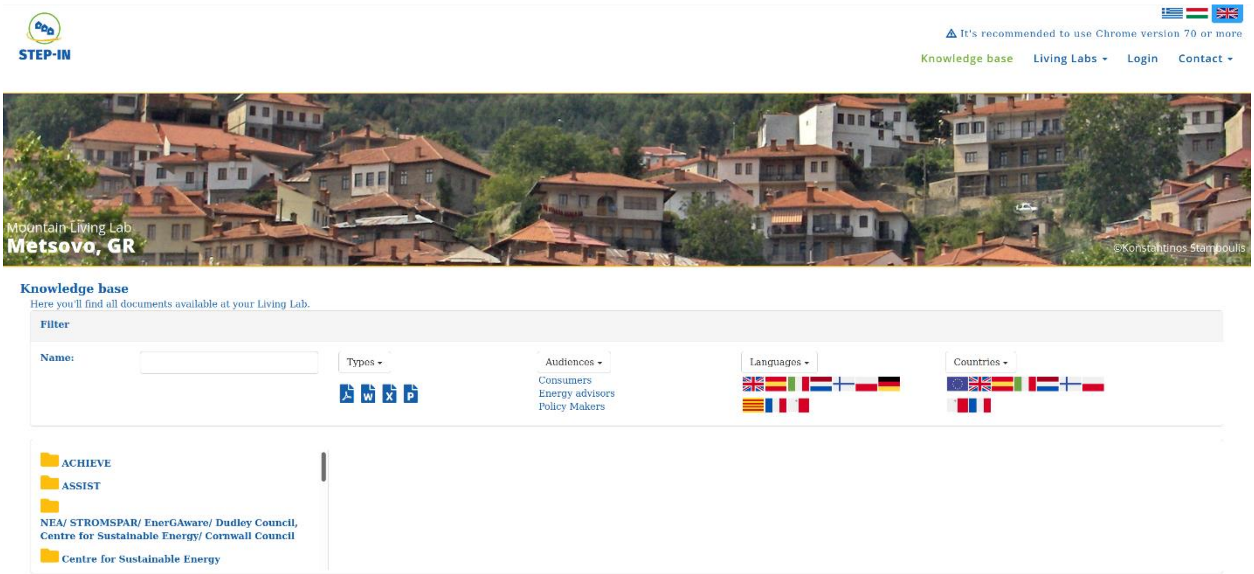
Not in all situations consumers and energy advisors are able to use ICT based tools due to non-availability of internet connections, digital devices and/or knowledge of their usage. For this purpose, we introduced non-ICT tools, such as paper-based diaries, and energy cafés for general exchange. In Living lab round V2 paper-based diaries were distributed throughout all Living Labs.

In Manchester there were no returns from V1 and V3. In Metsovo, 30 energy diaries were distributed and 20 returned in V2, but the data were incomplete and not useful. In V3, another 50 energy diaries were distributed, mainly in September/October when the cold season starts, but no sufficient return was achieved. In Nyírbátor, 200 paper-based energy diaries were distributed in V3 with an expected return rate of 10%, i.e. 20-30 diaries, but no return was captured.

This is essential for future projects as it seems that without incentives, paper-based energy diaries are difficult to get returned by vulnerable people.

### 4.6.7 Knowledge Base

With the growing amount of documentation available for consumers, advisors, and policy makers it was also implemented a knowledge base which was integrated into the user interface of the STEP-IN platform. The need was to implement a feature to filter information according to language, target audience and country (see Figure 6).



It's recommended to use Chrome version 70 or more

**Knowledge base**

Here you'll find all documents available at your Living Lab.

Figure 6 Knowledge base user interface

On the left side the user can see the folder where the document is stored (its name usually corresponds to the project providing this document). On the right side the user can see the documents from the selected folder. Clicking on a document displays information about it as a tooltip, clicking again will download the document.

This feature is available on the public website and does not require any login.

### 4.6.8 ICT tools implementation V1

Version 1 of the ICT tools developed for Living Lab cycle V1, focussed primarily on the software architecture implementation and setup of the platform backend and frontend as well as data collection and making that information available to energy advisors and help to visualise it. A prototype of the STEP-IN platform was developed and deployed to the living labs of Metsovo (Greece) and Nyírbátor (Hungary). Manchester decided to use the LEAP app from the UK which is linked to a large nationwide energy advice programme, LEAP, which makes the analysis and advice targeted to this programme much easier. Version 1 of the platform was a direct result of extensive work between the living labs and LIST, in particular around the requirements and also identifying the current users of the platform. For example, during the early stages of the project it was intended for consumers to be the sole end users, however it emerged that many consumers will not have continuous access to mobile devices or the internet and also need some assistance through energy advisors. Therefore, it was decided to focus on providing a platform for use by energy advisors, as well as consumers, who wish to use the platform and access their individual, personalised report. Since the system is web based no installation by the end users is required, and the users do not need to worry about updating any software. Instead, updates were available automatically with each update deployment by LIST to the local servers of the Living Labs. Where consumers are not able to access the internet platform, advice reports can be printed for these by energy advisors.

For version 1 the ICT tools were designed to be used by the energy advisors and accessible to consumers for their personalised advice reports. As version 1 and living labs were in operation new features and improvements were added based on feedback. Version 1 implemented some of the core features along with aspects of data protection which ultimately influenced the deployment model. The approach leveraged some existing tools and techniques and added new features. Furthermore, as it is web based it does not require the installation of an application and can run on any Internet enabled device with a suitably sized screen. A web-based approach avoids problems connected to installing or updating software.

### 4.6.9 ICT tools implementation V2

After analysis and feedback of Living Lab cycle V1 and its first usage of ICT tools, LIST improved tools and implemented more features for version 2 (Living Lab cycle V2). The ICT tools were improved for usability, energy analysis and personal advice as well as including a first simple knowledge base. This version 2 also enabled multiuser access for researchers, energy advisors, consumers as well as the public. As Living Lab cycle V2 operated feedback was received, reviewed and improvements were made to usability, in particular user interface and the personal energy analysis and advice tool.

After version V2 an evaluation session was organised at the Athens meeting in May 2019 with all Living labs. A second evaluation session in Budapest STEP-IN was held with the LL leaders to improve the usability and the design as well as to develop new components such as the questionnaires status page, or visualisation tools.

### 4.6.10 ICT tools implementation V3

Using all feedback and improvements after the Living Lab cycle V2, version 3 of the STEP-IN platform was released for the final Living Lab cycle V3.

One of the most asked for improvements was the User Interface design and icons. For this specific task, LIST integrated a graphics designer from LIST to help improving layout and design of the web interface for a better the look and feel. This resulted in a reorganisation of some of the navigation bar, changes in the general layout of the User Interface, choosing a new colour scheme and using new icons.

In V3, LIST implemented a dedicated translation dictionary, which is gradually improving with the help of the LL partners. Each LL platform has its own default language setup where the user can also switch the display language by selecting the corresponding flag on the top right of the User Interface.

With the growing amount of documentation available for the consumers, it became clear that the simple user interface for the knowledge base, LIST implemented during V2 was not sufficient and that a feature to filter information must be provided. Thus, LIST implemented a new feature for filtering and displaying documents.

Upon request from the Living Labs users, in particular the energy advisors and researchers, LIST implemented a global view of consumers in the platform, listing all consumer filled questionnaires at once and provide the possibility export all questionnaire data (answers) as a tabulated CSV file. This CSV file contains a column for each question and a line for each filled questionnaire, each cell contains a code value or a string for textual response. LIST also added the possibility to generate multiple reports at once by allowing the selection of multiple questionnaires.

Another final feature was added to explore uploaded (temperature) sensor data. It lets the user, e.g. an energy advisor, pick a data file among the list of data which was uploaded for a selected user, and then, select a data set for display with the start and end date and its temporal resolution.

LIST also added a survey feature to provide the possibility to provide feedback about the STEP-IN ICT tool platform. This reuses parts of the code and work done for the consumer questionnaire. Unfortunately, due to COVID-19 this feature was not really used in the last Living Lab round.

Overall version 3 of the STEP-IN platform delivered a final comprehensive platform with tools for energy advisors, consumers and policy makers. The main functionalities of data collection (input, upload, download), data analysis, personal advice through automated processing of questionnaire data and visualisation of energy advice for the individual consumer as well as the knowledge base targeting different end users this platform has a lot of potential to be used in other living labs across Europe and beyond. Since it is web based and interoperable, it allows and easier data integration and analysis tool integration for specific energy advice.

## 4.7 Discussion

We devised the STEP-IN methodology at the start of the project, and as part of the co-created and reflexive process we fully expected it to evolve. As noted earlier, the purpose of the living labs was to improve the quality of life for those citizens involved, while also considering aspects such as energy efficiency and green issues. With these aspects in mind, it is important to review what we believe are the key components required to deliver similar schemes in the future.

### 4.7.1 Clear Benchmarking and Evaluation Process

Benchmarking via methods such as surveys or pre-existing data are key to understanding the areas and the needs to the citizens involved in energy advice programmes. They allowed the STEP-IN project to identify a range of issues including the nature of the housing stock, types of energy supply, financial and social issues along with more pressing aspects such as the need for a safe energy supply. The process made clear the widely different experiences that energy vulnerable consumers have across Europe. Benchmarking also permits more accurate comparisons of the impact of the project on vulnerable consumers. Although as noted later, Covid-19 impacts the comparability of the data.

### 4.7.2 Data Collection Techniques

STEP-IN relied upon a range of data collection techniques. While some of these changed because of the pandemic (for example, it was not possible to visit people's homes) certain points are more generic. At the outset of the project, we considered that energy diaries in paper form would be one method to collect information from citizens who were not online. However, this approach was found not to be suitable in most circumstances. We however found it to be useful in making people aware of their energy consumption patterns, even if they did not actually use the diaries. It should be noted that the home energy advisors could often collect diary-like information, and therefore the added value of energy diaries is furthermore questionable. Therefore, any data collection techniques used should avoid further complicating the work of home energy advisors.

Using temperature and humidity sensors also had mixed results and was very dependent on the location in which they were used, with Greece providing more useful data from this source. Although not extensively used in this project, aggregated energy consumption data for a locality can also provide valuable insights. While individual consumption data collected from meters can provide greater insights. In almost all cases, the data collection approach needs to consider ethical and data collection concerns.

### 4.7.3 Relevancy of Advice Provided

Overall, the STEP-IN Living Labs provided relevant assistance for vulnerable consumers. Across the living labs, the advice and measures ranged from energy bill and efficiency awareness measures through providing access to boiler maintenance schemes and ultimately to reconnecting people to the energy grid. While certain issues were identified during the benchmarking process, it was often during the more active phases of the labs when certain challenges become clearer. It is essential that the advice provided is adapted to fit local needs, for example providing advice on switching energy provider was highly effective in the UK, whereas in Greece the need was often to provide advice on routine maintenance. In contrast, in Hungary the challenge early on related to the lack of energy supply to many homes.

### 4.7.4 Range of Organisations Involved and Their Roles

The success of the living labs depended on the range of partners, and external stakeholders involved. The clear and simple management structure of each living lab ensured local accountability and a high degree of autonomy. The range of organisations also ensured that relevant skills were available, for example organisations such as universities and consultancies which are strong on methodological and data collection/analysis aspects, through to those who are connected to the wider energy poverty stakeholder ecosystem and services, through to those who operate on the ground either as advice or energy providers.

### 4.7.5 Involvement of Local Stakeholders

Local stakeholders play a critical role in the role out and acceptance of energy advice programmes. Initially, communities can often distrust new organisations offering advice, by going through trusted parties, citizens seem to be more likely to take part in programmes. Local stakeholders can in this context play a triple role, for example: acting as referrers to the STEP-IN programme, we refer people to them, or we work with them directly. Importantly, even if the stakeholder organisation technically exists in the area, it must also be seen as being active. For example, in Hungary in the area where Maltai has a strong presence the participation in the STEP-IN living lab was higher.

The role and structure of the stakeholder organisations also needs to evolve during the project. For example, due to COVID-19 certain operations in Manchester were run directly by the consortium rather than by local supporting organisations. While this was unique to the particular case, it also points to the need to make sure that there are effective contingency plans in place. In Hungary, the reconnection programme required a specific committee to be set-up to assist in the allocation of grants to those who required reconnection.

### 4.7.6 Reflexive and Co-Creation Approach

Living labs are by nature co-creative and reflective. In STEP-IN, we adapted the labs around the local context and through the feedback received from the participants. We collected this feedback in questionnaires and via focus groups. In Manchester, the increased uptake of energy advisor visits was largely down to the improved communication strategy which was identified by the focus groups.

### 4.7.7 Impact COVID-19

The pandemic had a significant impact on the STEP-IN Living Labs, they largely had to move from face-to-face to remote support. Face-to-face events only took place where local regulations permitted. It should be noted that there is a feeling that while remote services had some success, face-to-face (in person) methods of interacting with vulnerable citizens remain better option. Many citizens were spending more time at home, thus making comparisons between rounds difficult both from a methodological and energy consumptions perspective. These issues aside, the pandemic forced STEP-IN to use different approaches, and the experiences gained from doing so are in themselves useful.

### 4.7.8 Relevance outside of Specific Localities

While each living lab location in STEP-IN is unique, we design the methodology such that it can apply in as many other locations as possible. For example, the energy café concept is derived from the World Café idea, which has been widely used. Focus groups and visits to homes are also generic regardless of location. We however acknowledged that the living conditions and circumstances across the living labs and globally vary. For example, with the advice being tailored to a specific location. While that location may be unique, many aspects will no doubt apply in many other locations and countries. Even if the entire suite of advice is not applicable. Good examples of this include heating maintenance and low-cost insulation measures.

## 4.8 Conclusions

The living labs operated under an overall methodology which was adapted to fit the needs of the local population, a range of stakeholders and advice schemes. This local adaptation was also reflected in the management structure, with each living lab being given a high degree of autonomy. Our approach meant that negative aspects in one living lab had no or minimal impact on the others, yet we were able to share experiences and best practices. This high degree of autonomy was also matched with a high level of local responsibility, and it is a credit to the leaders at each location that they in partnership with local stakeholders (including other partners) could deliver successful results. A key element is also the right mix of partners for each location.

In terms of specific methodologies, it should be noted that all the options ranging from information campaigns, energy cafes through to advisor visits were successful, although they required an element of adaptation in terms of the advice offered in each location. However, despite the local specificities, demographics and challenges the methods used can be applied across a range of location (urban, mountainous and rural) and market segments. The co-creative and reflexive nature is critical to success, as is the ability to modify the programmes during the operation of each living lab. All relevant stakeholders, including the citizens involved, should be part of this process.

While Covid-19 had a negative impact on the population at large, it also provided an opportunity to explore alternative methods of delivering schemes. Our experiences show that while it is possible to offer remote services that a range of problems arise with participation rates and engagement. These specific lessons learned will be useful for others who may have to operate schemes under conditions similar to pandemics or who are considering the use of remote services. Therefore, the preference should be to provide in-person face-to-face advice.

# 5 Rebound Effects

*Rebound effects* (in the context of energy economics literature) is a widely used term for economic responses to improve energy efficiency or energy sufficiency actions, i.e. actions that can affect energy consumption by households. The net result of these effects is typically to increase energy consumption and greenhouse gas (GHG) emissions relative to a counterfactual baseline in which these responses do not occur, i.e. engineering effect. In other words, rebound effects come about the difference between engineering concept and economics concept. In engineering calculations e.g. 20% increase in energy efficiency will result in 20% reduction in energy consumption hence full expected reduction in energy consumption will be achieved, rebound effect is zero and no economic response is accounted for in the energy saving calculations. Energy economists argue that the full expected reduction from engineering calculations might not be achieved because of rebound effects due to consumer economic response which in turn will affect the final energy consumption (see below). To the extent that rebound effects are neglected in policy appraisals, the energy and emissions 'saved' by such measures may be less than anticipated (Chitnis & Sorrell, Living up to expectations: Estimating direct and indirect rebound effects for UK households, 2015) and therefore energy and emission reduction targets might be missed. Rebound effects can be 'direct' or 'indirect'. A simple representation of rebound concept is shown in Figure 7:

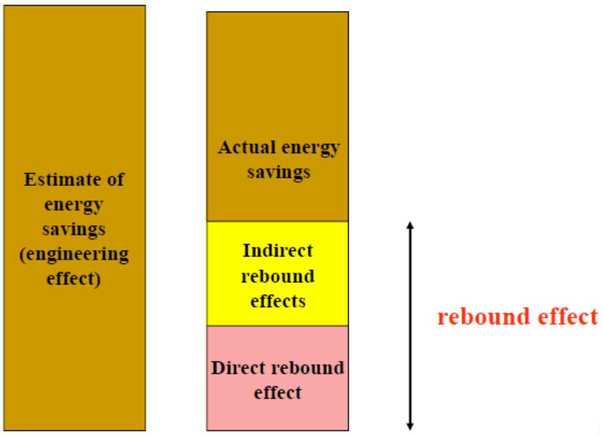


*Figure 7 Concept of rebound effects*

*Direct* rebound effect results from *improved energy efficiency* of an energy service. The increased energy efficiency decreases the *effective price* of that energy service and should therefore lead to an increase in consumption of that energy service (where the efficiency improvement has taken place) and hence energy consumption (which can offset part of the expected energy savings from engineering effect). In other words, direct rebound effect results from increased consumption of cheaper energy services and subsequent substitution and income effects. When the energy service gets cheaper relative to other goods and services, the consumer uses more of that energy service and less of other goods and services (substitution effect). The decrease in energy service price also leads to an increase in real disposable income, which in turn increases the use of energy service and other goods and services (income effect, assuming normal goods). For example, a more efficient boiler makes heating service cheaper, so household might increase the indoor temperature and/or leave the heating on for longer time.

*Indirect* rebound effect results from the lower effective price of the energy service which can lead to changes in the demand for *other* goods and services that also require energy for their provision (again this can offset part of the expected energy savings from engineering effect). For example, reduced effective price of heating from more efficient boiler may be put towards increased consumption of other goods and services such as lighting service (other energy service type), travel for holiday or clothing (non-energy goods) whose provision also involves energy use. Total rebound is therefore the sum of direct and indirect rebound effects. A simple representation of direct, indirect and total rebound concept is shown in Figure 8:

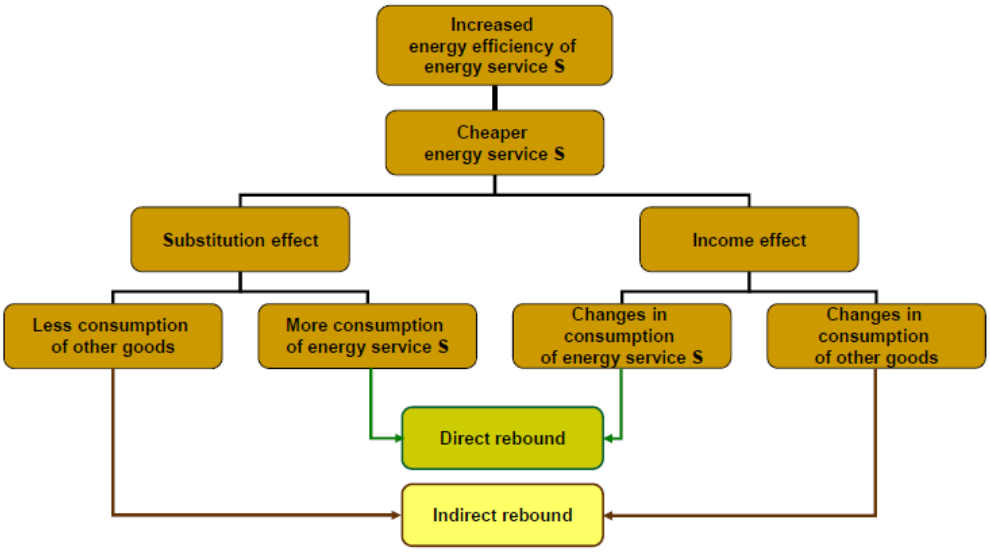


*Figure 8 Concept of direct, indirect and total rebound effects*

Rebound effects can also be a result of *sufficiency* or conservation actions. Rebound effects for households do not result solely from energy efficiency improvements, such as installing energy-efficient boilers or boiler maintenance, but also from behavioural changes such as reducing average internal temperatures and use of thermostat. Although these measures do not affect the energy efficiency and therefore the effective price of energy service (heating service in this case) but the cost savings from these sufficiency measures can either be spent on other goods and services or saved/invested which in turn can affect the energy consumption and GHG emissions. While energy efficiency improvements lead to both direct and indirect rebound effects, sufficiency measures only lead to *indirect effects* (Chitnis et al. 2014). In the example of lowering the thermostat for space heating, the household is willing to reduce the space heating consumption and is not expected to re-spend the saved expenditure on space heating but probably on other goods and services such as lighting.

In terms of calculation $rebound\ effect = \frac{engineering\ effect - actual\ effect}{engineering\ effect}$ where *engineering effect* is the expected energy saving from energy efficiency improvement and *actual effect* is the energy saving occurred after energy efficiency improvement. To ensure the actual effect is purely associated with improved energy efficiency, everything else must remain constant (e.g. temperature, household size, etc.). However, in practice might be difficult to make sure that the only reason for actual change in energy consumption is just the result of improved efficiency.

The calculation of rebound effect might appear straightforward, however quite the contrary is the truth. Rebound estimation is not straightforward as it requires detailed data regarding efficiency improvements and energy savings which might not be easily available or measurable. Most of the empirical studies use economic modelling for residential energy demand and employ econometric techniques to estimate rebound effects, mainly focusing on direct rebound effect only. This is because estimating indirect rebound requires even more data and information including disaggregated household consumption for other goods and services (e.g. COICOP categories such as food, clothing, etc.) together with their prices and embodied energy (Chitnis M. , Sorrell, Druckman, Firth, & Jackson, 2013) and (Chitnis M. , Sorrell, Druckman, Firth, & Jackson, 2014). The collection of such detailed data from households would have added more complexity for data collection e.g. thorough survey (e.g. adding significantly to the survey length and time) and it could have resulted in deviation from the main purpose of this project i.e. energy focus. In addition, calculation of embodied energy for other goods and services which in turn requires other methods of calculation such as the use of input-output models is out of the scope of this project. On the other hand, (Chitnis & Sorrell, Living up to expectations: Estimating direct and indirect rebound effects for UK households, 2015) find that a large part of total rebound effect comes from direct rebound hence it is sensible to focus on direct rebound only. Having said that similar to (Chitnis, Fouquet, & Sorrell, 2020) (Chitnis, Fouquet, & Sorrell, 2020), in this project the indirect 'energy' rebound is considered, for instance the indirect rebound from improved energy efficiency of heating system is estimated for electricity but not for food (focus on energy use at home).

The range of estimated rebound differs widely among different studies, from very low to very high. However, (Chitnis M. , Sorrell, Druckman, Firth, & Jackson, 2014) find that rebound effect for lower income households is larger than higher income households. This is because lower income households might have not reached the standard comfort levels from energy services and they are more likely to increase their energy consumption to achieve higher comfort (e.g. for space heating). In this case, rebound effect is not necessarily a bad thing since there might be other positive impacts on the well-being of the lower income households including improved health conditions. Since the sample in this project includes lower income households the rebound effect is expected to be on the higher side.

The methodology for rebound effect estimation used for each living lab is different as it is based on the information and data availability for each living lab. In the following sections, the methodology used for rebound effect estimation is explained briefly together with the results for each study area.

### 5.1.1 Manchester: UK (urban area)

In the case of Manchester, the expected and actual energy savings from energy efficiency measures are not available for all waves. However, the information from the second wave of living lab is almost sufficient to conclude on rebound effects for energy use at home. The data for wave two relates to pre-Covid 19 pandemic and therefore consistent for comparison of energy consumption changes. In wave two, rather than a decrease in energy consumption, the energy efficiency or sufficiency measures implemented by the advisors resulted in a small projected overall increase in energy consumption of 26 KWh per household. Although the detailed data for exact calculation of rebound effect is not available but it is very clear that there is a very high ***rebound effect*** of slightly ***over 100%*** which is known as backfire. Therefore, an increase in energy efficiency or sufficiency actions are expected to reduce the energy consumption if the demand for the energy services remains constant.

When the rebound is over 100% it means that not only energy consumption is not reduced as expected but also the level of energy consumption has increased compared to its original level before any efficiency improvements or sufficiency actions. Although the occurrence of backfire is a rare case but given energy is a necessity good it can happen especially for very low-income groups (Chitnis M. , Sorrell, Druckman, Firth, & Jackson, 2014). The projected saving of 12.41% on annual household energy bills in wave two because of measures introduced to households means that they could use energy services more at home to achieve the standards of living, hence the direct rebound for overall energy is very high. This finding is not surprising as 80% of the households in the sample were eligible for the advisor visits based on benefits, and they live in some of the most deprived areas of the UK. The improved health conditions of the households' sample is clearly a significant benefit of increase or no change in energy consumption, thus well justifying the full rebound effect with no energy savings.

It is worth noting that to conclude above results, all other conditions that might affect energy consumption should have remained constant during wave two period. Given the relatively short period of wave 2, it is very likely that household condition has remained unchanged (income, household composition etc.). However, changes in the weather temperature might have affected the energy use to some extent and results should be treated with some caution.

### 5.1.2 Metsovo: Greece (mountainous area)

In the case of Metsovo, expected and or actual energy savings from energy efficiency improvements are not available. However, all required data for estimation of direct rebound from heating energy efficiency improvement is available for a sub-sample of households in the social survey (although 303 households are included in the social survey but required data is missing for some households). Data is collected after covid-19 pandemic, hence consistent among households. Table 8 shows the summary statistics of the relevant variables from social survey:

| Variable description (unit) | Vaiable name | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Heating expenditure (€) | *heat_exp* | 2013.10 | 893.38 | 400 | 5000 |
| Electricity expenditure (€) | *elec_exp* | 893.84 | 424.23 | 70 | 4000 |
| Heating fuel price (€/KWh) | *fuel_price* | .054 | .027 | .02 | .083 |
| Heating service price (€) | *heat_price* | .0007 | .0003 | .0003 | .001 |
| Heating efficiency (%) | *heat_eff* | 79.66 | 15.02 | 20.26 | 100 |
| Income | *income* | 16560.16 | 8607.38 | 3000 | 35000 |
| Dwelling size ($m^2$) | *dw_size* | 98.71 | 29.07 | 40 | 250 |
| Heating hours (hours) | *heat_hrs* | 3.69 | .6 | 1 | 4 |
| Dwelling age (years) | *dw_age* | 45.60 | 29.81 | 3 | 320 |
| Household size (number) | *house_size* | 2.96 | 1.47 | 0 | 8 |
| Age of household reference person (years) | *age* | 50.89 | 16.65 | 18 | 102 |
| Dummy for dwelling type (Ddw=0 for detached house, D=1 otherwise) | *Ddw* | .63 | .48 | 0 | 1 |
| Dummy for household reference person gender (Df=0 for male, Df=1 for female) | *Df* | .35 | .48 | 0 | 1 |

*Table 8 Summary statistics for Metsovo social survey*

In line with rebound effects literature, the price of heating service (*heat_price*) in Table 9 is equal to heating fuel price (*fuel_price*) divided by heating efficiency (*heat_eff*), increase in heating efficiency reduces the price of heating service. Households in Metsovo consume different type of fuels for heating, including wood, oil and pallet. The price for each fuel type varies significantly, so does the efficiency of the heating system. These variations mean households face a different price for heating service in the cross-sectional data. Data for efficiency of heating system is based on existing literature and an average price for heating fuel is used for each heating system. Table 9 shows the assumptions for heating efficiency and price by heating system.

| Heating system | Average Efficiency | Fuel price (original unit) |
|---|---|---|
| Oil- fired central heating system | 90% | 0.9 (€/lt) |
| Wood-fired central heating system | 75% | 0.12 (€/kg) |
| Pellet-fired central heating system | 80% | 0.28 (€/kg) |
| Wood / pellets burning stove | 50% | 0.12 (€/KWh) |

***Table 9 Assumptions for heating efficiency and price by heating system***

Following Chitnis et al. 2020, the demand for heating and electricity services is estimated separately where estimated *own price elasticity of heating service* represents the direct rebound effect from heating efficiency improvement. Table 10 shows the OLS (robust standard errors) estimation results for log-log household heating service demand.

| Variables | lheat_exp expenditure |
|---|---|
| lheat_price | 0.5207*** |
| | (0.0695) |
| lincome | 0.1312** |
| | (0.0639) |
| ldw_size | 0.3433*** |
| | (0.0951) |
| lheat_hrs | 0.2582* |
| | (0.1320) |
| ldw_age | 0.0381 |
| | (0.0535) |
| lhouse_size | 0.1365** |
| | (0.0603) |
| lage | 0.1498* |
| | (0.0850) |
| Ddw | -0.0522 |
| | (0.0582) |
| Df | 0.1699*** |
| | (0.0615) |
| Constant | 7.3221*** |
| | (1.0285) |
| Observations | 211 |
| R-squared | 0.3434 |

***Table 10 OLS (robust standard errors) estimated***

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

All variables, except dummy variables, are in natural logarithm.

Own price elasticity of heating service demand is 0.52 meaning that 1% increase in heating service price will result in 0.52% increase in heating service expenditure, price has the highest impact on demand. Income elasticity is 0.13 meaning that 1% increase in household income will increase heating service expenditure by 0.13%. Dwelling size has the second highest impact after price, 1% increase in dwelling floor area will increase heating service expenditure by 0.34%. Similarly, 1% increase in heating hours will increase heating service expenditure by 0.26%. Increase in household size by 1% will increase heating service expenditure by 0.13%. 1% increase in household reference person age will increase the demand by 0.15%. Where household reference person is a female, heating service expenditure is higher by €0.17. All above effects are statistically significant, at least at 10% significance level. Dwelling age has the expected positive sign meaning that older dwellings use more heating, but the effect is too low and is not statistically significant. Similarly, dwelling type has the expected negative sign showing that non-detached houses (apartments, flats etc.) use less heating than detached houses possibly because of better building insulation and/or less heating loss, however this effect is very low and statistically insignificant probably because the number of detached houses in social survey is relatively low to give a significant difference between house types.

Direct rebound effect is defined as negative of the own-price elasticity of heating service demand in terms of quantity, therefore the own-price elasticity of heating service demand in terms of expenditure in Table 10 is converted to former using below relationship:

$$own\ price\ elasticity\ of\ heating\ service\ (quntity) = own\ price\ elsticity\ of\ heating\ service\ (expenditure) - 1$$

This results in ***direct rebound of 48% for heating*** service meaning that 48% of the expected reduction in energy savings from engineering estimations is not achieved due to increase in energy consumption by households from heating efficiency improvement. Direct rebound is on the high side, but this is expected given the sample condition. Households in Metsovo have relatively lower income than average national level, they are not heating up their homes adequately and are cutting back on heating costs. This is in line with (Balezentis, Butkus, Streimikiene, & Shen, 2021) who estimated a direct rebound of 32% for Greece national level, confirming that rebound effect for lower income groups in higher. In addition, heating efficiency has greater potential for improvement for our sample hence greater potential for energy saving.

Since the energy efficiency of electricity services, mainly appliances, for the sample is not available it is not possible to estimate the direct rebound effect from electricity efficiency improvements using above method for heating. However, using the method in (Chitnis M. , Sorrell, Druckman, Firth, & Jackson, 2013) (Chitnis M. , Sorrell, Druckman, Firth, & Jackson, 2014) income elasticity is used to estimate the indirect electricity services rebound effect because of heating efficiency improvement (as explained earlier, in this project the focus is only on energy use at home rather than non-energy goods and services). To estimate the income elasticity for electricity services, *stochastic frontier model* of electricity services demand is estimated, the main advantage of this method is to estimate energy efficiency scores alongside the effect of variables included in the model.[4] The idea behind such models in the energy economics literature is to estimate an energy (here electricity) demand frontier, households on the frontier are fully energy efficient hence those below the frontier are relatively energy inefficient. Table 11 shows the *stochastic frontier model* estimation results for log-log household electricity service demand.

---

[4] For more information see Filippini, M. and Hunt, L. C., 2015. Measurement of energy efficiency based on economic foundations. Energy Economics, 52, pp. S5–S16.

| VARIABLES | lelexp |
|---|---|
| lheat_price | 0.0755 |
| | (0.0671) |
| lincome | 0.1707*** |
| | (0.0617) |
| ldw_size | 0.1780** |
| | (0.0896) |
| lhouse_size | 0.1845*** |
| | (0.0598) |
| lage | -0.1653** |
| | (0.0812) |
| Df | -0.0039 |
| | (0.0601) |
| Constant | 5.6390*** |
| | (1.0177) |
| sigma_v | 0.2874 |
| sigma_u | 0.4303 |
| lambda | 1.4974 |
| Observations | 210 |

***Table 11 Estimated stochastic frontier model for electricity service demand in Metsovo***

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

All variables, except dummy variables, are in natural logarithm.

v and u are standard error term and non-negative inefficiency term (half-normal distribution) respectively.

Since the price of electricity is constant among households in the sample cross-sectional data and efficiency for electricity services is not available, therefore, we do not include these variables in the model in Table 11 Estimated stochastic frontier model for. Cross price elasticity of electricity service demand with respect to heating services is 0.08 meaning that 1% increase in heating service price will result in 0.08% increase in electricity service expenditure, however this is not statistically significant. Income elasticity is 0.17 meaning that 1% increase in household income will increase electricity service expenditure by 0.17%. Dwelling size has a similar impact as income, 1% increase in dwelling floor area will increase electricity service expenditure by 0.18%. A 1% increase in household size will increase electricity service expenditure by 0.18%. A 1% increase in household reference person age will decrease the demand by 0.17%. Household reference person being a female does not have a significant impact on electricity service demand. Apart from price of hearing service and gender, all other above effects are statistically significant, at least at 5% significance level.

Indirect rebound effect from improved efficiency of the heating service is determined by the cross-price elasticity of electricity service demand in terms of quantity. This results in ***indirect rebound of 8% for electricity*** service meaning that 8% of the expected reduction in heating energy savings from engineering estimations is not achieved due to increase in electricity consumption by households. The indirect rebound is on the low side and it is statistically insignificant, this implies any improvements in heating efficiency will be put towards more consumption of heating itself. The result is consistent with Chitnis and Sorrell 2015 i.e. direct rebound is significantly larger than indirect rebound. ***Total rebound***

***is 56%*** but as mentioned earlier in this project we are not including any indirect rebound associated with non-energy goods and services.

The summary statistics for estimated energy efficiency scores from stochastic frontier model are shown is Table 12 Summary statistics for estimated technical efficiency scores for electricity in Metsovo. Note that efficiency score is not equal to engineering energy efficiency of electricity appliances etc. but it is a measure of underlying energy efficiency of electricity service demand based on economics concept. The efficiency score of one represents full efficiency and zero represents full inefficiency. The mean estimated efficiency score is 0.74 meaning that there is room for efficiency improvements for electricity services. The inefficiency here represents both inefficiency from appliances and the improper use of appliances such as management or behaviours. For instance, household leaving the light on when not in the room. Since the overall energy efficiency of electricity services in Metsovo sample is relatively high it is quite likely that most of the inefficiency comes from household habits and behaviours.

| Mean | Standard deviation | Minimum | Maximum | Observations |
|---|---|---|---|---|
| 0.7352 | 0.1087 | 0.1585 | 0.9313 | 210 |

***Table 12 Summary statistics for estimated technical efficiency scores for electricity in Metsovo***

Efficiency scores are calculated as efficiency=exp(-$\hat{u}$).

### 5.1.3 Nyírbátor: Hungary (rural area)

In the case of Nyírbátor, actual energy savings data from energy efficiency improvements are affected by COVID-19 pandemic, the difference in energy consumption is not taken in a consistent period all before or after covid-19 hence it is not possible to disaggregate the changes in energy consumption purely to energy efficiency improvements or the pandemic effect. Therefore, it is not appropriate to use the actual saving data to estimate the rebound effects.

However, required data for estimation of indirect rebound effect from sufficiency (conservation) actions is available for a sub-sample of households in the living labs. The energy consumption data collected in the first wave of living lab is less reliable since the households were asked to report their consumption in units of consumption (e.g. KWh) and this appeared to be more difficult to report by households. In addition, the sample in the wave one is much smaller with 51 households (after cleaning the data). Wave two living lab includes mixed household data before and after COVID-19, hence not consistent as the pandemic has affected the energy consumption. Wave three living lab data is all collected after the pandemic, therefore consistent among households, and includes the largest number of observations in the sample data (after cleaning includes 209 households). Energy consumption data in wave three is more reliable as household bills were used directly. In addition, the energy demand estimations for wave one and wave two proved to produce poor results which confirms the lower quality of the data for estimation purpose. Therefore, wave three data are used for estimation of energy demand models and indirect rebound effects. It should also be noted that prices for fuels and electricity have been frozen in Hungary for eight years; hence there is no variation in prices. In addition, the price for gas and firewood for heating is almost similar. Table 13 shows the relevant summary statistics.

| Variable description (unit) | Variable name | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Heating fuel consumption (KWh) | *heat_con* | 17555.16 | 14306.51 | 1000 | 75000 |
| Electricity consumption (KWh) | *elec_con* | 3060.82 | 1518.46 | 657.92 | 9868.73 |
| Income (Hungarian Forint) | *income* | 201589.76 | 119630.95 | 15000 | 500000 |
| Household size (number) | *hous_size* | 3.98 | 2.21 | 1 | 10 |
| Dwelling size ($m^2$) | *dw_size* | 85.57 | 27.06 | 10 | 240 |
| Age of household reference person (years) | *age* | 41.79 | 14.19 | 19 | 87 |
| Dummy for dwelling type (Ddw=0 for detached/semi-detached house, D=1 otherwise) | *Ddw* | .05 | .22 | 0 | 1 |
| Dummy for household reference person gender (Df=0 for male, Df=1 for female) | *Df* | .78 | .42 | 0 | 1 |

**Table 13 Summary statistics for Nyírbátor wave 3 living lab**

Following Chitnis et al. 2014, since there is no price variation for wave 3 cross-sectional data, the Engel curve for heating and electricity is estimated separately. The Engle curve shows the relationship between household consumption and income (i.e. does not include price). The estimated *income elasticity* is used to estimate indirect rebound effect for thermostat (sufficiency action). Table 14 shows the estimated stochastic frontier model for log-log household heating fuel and electricity consumption.

| VARIABLES | lheat_con | lelec_con |
|---|---|---|
| lincome | 0.1953** | 0.1320** |
| | (0.0886) | (0.0557) |
| ldw_size | 0.3170** | 0.0793 |
| | (0.1413) | (0.1101) |
| lage | 0.0101 | 0.1078 |
| | (0.1897) | (0.1196) |
| lhouse_size | -0.1037 | 0.1031 |
| | (0.1033) | (0.0684) |
| Ddw | -0.3533 | - |
| | (0.3541) | |
| Df | 0.1698 | 0.2410*** |
| | (0.1667) | (0.0816) |
| Constant | 6.4791*** | 5.5926*** |
| | (1.2710) | (0.7017) |
| sigma_v | 0.5805 | 0.3846 |
| sigma_u | 0.9453 | 0.3940 |
| lambda | 1.6285 | 1.0242 |
| Observations | 180 | 180 |

***Table 14 Estimated stochastic frontier model for heating fuel and energy consumption in Nyirbator***

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

All variables, except dummy variables, are in natural logarithm.

v and u are standard error term and non-negative inefficiency term (half-normal distribution) respectively.

From Table 14 results for *heating fuels*, the income elasticity is 0.20 meaning that 1% increase in household income will increase heating fuel consumption by 0.20%. Dwelling size has the highest impact on consumption, 1% increase in dwelling floor area will increase heating fuel consumption by 0.32%. Both income and dwelling size are statistically significant at 5% probability level. Dwelling type has the expected negative sign showing that apartments, flats etc. use less heating than detached or semi-detached houses possibly because of better building insulation and/or less heating loss, however this effect statistically insignificant probably because most houses in wave 3 living lab are detached houses and there is an insufficient number of other housing types to give a significant difference in consumption between house types. Household size does not have the expected positive sign, but it is also statistically insignificant. Household reference person age has a very small positive effect which is statistically insignificant. Where household reference person is a female, the heating fuel consumption is higher but again this effect is statistically insignificant. As a result, household income and dwelling size appear to be the main drivers of heating fuel consumption.

From Table 14 results for *electricity*, the income elasticity is 0.13 meaning that 1% increase in household income will increase electricity consumption by 0.13%. Where household reference person is a female, electricity consumption is higher by 0.24 KWh. Both household income and being a female appear to be the main drivers of heating fuel consumption. Dwelling size, household size and household reference person age all have positive effects between 0.08 to 0.11 on electricity consumption, however these effects are statistically insignificant. Therefore, income appears to be the main driver of electricity consumption though its effect is on the small side.

We show the summary statistics for estimated energy efficiency scores from stochastic frontier models is Table 15. The mean estimated efficiency score for heating fuels is 0.54 (full efficiency score is one) meaning that there is a very large potential for efficiency improvements for heating. Given the situation in Nyírbátor, this result is not surprising at all. Old buildings, lack of proper maintenance, poor windows and missing insulation resulting in inefficient heating together with inefficient energy consumption patterns and behaviours such as leaving the windows open when heating is on. Therefore, the low estimated efficiency score represents both inefficiency from household habits, and heating system or insulation. The mean energy efficiency score for electricity is 0.75 showing that there is room for efficiency improvement both in the form of behaviours and appliances. For instance, a household might leave the TV on while being in the garden, which is not an efficient way of using electricity for appliances. Overall, heating efficiency is much lower than electricity efficiency and we should place more emphasis on reducing inefficacies related to heating consumption of households.

| Energy type | Mean | Standard deviation | Minimum | Maximum | Observations |
|---|---|---|---|---|---|
| Heating fuels | 0.5401 | 0.1635 | 0.0953 | 0.8226 | 180 |
| Electricity | 0.7498 | 0.0849 | 0.4251 | 0.8958 | 180 |

***Table 15 Summary statistics for estimated technical efficiency scores for heating fuels and electricity in Nyírbátor***

Efficiency scores are calculated as efficiency=exp(-$\hat{u}$).

As mentioned earlier, use of thermostat does not affect the efficiency of heating system and it is a sufficiency action by households with the purpose to reduce heating consumption hence no direct rebound is expected i.e. households will not increase their heating consumption. Indirect rebound effect for energy from thermostat for heating is determined by the income elasticity of electricity demand (Chitnis et al. 2014). The indirect rebound is calculated as the ratio of changes in electricity consumption to expected reduction in heating fuel consumption. The changes in electricity consumption are calculated using income elasticity of electricity and energy cost savings for heating.

$$Indirect\ rebound\ effect\ for\ electricity = \frac{changes\ in\ elctricity\ consumption\ (KWh)}{expected\ energy\ saving\ for\ heating\ (KWh)} \times 100$$

$$= \frac{income\ elasticity\ for\ electricity \times energy\ cost\ saving\ for\ heating\ (€)}{expected\ percentage\ reduction\ in\ heating\ consumption \times\ mean\ \ heating\ fuel\ consumption\ (KWh)} \times 100$$

With the assumption that thermostat reduces heating energy consumption by 5% the mean expected heating energy savings for the sample is equal to $0.05 \times 17555.16\ KWh = 877.76\ KWh$ (mean values are taken from Table 13 Summary statistics for Nyírbátor wave 3 living lab). The average weighted price of heating fuels for the sample is €0.039/KWh therefore the mean energy cost saving for heating is $€\,0.039 \times 877.76\ KWh = €\,34.23$. Using the definition of income elasticity i.e. $income\ elacticity\ for\ electricity = \frac{\Delta elec\_con}{\Delta income} \times \frac{income}{elec\_con}$ and estimated electricity consumption equation in Table 10, the mean changes in electricity consumption (KWh) for the sample is equal to $(0.132 \times €\,34.23 \times 3060.82\ \mathrm{KWh})/201589.76 \times €0.002858) = 24\ KWh$ (1HUF= 0.002858EUR in 2020). Therefore the ***indirect rebound effects for electricity*** is equal to (24 KWh/877.76 KWh)*100=***2.73%*** meaning that only 2.73% expected reduction in heating fuel consumption is not being achieved. The very small estimated rebound for a thermostat shows that this measure is certainly worthwhile to apply and will result in a minimal increase in total energy consumption.

Similarly, with the assumption that turning off lights and appliances such as TV when not in room reduces the electricity consumption by 5%, the indirect rebound effect for heating fuels can be calculated as follows:

$$Indirect\ rebound\ effect\ for\ heating\ fuels = \frac{changes\ in\ heating\ fuel\ consumption\ (KWh)}{expected\ energy\ saving\ for\ electricity\ (KWh)} \times 100$$

$$= \frac{income\ elasticity\ for\ heating \times energy\ cost\ saving\ for\ electricity\ (€)}{expected\ percentage\ reduction\ in\ electricity\ consumption \times\ mean\ \ electricity\ consumption\ (KWh)} \times 100$$

The mean expected electricity energy savings for the sample is equal to $0.05 \times 3060.82\,KWh = 153\,KWh$ (mean values are taken from Table 13 Summary statistics for Nyírbátor wave 3 living lab). The average electricity price for the sample is 0.104 €/KWh therefore the mean electricity cost saving is $€\,0.104 \times 153\,KWh = €\,15.92$. Using the definition of income elasticity i.e. $income\ elacticity\ for\ heating\ fuels = \frac{\Delta heat\_con}{\Delta income} \times \frac{income}{heat\_con}$ and estimated heating fuels consumption equation in Table 11, the mean changes in heating consumption (KWh) for the sample is equal to $(0.1953 \times €\,15.92 \times 17555.16\ \text{KWh})/201589.76 \times €0.002858) = 7.74\,KWh$ (1HUF= 0.002858EUR in 2020). Therefore the ***indirect rebound effects for heating fuels*** is equal to (7.74 KWh/153 KWh)*100=***5.06%*** meaning that only 5.06% of expected reduction in electricity consumption is not being achieved. Although this is a bit higher than indirect rebound for thermostat, the estimated rebound is very small indicating that the increase in heating consumption is not relatively high compared to electricity savings coming from change in habits and behaviours.

It is not possible to estimate the direct rebound for Nyírbátor but it is worth noting that (Balezentis, Butkus, Streimikiene, & Shen, 2021) estimate the direct rebound effect of about 80% for Hungary's residential sector. They conclude that Hungary is among the European countries with very high rebound effect.

## 5.2 Conclusion

Rebound effect typically refers to an increase in energy consumption relative to a counterfactual baseline in which economic responses to energy efficiency improvements or sufficiency actions do not occur. There are different approaches to estimate the magnitude of rebound effects, mostly relying on economic modelling of energy demand. Existing literature mainly focuses on direct rebound effect. The estimation of indirect rebound effect requires more detailed information and hence less investigated in the literature.

In this project, given that each lab adapts the overall methodology to its needs, the approach used for rebound effect estimation depends on the information and data available through each living lab case study and associated social survey. Overall, the results show the direct rebound effect is large both for Manchester and Metsovo with Manchester having a backfire. The estimated indirect rebound effect for energy use in Nyírbátor is relatively small, however the estimated efficiency scores for heating indicate very large inefficiencies for heating implying poor energy use behaviours, inefficient heating systems and poor insulation or old housing stock. The results are not surprising as the sample households are low-income groups and generally cutting back on the energy use to save on their bills. The rebound effect in this case is not necessarily a negative phenomenon, but rather should be viewed as helping them reach minimum living standards as they improved their levels of comfort and in turn their health.

# 6 Results from Each Living Lab

## 6.1 Overview

The following chapter summarises the results from each living lab, while some methodological and ethical issues are considered the focus is on aspects on the specific measures undertaken and associated changes in energy consumption. The chapter also contains a summary of findings which apply across all the living labs.

## 6.2 Manchester – United Kingdom

The Manchester Living Lab generated extensive and tangible results in relation to all project objectives. In the course of its lifetime, the Lab engaged with a total of ***4620 people***, out of which approximately one third were citizens in the Greater Manchester Urban Area. The Lab's recruitment was particularly strong in the energy advice domain, and this component continued to function remotely (in the form of telephone-based and online advisor consultations) during the COVID-19 crisis, despite significant challenges posed by the lockdown and the pandemic itself.

Due to the structure of the report below, project objectives are not covered in their original order within the different sections that follow. Section 7.2.1 covers ***objectives 2, 6, 1, 7*** and ***8***. In section 7.2.1, we discuss project ***objectives 4***, ***5*** and ***3***.

### 6.2.1 Impact on Consumers

As a whole, STEP IN had significant impacts on consumer well-being, market participation, energy efficiency and institutional structures. The main lynchpin for this activity was the assessment and benchmarking exercise that was undertaken in the first 9 months of the Lab. This resulted in a detailed report (Deliverable 2.1) that identified different types of vulnerable citizens, the pathways that lead to energy vulnerability, and current measures to address it. The report directly related to project ***Objective no. 2*** ('***Assessment and Benchmarking'***) and provided a basis for developing tangible results in relation to ***Objective no. 6*** (***'Support Clearly Defined Target Groups of Citizens'***).

The assessment showed that energy poverty is present throughout the Greater Manchester region, with inner-city areas being particularly vulnerable due to housing energy efficiency factors. At the same time, other social disparities – related to income, disability and particular socio-demographic household characteristics – are leading to the expansion of domestic energy deprivation in more suburban and rural areas. As a whole, the Greater Manchester urban area is facing major structural issues that will continue to drive the problem in years to come – including the lack of particular energy infrastructures in some areas, and the relatively poor energy efficiency of the housing stock in others. This is unfolding against the background of rising levels of income inequality, cuts to public services, and energy price pressures.

The Lab's eligibility streams responded directly to the outcomes of the benchmarking exercise. Notably, citizens were referred to the Lab on the basis of social vulnerability, health, low income and being in receipt of benefits. In the first and second iterations, when we tracked the referrals to LEAP by source, it was evident that the majority of households targeted by the advisor visits (Figure 9) experienced issues around vulnerability (involving domestic violence, recent bereavements, moving in and out of homelessness, being a recent immigrant or asylum seeker).

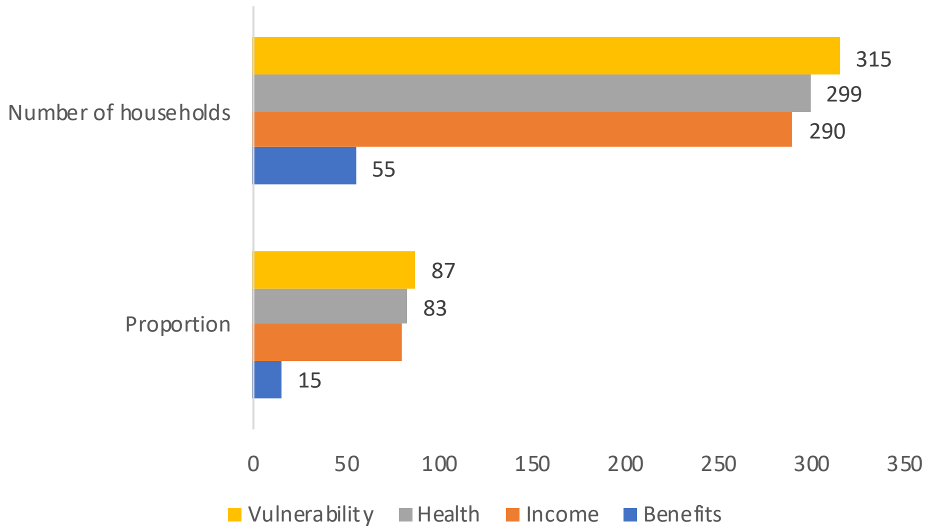


*Figure 9 Key eligibility streams in Living Lab participants (in numbers of households for each stream), in Living Lab iterations 1 and 2. Note that a household may fit more than one criterion (n=368).*

In the third iteration, when data on eligibility was not collected due to the cessation of LEAP, we established that the largest single referrer to the phone consultations were local councils and schemes run by them, followed by companies and self-referrals. As a whole, the 'other' category was the largest, however, including a wide range of non-governmental organisations, community groups and health practitioners. Qualitative evidence suggests that council-referred households tend to face income problems, while those who are self-referred are among the most vulnerable (Figure 10).

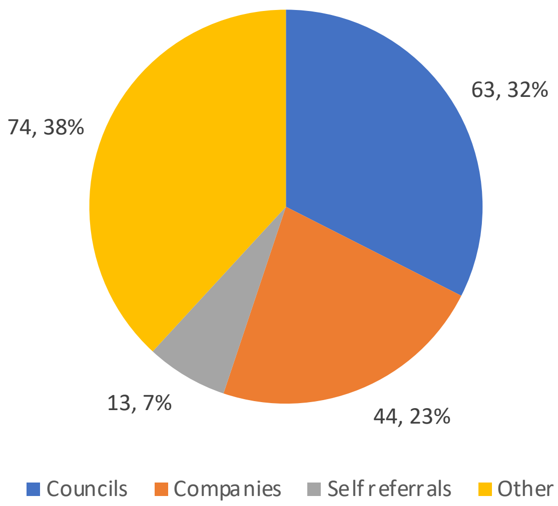


*Figure 10 Key referral sources of households receiving advice in the third iteration of the Living Lab (n=197).*

There is extensive and demonstrable evidence to show that Lab's ***Objective no. 1*** (***'Positive Impact on Citizens'***) was met and exceeded. In the first two rounds, the Lab resulted in the installation of a total of ***686 'small measures'***, such as LED bulbs (74% of households in the first round, rising to 89% in the second round) but also the introduction of reflective film behind radiators (for 46% and 58% of households in the first and second rounds, respectively) and door brushes (24% and 23% in the first and second rounds respectively). All other 'small measures' were adopted by fewer than 20% of households, although it is worth noting that 9% and 7% of households, respectively, pledged to switch electricity and gas suppliers after the first visit; these figures increased to 11.7% for both measures in the second Living Lab round (see Figure 11).

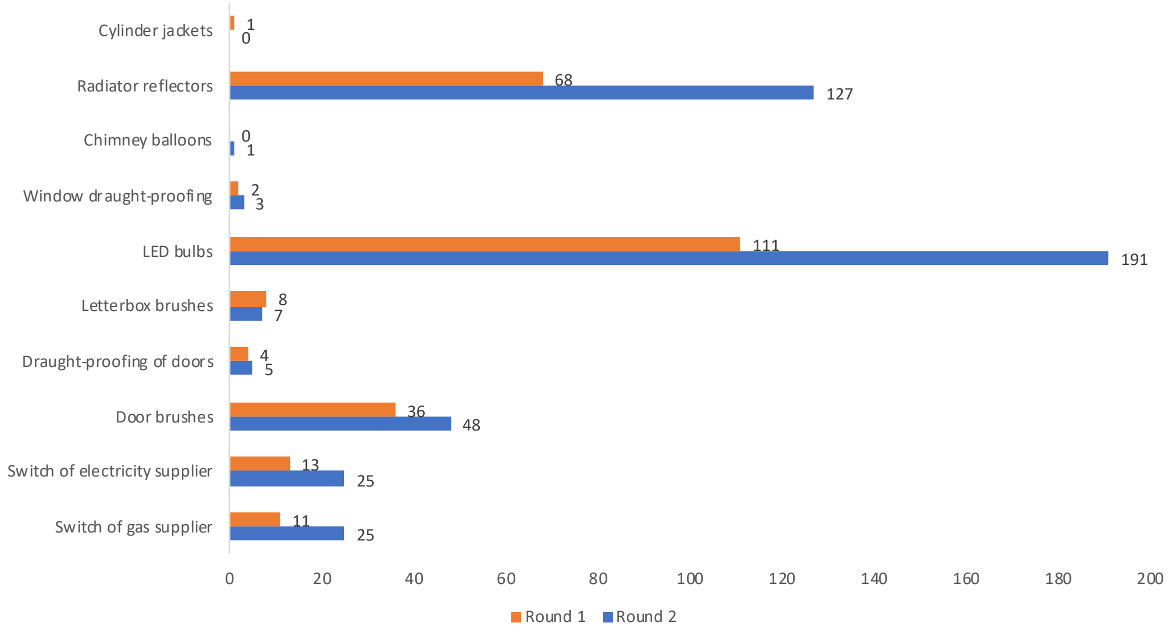


***Figure 11 Total numbers of small measures installed in Living Lab iterations 1 and 2 (n=368). Note that a single household may install more than one measure.***

Significant improvements were noted in terms of reducing energy bills for households, thanks to the support received via advisor visits, focus groups and energy cafés. The aforementioned change in methodology between Rounds 1 and 2, to include estimated savings in terms of energy consumption (kilowatt hours) rather than monetary energy expenditure, provided further insights in this regard. Still, we had to revert to expenditure measurements in the third round due to the advisors' inability to access people's homes and read their meters and bills. In the second Living Lab round, rather than a decrease in energy consumption, the measures implemented by the advisors resulted in a small overall increase in energy consumption of 26 kwh per household (0.2% of average annual consumption as measured in kwh). The finding that household consumption increased, as 80% of the households in our sample were eligible for the advisor visits based on benefits, and they live in some of the most deprived areas of the UK.

Otherwise, there were projected bill savings across the entire lifetime of the Living Lab, mainly as a result of supplier switching to cheaper tariffs aided by the energy visits:

- In the first round, the total projected bill saving was 9.91% of all entire annual household bills paid by citizens in the Lab. This translates to £107 per consumer;
- In the second round, there was a projected annual bill saving of 12.41%, or £133.
- In V3, despite the physically remote nature of the consultations, an actual (rather than projected) bill saving of 2.91% was generated, equivalent to £31 per consumer.
- Altogether, the Lab achieved an estimated annual bill reduction of ***8.47%***, or ***£91 per consumer***.

Another tangible result on the quality of life of affected residents was the decrease in the relative number of households who reported being unable to pay their bills on time (Figure 12). This percentage share went down by more than half during both the first and second Living Lab iteration, although there was a doubling in the third iteration – largely attributable to COVID-19.

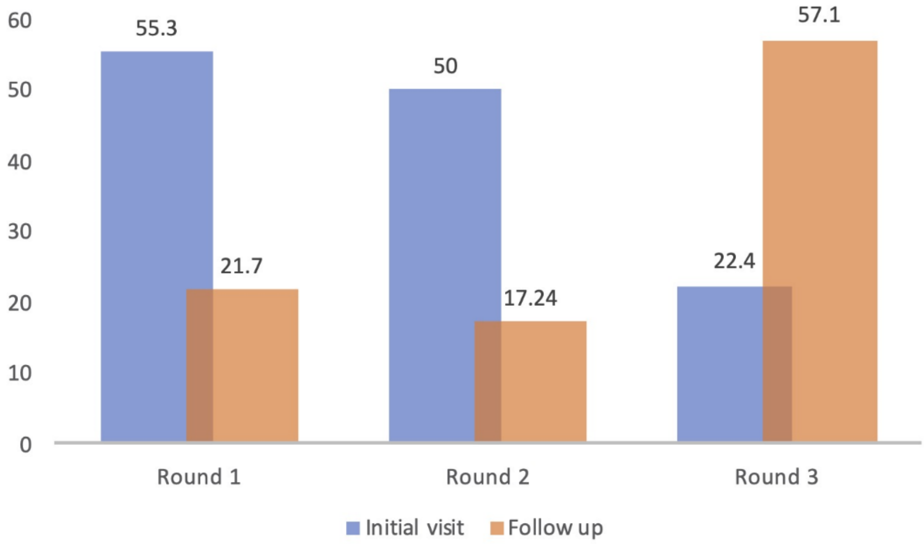


*Figure 12. Percentage shares of households reporting the 'inability to pay bills on time', in the first advisor visit, and in evaluation visits for each Living Lab round.*

In response to the advice received by the STEP-IN project under LEAP, citizens pledged to implement a number of energy saving behavioural measures (Figure 13). The most prominent of these was the reduction of thermostats by one degree – affecting 43% and 52% of households in the first and second iterations of the Living Lab, respectively. The reduction of shower times was also commonly observed, at 64% of households in the first iteration, to 52% in the second. The pledge to wash at 30 degrees was in third place, from 22% of households in the first iteration, and 28% in the second round. At the other end of the spectrum, the additional turning off of unwanted lights was rarely observed – mainly because most advice recipients stated that they were already doing it. All of these measures contributed to the achievement of ***Objective 7*** (***'Reduce Environmental Impacts'***). Extensive energy saving advice was also provided at the energy cafés, and this was evaluated highly positively by participants.

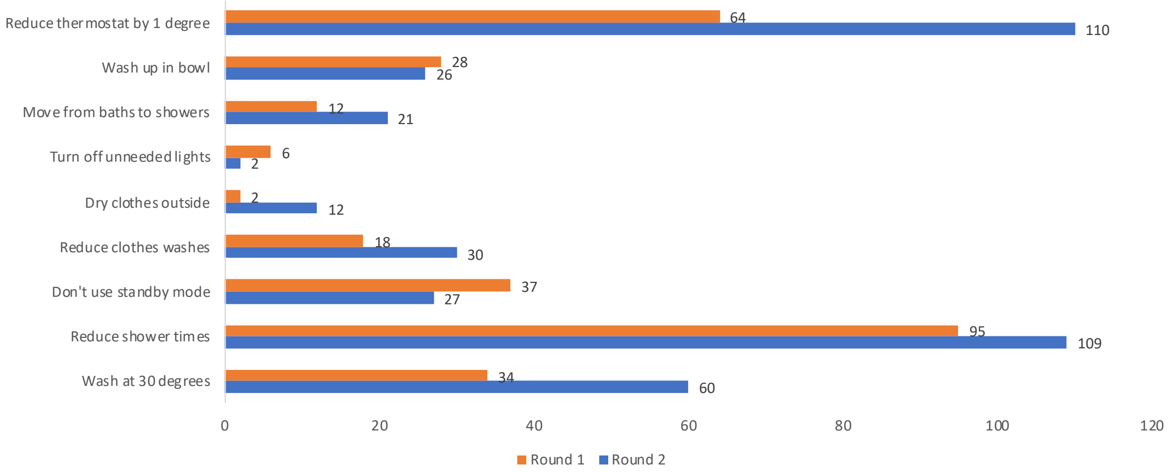


*Figure 13 Total numbers of behavioural energy conservation measures in Living Lab iterations 1 and 2 (n=368). Note that a single household may have undertaken more than one measure.*

Many households were referred onto different external services as a result of the advisor visits. The majority of these were in the direction of income maximisation services provided by the local council, and the government's ECO energy efficiency scheme, although fire safety issues were detected in a significant number of homes, and subsequently triggered a fire safety referral (Figure 14).

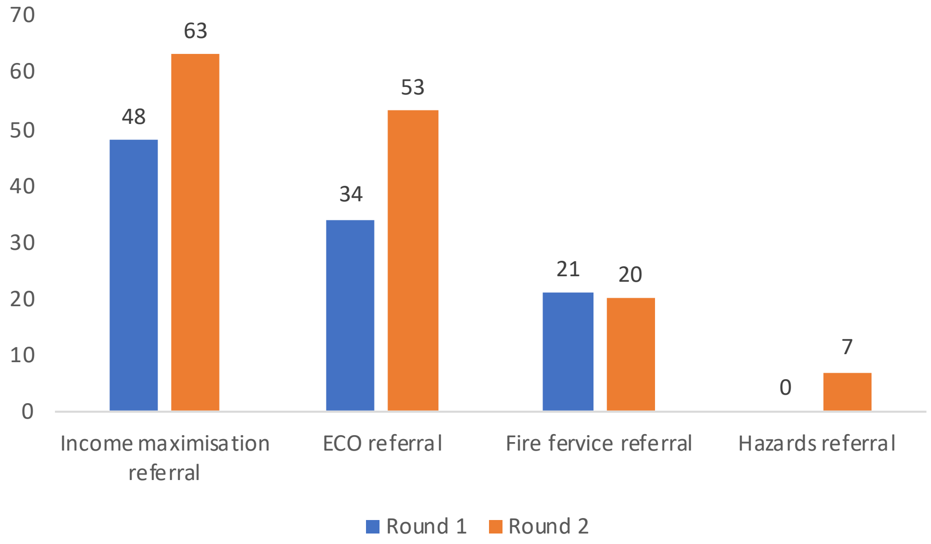


***Figure 14 Total numbers of further referrals in Living Lab iterations 1 and 2 (n=368). Note that a single household may have received more than one referral.***

It should be noted that the rate of referrals in the third iteration was similar to that recorded in the first two, at 38% of all households; but they were not registered in the same manner due to changes in the referral pathways and the options available (as LEAP was not running, and there were other restrictions imposed by the pandemic). Nevertheless, the Lab was able to refer local citizens to a wider range of more customised services (see Figure 15), including the Warm Home Discount (a national scheme, which provides a set rebate on the electricity bills of eligible customers), the Citizens Advice Bureau (provides confidential information and advice to assist people with financial, legal, consumer and other problems), Priority Services Register (as all energy suppliers are obligated to keep a dedicated fuel priority register for elderly or disabled customers) and the Emergency Central Heating Offer (an emergency assistance for vulnerable or fuel poor households to repair or replace broken or condemned gas boilers). Households were also referred to a number of utility company schemes that may help cap bills or provide specific assistance. All of these activities contributed to the achievement of ***Objective 8*** (‘***Identifying viable financial schemes at local, national and European scale***’).

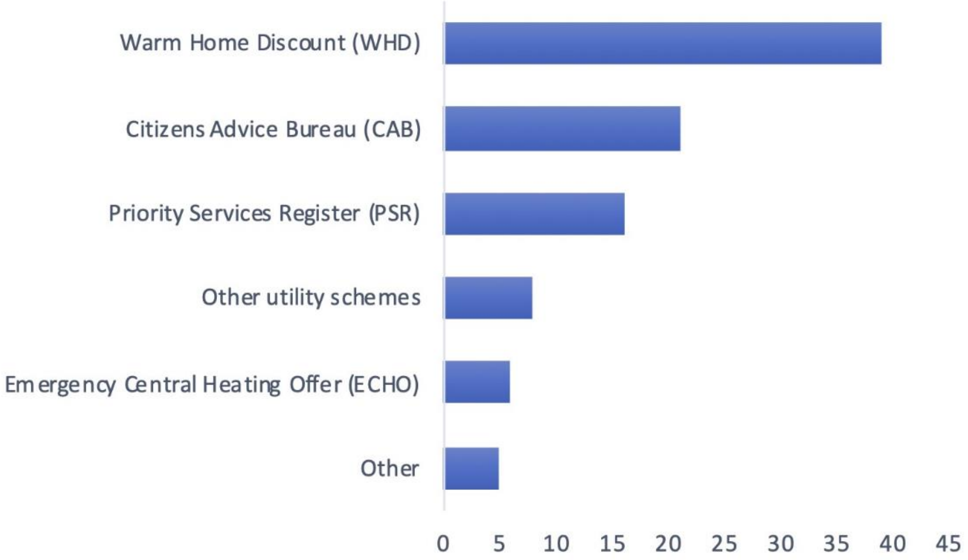


**Figure 15 Total numbers of further referrals in Living Lab iteration 3 (n=197). Note that a single household may have received more than one referral.**

Returning to ***Objective 7***, the evaluation surveys at the end of each Living Lab iteration also showed that there had been significant additional upgrades as a result of the advice received (Figure 16). These upgrades extend beyond the measures already implemented in relation to the advisor visits and consultations. The most significant improvement was the additional installation of small measures (reaching a record 82% of households included in the second iteration of the Lab, up from 63 in the second iteration), although a significant proportion of boiler upgrades were also observed in both the first and second iteration.

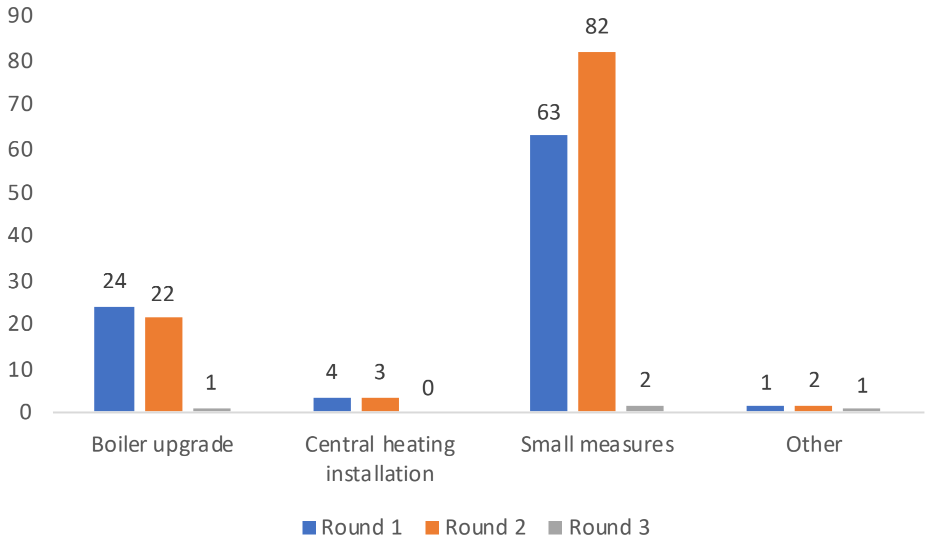


**Figure 16 Further upgrades as a result of the advisor consultations, as a percentage of all households in the evaluation visits for Living Lab iterations 1, 2 and 3 (n=303). Note that a single household may have undertaken more than one upgrade.**

As for behavioural changes to support ***Objective 7*** (Figure 17), further referrals to other services were particularly common in the first round of the Lab, present in over half of the households who received advice. The use or price comparison sites was also frequent in the first iteration (and, to a lesser degree the, the second). The second iteration saw a particularly high number of tariff provider switches and 'other' measures (particularly energy conservation behaviours at home), while a significant change in heating patterns (nearly one quarter of the sample) was noted in following the evaluation of the advice provided during the third iteration.

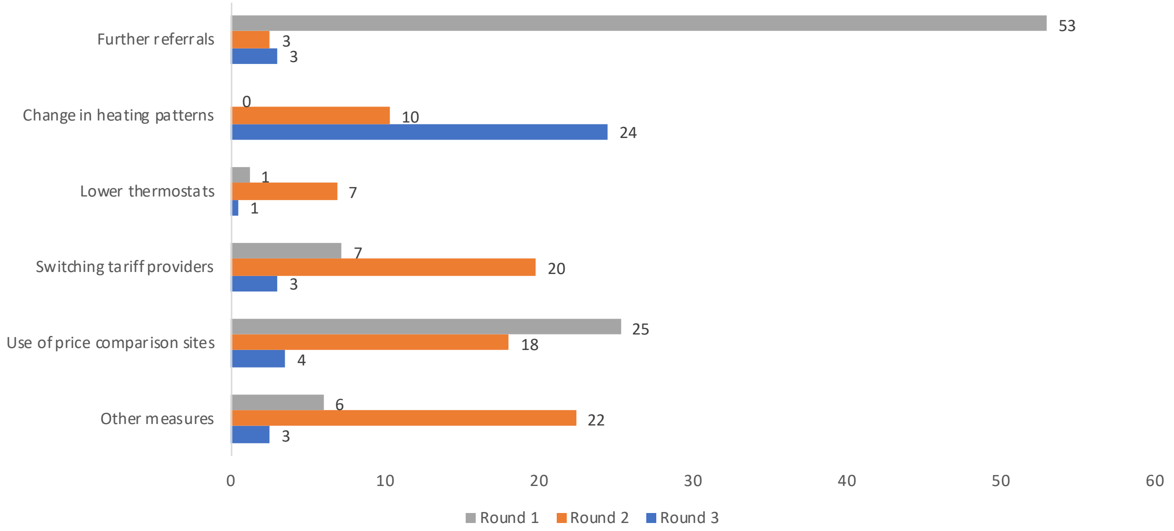


***Figure 17 Behavioural changes as a result of the advisor consultations, as a percentage of all households in the evaluation visits for Living Lab iterations 1, 2 and 3 (n=303). Note that a single household may have undertaken more than one step.***

The achievement of all project objectives was also extensively supported by the energy cafés – particularly in terms of positive impacts of people's quality of life, energy saving measures, referrals to relevant services, and the identification of vulnerable consumers (as they supported clearly defined groups of citizens in low-income areas of Greater Manchester) The results of the cafés are described in detail in Deliverable 2.3, but Table 16 provides an overview of some of the qualitative feedback received after the events.

| Theme | Comments |
|---|---|
| **Knowledge about reducing energy costs and consumption** | 'I will know more after the home visit'<br>'Received information but I'll know more after the visit from an energy advisor'<br>'Waiting for home visit from advisor'<br>'I'll change my water and electric tariffs'<br>'Haven't done anything yet. But might do after further calls'<br>'I'll see if I can save anything first.'<br>'Know more when (energy advisor) visit's done.' |
| **Learning from the energy café** | 'The energy services. What is out there. Really opened my eyes'<br>'The help and support we can get from people who were there'<br>'Learning about the gadgets at the energy stall, especially the radiator foil and draftproofing. Increased my awareness of Energyworks and have booked in 2 visits'<br>'Useful information about energy saving gadgets. Booking energy advisor appointment. Learnt about Energyworks.'<br>'Energyworks - 2 people signed up for an appointment. Been to all the stalls and collected information'<br>'What LEAP does and what services are offered at a home visit.'<br>'Leap visits - the services they provide and the eligibility criteria.'<br>'Signed up for a [home] visit - learned can sign up for further visits! Also learned about the services on offer and the organisations.'<br>'Services on offer - Electricity NW, Energyworks.'<br>'Referral information! This will be a help for a vulnerable contact.'<br>'LEAP. Awareness of who Energyworks are. Possibility of contacting environmental health about property.'<br>'Draft excluders and radiator reflectors - their usefulness and how they work. And that Energyworks can fit them. LEAP appointments, what this involves and how to arrange.'<br>'LEAP - took a leaflet, I now understand what it involves including fitting of small energy efficiency measures, and how it can help.'<br>'The LEAP programme. Energyworks and how its funded, and that they're not cowboys.'<br>'Services offered by Energyworks. Different kinds of lightbulbs, differences between LEDs and CFLs and where good LEDs can be purchased from.'<br>'LEAP programme and its eligibility criteria. Lightbulbs, the different types that are available and that these can be fitted as part of LEAP, along with other free measures that are available.'<br>'The LEAP service and what it can offer. Energy works as an organisation - I'd never hear of them before.' |
| **Actions taken as a result of the energy café** | 'I arranged a LEAP visit'<br>'I arranged for Energyworks to visit our organisation.'<br>'Took away a LEAP leaflet.'<br>'Signed up for a LEAP visit.'<br>'May sign up to a home visit.'<br>'Signed up for a [home] visit - learned can sign up for further visits! Also learned about the services on offer and the organisations.'<br>'I've signed up for a LEAP visit.'<br>'arranged a LEAP visit for my dad.'<br>'I will contact Energyworks to arrange a LEAP visit.'<br>'Signed up to LEAP. They're going to fit a Carbon Monoxide safety system as well.' |

| Theme | Comments |
|---|---|
| | 'Taken away a leaflet, will ring up to sign-up for LEAP.'<br>'I'll pass on LEAP leaflets to friends.'<br>'I'm staying with my brother, but I'll try and convince him to sign-up. If it was my house I would definitely sign-up.'<br>'I'm going to refer LEAP to customers. I might even sign up myself.'<br>'I've arranged for Energyworks to visit our community centre.' |

*Table 16 A selection of written responses to the survey from each energy café*

## 6.2.2 Methodological Issues

Most of the Lab was implemented as planned, with the exception of the major changes that had to be undertaken during the COVID-19 crisis. In any case, the iterative approach worked extremely well, allowing for constant modifications and improvements with regard to the advisor visits and energy cafés in particular. In the first two iterations, the advisor visits exceeded the initially set target by 68 households, and the energy cafés recruited approximately 260 participants – just under the 300 targeted for the entire duration of the Lab. In the third round of Living Lab activities (held during the lockdown), advisor consultations also exceeded the target, but we only managed to attract 11 participants at the online energy cafés. Low attendance at the cafés was extensively discussed and deliberated at focus groups, of which we organised more than initially intended in this iteration (5 rather than 2, attended by approximately 6 people each). The reasons for low attendance are laid out in detail in the final Living Lab report (Deliverable 2.3) but can be principally connected to time and resource constraints faced by Greater Manchester citizens during the course of the pandemic.

In the Lab, we also encountered specific challenges regarding the application of IT methodologies. The Lab functioned under the auspices of an already established IT scheme, as the advisors already used a distinct and well-built IT architecture (relying on the Zoho app). Rather than creating a new IT platform, we adapted the Zoho app and existing advice information system to the needs of the Lab, by adding a series of questions to the app, and generating data directly from them. The data processed in this manner was also used to generate a novel, free of charge advice web portal for general public use, directed (the portal is available at www.energyadvice.info).

Unlike the energy cafés and advisor visits, which were highly useful and productive for local citizens, the energy, temperature and humidity monitors – as well as diaries – did not always generate useful results. This is due to their specific interactions with the real-life circumstances faced by local residents – issues of fire safety, theft, time poverty came to the fore (they are discussed in further detail in Deliverable 2.3). During the Covid-19 pandemic, we were unable to use any of these methods due to the need to conduct all activities remotely.

## 6.2.3 Ethics and Data Protection

Throughout the project, we fully followed and implemented relevant ethics procedures and national codes of practice with regard to informed consent, confidentiality and data protection. The Living Lab team have extensive experience with interview, ethnographic and observational research methods, including previous field research in Greater Manchester urban areas. This includes work with potentially sensitive subjects and vulnerable people. In such instances, we adhered to appropriate safeguarding and disclosure processes; and indeed, the entire Lab was directed at referring any vulnerable interviewees to further support.

All participants were asked to sign a statement of informed consent. This included a request to use and store personal data in line with current legislations and codes. Permission to record data from all relevant instances was also asked. The respondents' wishes were respected in cases where such consent was not provided. Upon request, all participants were able to see any transcripts and notes produced, so as to obtain comments and verification. Data that could identify any interviewees or that may have contained personal information of any kind was stored securely and was not shared with third parties.

Findings have been presented in a form that ensures the anonymity or confidentiality of respondents in full, where this has been requested and agreed.

### 6.2.4 Other Findings

The first two iterations of the Lab (when the methodology was directly consistent and comparable due to the use of similar advisor visits) provided important findings about the factors that drive energy poverty among households who are referred for energy advice. When the resident reported feeling insufficiently warm in the home during both Living Lab rounds, a multi-variate linear logistic regression revealed that the key variables of significance were the presence of a non-condensing gas boiler and the lack of insulation (both leading to higher energy costs), as well as low incomes (Table 17).

| | Coefficients | 95% CI | z | Significant Level |
|---|---|---|---|---|
| (Intercept) | 0.0787 | 0.3674 | 0.4285 | |
| Older Person | -0.0681 | 0.1684 | -0.8091 | |
| Young Children | 0.1141 | 0.1878 | 1.2152 | |
| Flat | 0.1610 | 0.2254 | 1.4287 | |
| Electricity | 0.0529 | 0.3076 | 0.3442 | |
| Non Condensing Boiler | -0.1681 | 0.1653 | -2.0336 | ** |
| Lack of Insulation | 0.1440 | 0.1712 | 1.6822 | * |
| Private Tenure | 0.0889 | 0.1560 | 1.1394 | |
| Benefits | -0.0322 | 0.1797 | -0.3587 | |
| Low Income | 0.2376 | 0.2165 | 2.1949 | ** |
| Poor Health | 0.0814 | 0.1883 | 0.8642 | |
| Vulnerability | 0.0562 | 0.1939 | 0.5798 | |
| One Degree | -0.0792 | 0.1476 | -1.0729 | |

***Table 17 Logistic regression – households reporting inadequately warm homes.***

The Lab's extensive stakeholder engagement and policy impact activities (see Table 18) contributed to the achievement of ***Objective 4*** (***'Engaging with the Energy Poverty Community'***) and ***Objective 5*** (***'Define Future Policies, Strategies and Research Areas'***). The fulfilment of these objectives was supported by multiple strands of work:

- The Lab's results were published in three peer-reviewed articles in leading journals (Bouzarovski et al 2021: https://doi.org/10.3390/en14040858; Bouzarovski 2020: https://doi.org/10.3389/frsc.2020.00029; Petrova and Simcock 2019: https://doi.org/10.1080/14649365.2019.1645200). These papers outlined and reviewed future research areas while also discussing the policy context for energy poverty alleviation. Further articles are being prepared for submission with the analysis of data from the Living Lab.
- In the early stages of the Lab, one of the key impact activities was our participation in a roundtable on 'How to drive engagement in the energy market for the most disengaged consumers'. Chaired by Yvonne Fovargue MP, Chair of the All-Party Parliamentary Group on Consumer Protection, the roundtable discussion brought together representatives from parliament, industry and other experts in energy, consumers and markets to explore next steps and opportunities for driving consumer engagement – including how to engage the most vulnerable customers.
- Also of importance was a talk about STEP IN to the Manchester Statistical Society in November 2019 https://manstatsoc.org/2019/08/23/november-2019-stefan-bouzarovski/). The Manchester Statistical Society is one of Manchester's premier discussion fora focusing on social and economic issues. It gathers preeminent experts, decision-makers, and private sector

representatives from across the Greater Manchester urban area. The talk was a stepping stone towards wider public policy impacts and engagements in the course of the Living Lab.

- Another key event was a dedicated roundtable with Energy Minister Kwasi Kwarteng, organised by the University of Manchester in July 2020. It was a unique opportunity to discuss the project with an Energy Minister and a series of senior government decision-makers. The meeting was preceded by a workshop gathering key stakeholders and a highly publicised Centre for Cities seminar 'What does the impact of Covid-19 mean for net zero and local fuel poverty'.
- The project was also presented at several major conferences, often in the form of keynote or open space presentations. This included EU Sustainable Energy Week, the Making Decarbonisation Fair conference, the Energy Evaluation conference, and the Royal Geographical Society annual conference.
- Inputs were provided towards a number of public policy debates, including the government's privately rented homes consultations and a consultation issued by the Department for Business, Energy and Industrial Strategy.
- Thanks to the project, there was reference to the importance of out-reach energy advice services in Greater Manchester's approach to decarbonising its buildings and tackling fuel poverty (see https://www.greatermanchester-ca.gov.uk/media/3894/decarbonising_greater_manchester_existing_buildings_sep19.pdf). The placing of these services at the heart of other energy saving initiatives in Greater Manchester, for example the Connected for Warmth (http://www.connectedforwarmth.org.uk/) scheme which installs first time central heating systems in the homes of fuel poor households.

| Event title | Event location | Event dates | Attendees | Details/URL | Type of audience | Method of presenting | Audience size |
|---|---|---|---|---|---|---|---|
| Royal Geographical Society | Cardiff, UK | 30.8.2018 | Stefan Bouzarovski (UMAN) | Session discussant | Scientific community, civil society | Oral | 100 |
| Citizens' Energy Forum | Dublin, IE | 20.9.2018 | Stefan Bouzarovski (UMAN) | Chair and rapporteur *https://ec.europa.eu/info/events/10th-citizens-energy-forum-2018-sep-20_en* | Civil society, media, investors | Oral | 300 |
| Workshop on Socio-Ecological Justice | Erfurt, DE | 21.9.2018 | Stefan Bouzarovski (UMAN) | Invited participant and presenter http://www.engager-energy.net/wp-content/uploads/2019/04/Minutes_Writing_Retreat_Erfurt_Mar_2019.pdf | Scientific community | Oral | 50 |
| City Under Construction conference | Thessaloniki, GR | 13.10.2018 | Stefan Bouzarovski (UMAN) | Keynote speaker *http://southeuropean-cities.arch.auth.gr/en/conference2018* | Scientific community, civil society, policymakers, media, general public | Oral | 300 |

| Event title | Event location | Event dates | Attendees | Details/URL | Type of audience | Method of presenting | Audience size |
|---|---|---|---|---|---|---|---|
| Third annual conference of the French energy poverty observatory | Bordeaux, FR | 23.11.2018 | Stefan Bouzarovski (UMAN) | Plenary speaker<br>http://www.planbatimentdurable.fr/le-3eme-colloque-de-l-onpe-aura-lieu-le-23-a1289.html | Scientific community, civil society, policymakers, media, investors, general public | Oral | 200 |
| EU Research and Innovation in our daily life conference | Brussels, BE | 27.11.2018 | Stefan Bouzarovski (UMAN) | Plenary speaker<br>http://www.europarl.europa.eu/resources/library/media/20181025RES17358/20181025RES17358.pdf | Scientific community, civil society, policymakers, media, investors, general public | Oral | 500 |
| Designing future energy policies conference | Brussels, BE | 22.1.2019 | Stefan Bouzarovski (UMAN) | Plenary speaker | Scientific community, civil society, policymakers, media, investors, general public | Oral | 100 |
| Energy systems workshop - working within the city of Manchester | Manchester, UK | 25.1.2019 | Stefan Bouzarovski (UMAN) | Presented the STEP-IN project to over 40 stakeholders from Manchester university and GMCA. | Scientific community, civil society, policymakers, media, investors, general public | Oral | 30 |
| Roundtable meeting on 'disengaged' consumers | London, UK | 2.4.2019 | Stefan Bouzarovski (UMAN) | Chaired by Yvonne Fovargue MP | Civil society, policymakers | Oral | 20 |
| Socio-Technical Interdisciplinary Approaches to Energy Studies | Cambridge, UK | 19.2.2019 | Stefan Bouzarovski (UMAN) | http://www.crassh.cam.ac.uk/events/28252 | Scientific community, civil society, general public | Oral | 100 |
| Disruptive Energy conference | Plymouth, UK | 23.3.2019 | Stefan Bouzarovski (UMAN) | Session chair | Scientific community, civil society | Oral | 100 |
| Goldman Award conference | Skopje, MK | 28.5.2019 | Stefan Bouzarovski (UMAN) | | Civil society, policymakers, media, | Oral | 150 |

| Event title | Event location | Event dates | Attendees | Details/URL | Type of audience | Method of presenting | Audience size |
|---|---|---|---|---|---|---|---|
| and reception | | | | | investors, general public | | |
| EUSEW | Brussels, BE | 19.-20.6.2019 | Stefan Bouzarovski (UMAN) | Chaired and took part in several sessions. *https://www.eusew.eu/stefan-bouzarovski* | Scientific community, civil society, policymakers, media, investors, general public | Oral | 250 |
| New Climate Urbanism workshop | Sheffield, UK | 4.9.2019 | Stefan Bouzarovski (UMAN) | Presenter | Scientific community | Oral | 50 |
| Manchester Statistical Society | Manchester, UK | 12.11.2019 | Stefan Bouzarovski (UMAN) | https://manstatsoc.org/2019/08/23/november-2019-stefan-bouzarovski/ | Scientific community, civil society, policymakers, local decision-makers, general public | Oral | 50 |
| Community solutions to energy poverty conference | Zagreb, Croatia | 15.01.2020 | Stefan Bouzarovski (UMAN) | https://www.hzn.hr/default.aspx?id=1865 | Scientific community, civil society, policymakers, local decision-makers, general public | Oral | 200 |
| Just transitions: a critical political ecology | Glasgow, UK | 6.2.2020 | Stefan Bouzarovski (UMAN) | | Scientific community | Oral | 40 |
| Fridays for Future online meeting | online | 30.4.2020 | Stefan Bouzarovski (UMAN) | | Civil society | Oral | 30 |
| The road to recovery: Leading the green agenda after COVID-19 | Online, Policy@Manchester | 24.6.2020 | Stefan Bouzarovski (UMAN) | Attended by Energy Minister Kwasi Kwarteng. | Scientific community, policy-makers | Oral | 20 |

| Event title | Event location | Event dates | Attendees | Details/URL | Type of audience | Method of presenting | Audience size |
|---|---|---|---|---|---|---|---|
| Centre for Cities seminar 'What does the impact of Covid-19 mean for net zero and local fuel poverty' | Online, Centre for Cities | 16.7.2020 | Stefan Bouzarovski (UMAN) | https://www.centreforcities.org/event/what-does-the-impact-of-covid-19-mean-for-net-zero-and-local-fuel-poverty/ | Scientific community, policy-makers | Oral | 40 |
| Third biennial conference of the Political Ecology Network (POLLEN) | Online | 22-25.09.2020 | Stefan Bouzarovski (UMAN) | Presenter, session organiser and discussant. https://politicalecologynetwork.org/2019/10/04/cfp-pollen20-energising-political-ecology/ | Scientific community, civil society | Oral | 100 |
| National Energy Assistance Directors Association Virtual Meeting | Online | 20.10.2020 | Stefan Bouzarovski (UMAN) | https://neada.org/wp-content/uploads/2020/09/2020annualmtgagenda.pdf | Policy-makers, , civil society, scientific community | Oral | 70 |
| The right to fair energy access | Online | 18.02.2021 | Neil Simcock and Ami Crowther (UMAN) | https://www.eventleaf.com/right-to-fair-energy | Policy-makers, , civil society, scientific community | Oral | 70 |
| The socio-spatial determinants of energy inequalities in Europe, Hong Kong University of Science and Technology | Online | 22.02.2021 | Stefan Bouzarovski (UMAN) | https://calendar.ust.hk/events/center-aging-science-seminar-socio-spatial-determinants-domestic-energy-inequities-europe | Scientific community | Oral | 30 |
| Making Decarbonis | Online | 4.03.2021 | Stefan Bouzarovski (UMAN) | http://www.fuelpovertyresearch.net/events- | Scientific community, civil society, | Oral | 100 |

| Event title | Event location | Event dates | Attendees | Details/URL | Type of audience | Method of presenting | Audience size |
|---|---|---|---|---|---|---|---|
| ation Fair' conference | | | | 2/making-decarbonisation-fair-1st-2nd-march-2021/ | policymakers, media, investors, general public | | |
| Keynote at Energy Evaluation conference | Online | 15.3.2021 | Stefan Bouzarovski (UMAN) | | Scientific community, civil society, policymakers, media, investors, general public | Oral | 150 |
| SocialWatt capacity building workstop | Online | 26.3.2021 | Neil Simcock (UMAN) | | Scientific community, policymakers, civil society, energy suppliers | Oral | 50 |
| **Total Estimated Attendance** | | | | | | | **3200** |

*Table 18 List of dissemination event activities attended by The UK Living Lab Partners*

### 6.2.5 Summary

Based on evidence presented in this report, we can conclude that Manchester Living Lab met or exceeded both the objectives of the project as well as the quantitative targets set out in the Grant Agreement:

- Over the lifetime of the Lab, 564 households received specialist advice from dedicated advisors (450 were planned), including 368 home visits in the first two iterations of the Lab, and 196 remote consultations in the third iterations. Overall, these households were estimated to contain 1085 people.
- We held a total of 5 physical and 5 online energy cafés, encompassing a total of 271 people (against 300 in the initial application, noting that one café had to be cancelled due to the pandemic, which also constrained attendance at the online cafés).
- The first two Living Lab round saw two sets of focus groups, with 8 participants each (one focus group had 9 participants). In the final round, five focus groups were organised online, with 6 participants each. The focus groups included a combination of experts and non-experts in each instance.
- Energy diaries and monitors, as well as temperature and humidity monitors were installed in the homes of 40 households in total during the first two iterations of the Lab (all of which also received energy advice); these methods were not used in the third iteration due to lockdown restrictions.
- Dissemination activities reached approximately 3200 people.
- In an evaluation survey, 95% of households who received advice during the COVID-19 pandemic thought that the advice was useful.

The Lab, as a whole, directly reached ***4620 people*** through energy advice, or participation in events where Living Lab members gave presentations (Table 19).

There were also significant improvements in the quality of life and environmental sustainability behaviours of Living Lab participants, including an estimated annual bill reduction of ***8.47%***. We would also note the significant impacts on policy and best practice identification.

| Type of activity | Total number of participants reached |
|---|---|
| Focus groups | 64 |
| Advisor visits | 1085 |
| Energy cafés | 271 |
| Dissemination activities | 3200 |
| **Total** | **4620** |

***Table 19 Total number of people that the Living Lab directly engaged with in face-to-face communication (virtual or physical).***

## 6.3 Metsovo – Greece

The Mountainous LL was established at Metsovo, a mountainous settlement of Greece, situated in the Northern Pindos mountain range, at an altitude of 1100m. The Municipality of Metsovo has an area of 363.656 km$^2$ and includes 3 Municipal Units (Egnatia, Metsovo, Milia), 10 local Units and 32 rural settlements and villages. The total population is more than 6,200 people (organised in more than 2,200 households). The settlement of Metsovo, where the Living Lab is located, has a total of 2,503 residents, organised in 888 households.

The LL engaged directly (i.e. households that participated in the LL activities) with ***442 people***, in the settlement of Metsovo and with ***670 people***, citizens in the Municipality of Metsovo, through the energy advice booklet. Moreover, the LL reached ***over 5,000 people*** through the distribution of the booklet. The Greek Facebook page is estimated to have reached an additional 2,000 people taking the total to over 7,000. In addition, conference presentations reached around 650 people. The local community's involvement was particularly strong in the energy advice domain and continued to be even in the last round. The last round functioned remotely (in the form of telephone-based and online advisor consultations) during the COVID-19 crisis.

Similarly, to Section 7.2, the eight project objectives (described in D.2.1 "Living Labs Global Methodology and implementation guidelines) are not covered in their original order. Section 7.3.1 covers ***objectives 2, 6, 1, 7*** and ***8*** and Section 7.3.4 discusses project ***objectives 4***, ***5*** and ***3***, respectively.

## 6.3.1 Impact on Consumers

The mountainous LL had significant impacts on households' well-being, energy efficiency and institutional structures. The first step for this activity was the assessment and benchmarking exercise that was undertaken in the baseline survey (Deliverable 3.1 "Baseline survey report (Mountain Living Lab"), which identified different types of vulnerable consumers. The report directly related to project ***Objective no. 2*** ('***Assessment and Benchmarking'***) and provided a basis for developing tangible results in relation to ***Objective no. 6*** (***'Support Clearly Defined Target Groups of Citizens'***), based on the LL activities which were implemented during the three rounds.

The baseline assessment showed that about 40% of the households seem to be energy vulnerable. Nevertheless, no statistically significant relationship seems to exist between vulnerability and specific market segments. The main problem faced in the case of the mountainous LL is the excess energy cost, the vast majority of the households (about 90%) claim to spend more than 10% of their income to cover their energy needs, especially for heating purposes. This problem is attributed to three factors:

- Harsh climate: Due to the harsh climate, the heating degree-days of the Metsovo Municipality range between 2,275ºC*days and 3,194ºC*days and are significantly high. The heating degree days in Metsovo are 50% more than in the nearby city of Ioannina (the distance from Metsovo is only 50 km) and more than 200% than in Athens.
- Building stock: more than 80% of Metsovo's residences were built before 1979 (when the first Thermal Insulation Regulation was applied in the country) and nearly 6 out of 10 residences in Metsovo have no kind of insulation.
- Remoteness and terrain inclination, which characterise the mountainous areas, create barriers to fuel transfer and electrification, increasing fuel costs by about 5-7%. Apart from geographical characteristics, incomes of mountainous populations are usually lower than those of lowland and urban areas, due to various reasons (i.e. low productivity land, lack of investments etc.).

The recruitment of the households for the activities in 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) and the energy cafés. In total, for the three rounds, 150 households were directly involved (50 households in each of the LL's rounds). These households were selected randomly and voluntarily. In every round, electricity, temperature and humidity monitors were installed in 30 out of the 50 houses and information was collected for the 50 households using questionnaires (at the beginning and the end of the round). In many houses, the energy advisors used an infrared camera to spot the "weak" points and areas of the building shell (thermal bridges, badly insulated walls, etc.), and an exhaust-gas analyser to measure the characteristics of exhaust gases from the heating systems. Several heating systems were services and old analogue thermostats were replaced with digital ones. As described in Section 5.4.2, in round V3, instead of installing the equipment to 30 new households, the monitoring equipment stayed at the same households as in round V2. This decision was made to gather data and information related to the impact of the pandemic-related restrictions on households' energy consumption. Further, in round

V3, information and assistance was collected and provided remotely due to coronavirus-related measures.

There is extensive and demonstrable evidence to show that Lab's ***Objective no. 1*** *(**'Positive Impact on Citizens'**)* was met and exceeded. In all three rounds, several participants were motivated by the project and implemented or planned to implement energy interventions, such insulation of external walls and roofs, replacement of energy consuming appliances, replacement of old analogue thermostats, maintenance of heating systems, etc. Citizens also changed their energy behavioural patterns with respect to home ventilation and thermostat setting, etc. The positive impacts on the citizens of Metsovo are detailed in D3.1 "Baseline survey report (Mountain Living Lab)" and D3.3 "Data analysis Report on Mountain Living Lab" and, thus, hereinafter only a summary is given:

- In round V1 of the LL, the minimum heating energy savings triggered by the project during the first iteration sum to 33,000 $kWh_{th}$ per year and the electricity energy savings are estimated at 2,000 $kWh_{el}$ per year (just from one household). The potential reduction heating energy consumption exceeds 100,000 $kWh_{th}$ per year. If only the over-consuming households were to reduce their thermal consumption - without downgrading their quality of life - over 48,000 $kWh_{th}$ could be saved.
- In round V2, twelve old and in many cases malfunctioning analogue thermostats were replaced by digital ones and three diesel oil-fired burners were serviced. Also, some of the participants said that they were motivated by the project and implemented or planned to implement energy interventions, such insulation of external walls and roofs, replacement of old analogue thermostats, maintenance of heating systems, etc., and changed energy behavioural patterns. During the V2 round, 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.
- In round V3, 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 thermal energy savings are estimated at 26,782 $kWh_{th}$. Moreover, six more households declared that they maintained their oil-fired central heating system (the annual thermal energy savings are calculated to 4,256 $kWh_{th}$) and two households stated that they replaced their old analogue thermostats with digital ones (the estimated reduction in thermal energy consumption is estimated at 6,000 $kWh_{th}$). 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 $kWh_{th}$ (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 $kWh_{th}$ and two more households were willing to place air insulation adhesive foam tape, saving 1,352 $kWh_{th}$ of thermal energy.

The remote operation of the LL cannot fully replace face-to-face LL activities. And this is 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.

The benefits of the LL to the participating households extend beyond energy savings. In total, 80% of those who participated in the V1 LL's activities said that the project was useful to them (approximately 25% maintained their heating system, 22% were helped to gain a better understanding of electricity bills, 20% claimed that they learn how to use their heating system more efficiently, etc.). More importantly, around 35% of them said that they noticed an improvement in the quality of their life during the V1 operation of the LL (e.g. reduction in energy spending, reduction in moisture/mould problems, improvement in thermal comfort, etc.). As far as the V2 round is concerned, in total, 70% of those who participated in the LL's activities said that the project was useful to them (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). Further, more than half of all the V2 households (i.e. 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. Finally, in the last round of the LL, 78% of those who participated in the LL's activities said that the project was useful (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). 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. Overall, around 32% of the households said that they noticed an improvement in the quality of their lives during the V3 operation of the LL. Half of these households mentioned a better level of thermal comfort at home and the other half claimed that they faced less moisture/mould issues.

Besides the improvements in the quality of life, the above-mentioned measures contributed to the achievement of ***Objective 7*** (‘***Reduce Environmental Impacts***’). Using 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 for the V1, V2 and V3 rounds of the LL are estimated at **32.9, 17.3 and 13.4 tn $CO_2$ per year**, respectively.

The project had also an impact on households that did not participate directly in the LL activities but received information material (e.g. the energy advice booklet). According to the ex-post assessment survey, about 11% of the non-participating households received information. 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%). Based on these findings, the potential heating energy savings due to heating system maintenance (85 houses) and energy retrofits (15 houses) are estimated at **86,520 $kWh_{th}$ and 139,050 $kWh_{th}$ per year**, respectively. The energy saved corresponds to a potential reduction in **$CO_2$ emissions of 51 tn per year**.

Households were referred to a number of supporting schemes that may help cap bills or provide specific assistance (e.g. Residential Night Tariff, Social Residential Tariff, Heating oil subsidy and “Saving at home” programme). All of these activities contributed to the achievement of ***Objective 8*** (‘***Identifying viable financial schemes at local, national and European scale***’).

### 6.3.2 Methodological Issues

Most of the mountainous LL activities were implemented as planned by the global methodology, with the exception of the major changes that had to be undertaken during the COVID-19 outbreak. The iterative approach worked extremely well, allowing for appropriate modifications and improvements with regard to the advisor visits and energy cafés in particular. In the first two rounds of the LL, the advisor visits reached the initially set target of 100 households. In the third round of the LL (which was held during the lockdown), the energy advisors provided remote consultations to 50 households, according to the original target, while monitoring an additional 30 houses with equipment installed to study the impact of the COVID-19 pandemic and the related restriction measures on households' energy behaviour and socioeconomic status. The first two energy cafés were close to the target of 50 participants. The third energy café was organised as an online event due to the pandemic-related restriction measures. Again, the number of participants was close to the target of 50 but their involvement in the online event was not the same as in the face-to-face events.

The energy, temperature and humidity monitors that were used during the LL activities proved to be very useful. In some houses, energy monitors detected malfunctioning appliances and the temperature and humidity sensors provided valuable information about the conditions prevailing in partially-heated houses. The monitors were also useful and helpful for the households to change their energy behaviour. For example, in the second round of the LL, approximately 67% of the owners said that they used the electricity monitoring app to check their electricity consumption and practically all said that they were reading the indications of the meteorological station. As a result, 9 out of 10 said that the sensors helped them in taking energy efficiency decisions, such as 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%). Also, around 54% of the total households said that they saw an improvement in their quality of life during the V2 operation of the LL. It is 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%).

The mountainous LL used a variety of ICT tools. The energy advisors used the web platform developed by LIST to upload and analyse monitor data about housing conditions (e.g. insulation, energy sources, room layout, etc.) along with information relating to bills and demographics. This platform provided support for assigning housing characteristics, creating personal advice, editing questionnaires, preparing reports, etc. The participating households could also use the same platform for downloading reports regarding their house, but they didn't use it extensively as this information was provided by the energy advisors during home visits. Additionally, the energy monitors used in the mountainous LL included a web app that could be accessed by the homeowners. 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. As mentioned above, more than two-thirds of the households used the electricity monitoring app. Finally, during the V3 round (i.e. during the lockdown), the NTUA team developed an online energy app that helps users to calculate the cost required to meet their heat and electricity energy needs and find out possibilities of reducing their energy expenses by changing the characteristics of their home or heating system (e.g. type of windows, the existence of thermal insulation, type of fuel, etc.). In the same direction, 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. Unlike the monitors, the energy diaries that were distributed during the V2 round did not work well. Less than half of them were returned completed, although the participants were asked to keep the diary just for two weeks.

Considering 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 frequent 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 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.

### 6.3.3 Ethics and Data Protection

The mountainous LL operated complying strictly with the EU's Charter of Fundamental Human Rights and Data Protection Regulations. The key ethical issues that were considered in the mountainous LL (as in each of the three LLs) are 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. Also, 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 and the protection of personal data and support of GDPR from the online platforms that were used during the last round was considered.

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, as well as the regulations:

- 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).

The citizens who were involved in data collection tasks (during the baseline survey, the energy cafés and the LL activities) were provided with a detailed information sheet 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.

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). 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.

### 6.3.4 Other Findings

The LL's extensive stakeholder engagement and policy impact activities and the Choice Experiment conducted in the context of the ex-post assessment survey contributed to the achievement of ***Objective 4*** (***'Engaging with the Energy Poverty Community'***), ***Objective 3*** (***'Supporting Best Practices'***) and ***Objective 5*** (***'Define Future Policies, Strategies and Research Areas'***).

The ex-post assessment survey investigated, among other, 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, i.e. house retrofit, upgrading of heating system and upgrading of household electrical appliances. In order to investigate the role of respondents' sociodemographic characteristics (SDCs) in energy efficiency investments, several SDC variables were included in the basic model ('SDC' model). 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 of Bouzarovski & Tirado Herrero (2017) 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 results of the models are given in Table 20.

| **Variable** | **Basic model** | **SDC model** | **CIEP model** | **SIEP model** |
|---|---|---|---|---|
| | ***Coeff.*** | ***Coeff.*** | ***Coeff.*** | ***Coeff.*** |
| ASC$_{\text{Insulation}}$ | 1.4599$^{***}$ | 0.9639$^{***}$ | 1.6096$^{***}$ | 1.5727$^{***}$ |
| | (0.1801) | (0.3741) | (0.1901) | (0.1906) |
| Cost$_{\text{Insulation}}$ | -0.0003$^{***}$ | -0.0003$^{***}$ | -0.0003$^{***}$ | -0.0003$^{***}$ |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| Savings$_{\text{Insulation}}$ | 0.0011$^{***}$ | 0.0011$^{***}$ | 0.0011$^{***}$ | 0.0011$^{***}$ |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| ASC$_{\text{Heating}}$ | 0.4118$^{*}$ | -0.0910 | 0.4975$^{**}$ | 0.4568$^{*}$ |
| | (0.2327) | (0.4042) | (0.2416) | (0.2421) |
| Cost$_{\text{Heating}}$ | -0.0013$^{***}$ | -0.0013$^{***}$ | -0.0013$^{***}$ | -0.0013$^{***}$ |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Savings$_{\text{Heating}}$ | 0.0045$^{***}$ | 0.0046$^{***}$ | 0.0044$^{***}$ | 0.0044$^{***}$ |
| | (0.0008) | (0.0008) | (0.0008) | (0.0008) |
| ASC$_{\text{Appliances}}$ | -0.0372 | -0.5483 | 0.0306 | -0.0103 |
| | (0.2341) | (0.4036) | (0.2447) | (0.2452) |
| Cost$_{\text{Appliances}}$ | -0.0027$^{***}$ | -0.0027$^{***}$ | -0.0027$^{***}$ | -0.0027$^{***}$ |
| | (0.0003) | (0.0003) | (0.0003) | (0.0003) |
| Savings$_{\text{Appliances}}$ | 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* |

**Table 20 Results of the basic, SDC and energy poverty models**

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

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. From a policy perspective, it is also 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. Also, vulnerable households hold different WTP values for each of the proposed interventions. These differences are not observed only across groups but also between groups. 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.

The dissemination actions of the project also contributed to the achievement of ***Objective 4*** (***'Engaging with the Energy Poverty Community'***), ***Objective 3*** (***'Supporting Best Practices'***) and ***Objective 5*** (***'Define Future Policies, Strategies and Research Areas'***). The main dissemination activities are outlined below. A table summarising which events is also provided (see Table 21).

- The project, its objectives and results, as well as its activities appeared in a widely read online energy portal (energypress.gr) in Greece:
    - https://energypress.gr/news/step-seminario-gia-tin-energeiaki-ftoheia-geniki-syneleysi
    - 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
- Four scientific papers were published in international peer-reviewed scientific journals:
    - L. Papada, N. Katsoulakos, I. Doulos, D. Kaliampakos & D. Damigos (2019) Analyzing energy poverty with Fuzzy Cognitive Maps: A step-forward towards a more holistic approach, Energy Sources, Part B: Economics, Planning, and Policy, 14:5, 159-182, DOI: 10.1080/15567249.2019.1634162
    - 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 (in development)
  - 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 and second review pending)
- One presentation was given at the 2019 Thessaloniki International Exhibition, with 50 participants:
  - L. Papada (2019). Tackling energy poverty: The STEP-IN European H2020 Project
- One presentation was given at the Conference of the "Twinning Project for Service Quality and Smart Metering in Georgia", with 20 participants:
  - 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", with over 100 participants in the Session (over 8,000 viewers in total attended the event):
  - 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).
- One presentation was given at the 9th Conference of the National Technical University of Athens and the Metsovion Interdisciplinary Research Center "Vision, planning and policies for the integrated development of mountainous and isolated areas", with over 200 participants:
  - N. Katsoulakos, L. Papada, D. Damigos, & D. Kaliampakos (2019). Tackling energy poverty in mountainous areas: The contribution of the STEP-IN research project. 9th Conference of the National Technical University of Athens and the Metsovion Interdisciplinary Research Center, 26-28/9/2019, Metsovo, Greece.
- Seven presentations were made at the 1st National Energy Poverty Web Conference, with over 220 participants:
  - 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.
- The energy advice 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. Assuming 10 downloads per website, the booklet reached at least 7,000 people.

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.

| **Event title** | **Event location** | **Event dates** | **Atten-dee(s)** | **Details/URL** | **Type of audience** | **Method of presen-ting** | **Audience size** |
|---|---|---|---|---|---|---|---|
| 2019 Thessaloniki International Exhibition | Thessaloniki, Greece | 9.9.2019 | Lefkothea Papada (NTUA) | Participant and presenter<br>*https://www.thessalonikifair.gr/el/programma-energeiakon-ekdiloseon-tis-rae* | Scientific community, civil society, policymakers, media, general public | Oral | 50 |
| 9th Conference of the National Technical University of Athens and the Metsovion Interdisciplinary Research Center "Vision, planning and policies for the integrated development of mountainous and isolated areas" | Metsovo, Greece | 27.09.2019 | Nikos Katsoulakos (NTUA) | Participant and presenter<br>*http://mountains.ntua.gr/sites/default/files/schedule_9o_synedrio_mekde_0.pdf 8* | Scientific community, civil society, policymakers, general public | Oral | 200 |
| "Twinning Project for Service Quality and Smart Metering in Georgia" Conference | Tbilisi, Georgia | 27.11.2019 | Lefkothea Papada (NTUA) | Invited participant and presenter<br>*https://www.e-twinning.at/projects/georgia-iii/* | Regulators, policymakers | Oral | 20 |

| Event title | Event location | Event dates | Atten-dee(s) | Details/URL | Type of audience | Method of presen-ting | Audience size |
|---|---|---|---|---|---|---|---|
| 5th HAEE Energy Transition Symposium "GLOBAL AND LOCAL PERSPECTIVES" | Virtual event | 1.10.2020 | Nikos Katsoulakos (NTUA) | Participant and presenter<br>https://haee.gr/media/2268/agenda_5th-haee-energy-transition-symposim.pdf | Scientific community | Oral | 100 |
| 1st National Energy Poverty Web Conference | Virtual event | 19.11.2020 | Anastasios Balaskas (NTUA) | Participant and presenter<br>http://energypoverty-conf.step-in-project.eu/agenda | Scientific community, civil society, policymakers, media, general public | Oral | 220 |
| 1st National Energy Poverty Web Conference | Virtual event | 19.11.2020 | Dimitris Damigos (NTUA) | Participant and presenter | Scientific community, civil society, policymakers, media, general public | Oral | 220 |
| 1st National Energy Poverty Web Conference | Virtual event | 19.11.2020 | Dimitris Kaliampakos (NTUA) | http://energypoverty-conf.step-in-project.eu/agenda | Scientific community, civil society, policymakers, media, general public | Oral | 220 |
| 1st National Energy Poverty Web Conference | Virtual event | 19.11.2020 | George Panagiotopoulos (NTUA) | Participant and presenter | Scientific community, civil society, policymakers, media, general public | Oral | 220 |
| 1st National Energy Poverty Web Conference | Virtual event | 19.11.2020 | Nikos Katsoulakos (NTUA) | http://energypoverty-conf.step-in-project.eu/agenda | Scientific community, civil society, policymakers, media, general public | Oral | 220 |
| 1st National Energy Poverty Web Conference | Virtual event | 19.11.2020 | Christina Kaliampakou (NTUA) | Participant and presenter | Scientific community, civil society, policymakers, media, general public | Oral | 220 |
| 1st National Energy Poverty Web Conference | Virtual event | 19.11.2020 | Lefkothea Papada (NTUA) | http://energypoverty-conf.step-in-project.eu/agenda | Scientific community, civil society, policymakers, media, general public | Oral | 220 |
| **TOTAL ESTIMATED ATTENDANCE** | | | | | | | **590** |

*Table 21 List of dissemination event activities undertaken by the Greek Living Lab Partners*

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. – 276 views just on Youtube.

Considering the above-mentioned figures, the total number of people that the LL engaged with in face-to-face communication (virtual or physical) is over 440 and the engagement through information material, dissemination of the results and round tables, etc. exceeds by far the target of 5,000 people.

### 6.3.5 Summary

| **Type of activity** | **Total number of participants reached** |
|---|---|
| Focus groups | 19 |
| Advisor visits | 442 |
| Energy cafés | 112 |
| Dissemination activities (e.g. energy advice booklet, FB page, energy advice videos, conferences & workshops, etc.) | <7,000 |
| **Total** | **<7,500** |

***Table 22 Total number of people that the Living Lab directly engaged (virtual or physical).***

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

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.
- Almost 3 out of 10 households that participated in the ex-post social survey and the LL activities stated that during the restrictive measures due to Covid-19 their heating system worked more hours than usual. 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%).
- 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). 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%. 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.
- 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.

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.
- 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.

## 6.4 Nyírbátor – Hungary

The Hungarian Living Lab was located in the eastern part of Hungary close to Nyíregyháza, in the district of Nyírbátor and its neighborhood. Around 50,000 people live in this area in more than 20 settlements. Most of the settlements are villages; there are only 5 cities. Nyírbátor is the biggest with a population of 12,000 people.

Within the Hungarian rural Living Lab, we organized 7 energy cafes, 2 focus group discussions, 2 expert meetings and a school visit in Nyírpilis. We trained three Energy Advisors, and they visited 602 households in the three LL rounds. The total number of people that the LL engaged with face-to-face communication was 709 and the engagement through information material, dissemination of the results, round tables, etc. was over 3800.

In common with section 7.3 and 7.3, the eight project objectives (described in D.1.1 "Living Labs Global Methodology and implementation guidelines") are not covered in their original order. Section 7.4.1 covers ***objectives 2, 6, 1, 7*** and ***8*** and Section 7.4.4 discusses project ***objectives 4***, ***5*** and ***3***, respectively.

## 6.4.1 Impact on Consumers

The needs of the rural communities in Hungary are massively different from those of the other sites. In addition, within the community also slightly different target groups can be found. We conducted a baseline survey with 300+ respondents to map the main target groups. They were the following:

- Pensioners living alone: The pension in rural areas in Hungary is usually quite low, compared with the upkeep cost of the large dwellings in which they live. The situation is even worse in one-person households. The pensioners also have to cover much higher medical costs than other groups.

- Households with 3+ children: These households usually live on a single salary, and especially with small children, females have to be at home all day, which increases the energy upkeep cost of the dwelling.

- Minority people living in segregated districts: The income situation is much worse than the average in this group, and the quality of the dwelling and the energy efficiency of the appliances are low. In some cases, there is no access to electricity in these dwellings because of arrears. As gas is not linked to these houses, firewood is the only heating option, which is more expensive than gas.

We summarized our results in D4.1. That report directly related to project ***Objective no. 2*** ('***Assessment and Benchmarking'***) and provided a basis for developing tangible results in relation to ***Objective no. 6*** ('***Support Clearly Defined Target Groups of Citizens'***).

In the baseline survey we identified a large number of energy poor people who lived in the Living Lab area. Roma and elderly people are the main risk groups, but more than half of our respondents suffered from some kind of energy-related problem. Though energy usage reduction is one of the key objective of STEP-IN, we very soon after the project started faced a serious ethical dilemma. 27% of the households had to cut back on heating, and 16% had to cut back on medicines in order to pay the energy bills. In these households we couldn't ask for further energy reduction; instead we had to focus on the increase of comfort level. We use this market segmentation throughout the project. 53% of the visited households were belonging to the Roma minority and 20% had 3+ children. There was a strong overlap between the two groups. 75% of the 3+ children's households were Roma. The third group the living alone pensioners was the smallest within the lab –7%.

We didn't set a strong eligibility criterium for those citizens who were willing to take part in the STEP-IN program. Based on our own energy vulnerability classification 61% of the participant households were energy poor (Figure 18). We have to highlight those households who didn't have formal access to the electricity grid – more than 10% of the respondent belonged to this group. We had to develop special strategies to deal with these households. It was a major success in our lab, that **we were able to support 14 households in the reconnection** process.

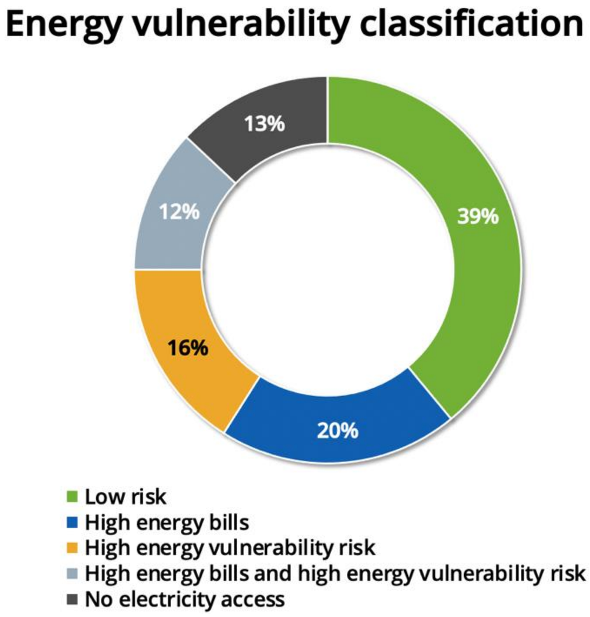


*Figure 18 Energy vulnerability classification of Living Lab participants (initial home visit)*

There is extensive and demonstrable evidence to show that Lab’s ***Objective no. 1*** (***‘Positive Impact on Citizens’***) was met and exceeded. 67% of the households did some refurbishment or bough new energy efficient appliances. **Based on these actions we could estimate a 5.3% possible reduction in energy bills and 5.9% reduction of energy usage in kWh. If we project this number to our whole sample, we could estimate an annual 0.66 GWh energy saving.** But it is important to highlight, that we couldn’t measure significant change in the consumption based on the energy bills. Even there was a small 0.2% increase in bills, and 1.1% increase in energy usage (Figure 19).

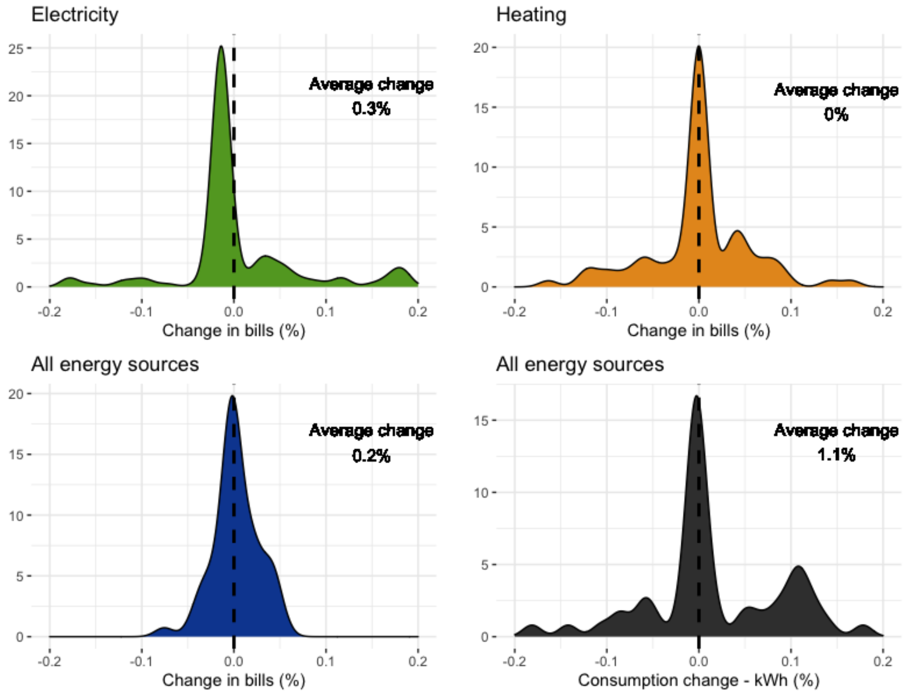


*Figure 19 Change in energy bills and consumption (impact assessment survey)*

As our initial home visits clearly showed, there was a massive underconsumption in many households. The comfort level was very low in the targeted population, and some households had to cut back on basic needs in order to pay their bills. So, we can assume that some above calculated estimated energy savings were turned back to improve the comfort level of these households. And we must consider how Covid impacted our results. Based on our COVID-19 question block, people stayed more at home and used their appliances more often. Some people lost their job; wages were cut, and more arrears accumulated. The aggregated energy consumption data provided by E. ON gives us a good estimation of how the overall electricity consumption changed in this area. The consumption was 9% higher between September-December 2020, compared with the previous year. This is alone enough to diminish the savings we measured. We don't have aggregated data on gas consumption, but we could assume a similar tendency here, as gas consumption is even more determined by the hours spent at home.

Figure 20 indicates that 13.2% of the households had better conditions regarding housing problems (mold, damp, condensation on the wall, leaking roof, ideal temperature) and 15.3% felt improvement in arrears.  and 18.8% of the households had an improvement on life quality. 36.8% of those who took part in the impact assessment questionnaire had improvement in at least one area.

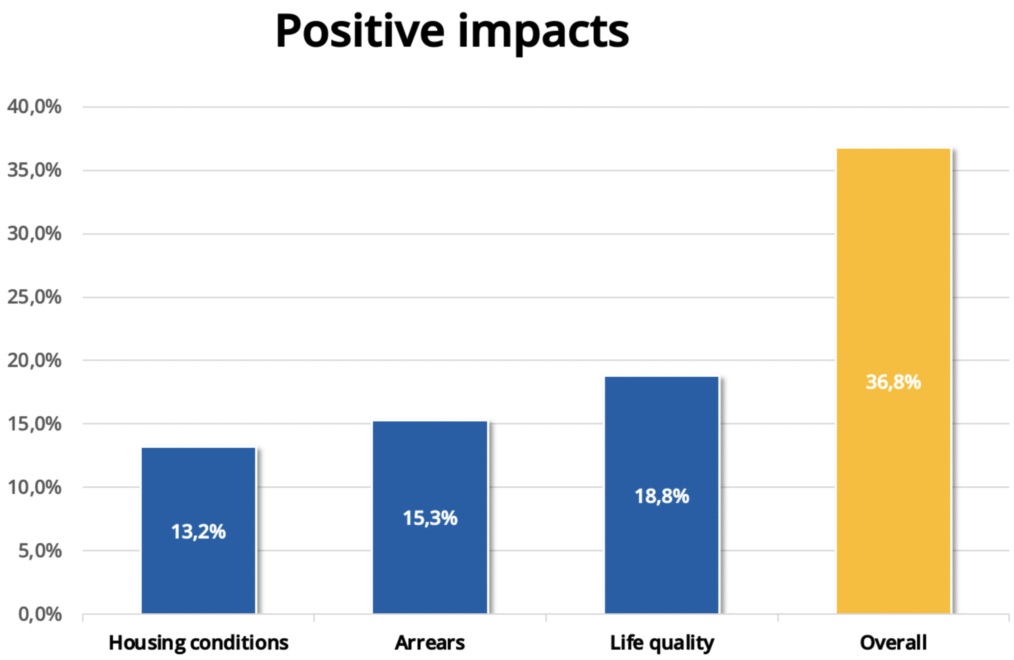


*Figure 20 Positive impact of the program (impact assessment survey)*

There were huge differences between the target groups regarding positive impact types. More than 20% of the Roma and households with 3+ children reported improvement in arrears, but this number was close to zero in the case of single pensioners (most of them did not have arrears). On the other hand, 30% of single pensioners felt improvement in life quality measurements, while this number was "just" 20% for the Roma community. All the three target groups had higher overall improvement than the sample average. This means we were able to help those households which were identified as the main victims of energy poverty. **In the project description we aimed to improve the life of 750 people. Based on our results we managed to improve the life of 793[5] people in the project period, despite the negative impact of COVID-19.**

Our school visit program was also linked to ***Objective no. 1*** *(‘**Positive Impact on Citizens**’)*. The primary school in Nyírpilis - which was one of the main locations of the Living Lab - is managed by Maltai. As strong cooperation has been developed among other programs of Maltai and the teachers of the school, and many parents have already participated in STEP-IN survey and the introduction of STEP-IN to the pupils was well-grounded. Sustainability Week, organised in October 2020, provided a good opportunity for this introduction. On October 8th, 2020, an Energy Adventure program was organized for 10-12 and 13-14 years old, respectively. **Altogether 36 students participated** in the 2x40 minute sessions. Low energy literacy is a key factor of inefficient energy use. If we can educate the young generation on how to use energy properly, we can achieve long-term effects, and we achieve a small step within the STEP-IN project.

The improvement of life quality went hand in hand with a positive behaviour change (Figure 21). 43% turn off the light more frequently when they leave a room, 28% set the temperature lower than before to avoid over-heating and 36% use less water when bathing. But as the effect of COVID, 28% use their electronic appliances more often. Overall 45% of the respondent changed their behaviour as a result of counselling and 70% said that they understood better their energy expenses. All of these measures contributed to the achievement of ***Objective 7*** (‘***Reduce Environmental Impacts***’). **In the project**

---

[5] The average household size was 2.58 in the sample. We used this number for the calculation.

**description we expected a positive behaviour change for 750 people. We reached a higher number at the end; 970 people changed their behaviour and took better decisions than before.** We didn't find significant differences between the target groups in this dimension.

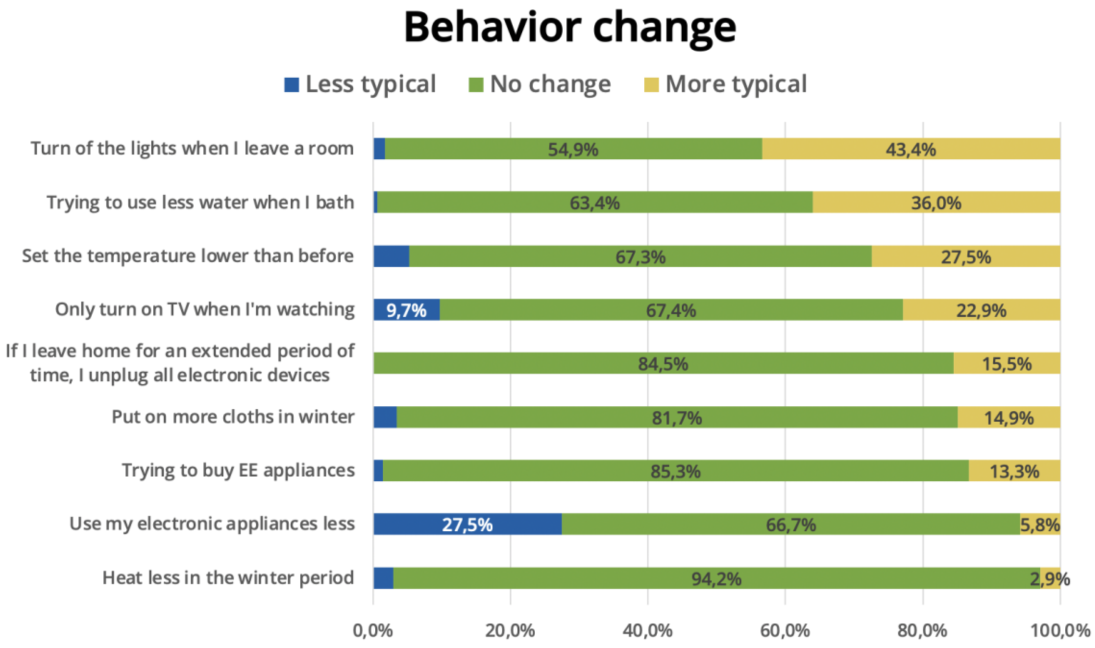


*Figure 21 Measured behaviour change (impact assessment survey)*

We found a strong negative consequence of COVID. Heating with rubbish was more common than before. 37% reported that they sometimes use rubbish for heating. This number was 10% lower in the initial home visit questionnaires.

We were also able to refer the participants to a wide range of customized service. The most complex one, was the reconnection program where we were able to reconnect 14 households to the electricity grid (more detail is available in D4.3 report). Besides other smaller schemes, special night energy tariff was referred to 115 citizens and pre-paid meters were referred to 75 people. All of these activities contributed to the achievement of ***Objective 8*** (***'Identifying viable financial schemes at local, national and European scale'***).

## 6.4.2 Methodological Issues

**Energy cafes** served as a promotion event and more importantly as a cooperation building opportunity where we could involve people having a visible role in the settlements, such as public worker group leaders, municipality and community house workers. The immediate result of energy cafes was that we could reach a narrow but typical group of the local population to introduce STEP-IN to them, emphasize the necessity of survey and how its outcome can be helpful for them.

Over the long term, energy cafes helped to make our presence accepted and understood. It was a good start to address people, as most of the participants were engaged in the surveys and advisory sessions. Those who were interested also articulated the program among their relatives, friends, neighbours, supporting successful conduction of establishment surveys.

It is an important lesson learnt that people prefer short, interactive events. Even when the topic was interesting from professional point of view, after a certain time it was quite hard to catch the attention of the participants. In the later stages, we adjusted energy cafes to be shorter with less but straightforward information. We shortened or skipped those topics which were not relevant for the respective participants and changed the flow of discussion according to their questions and interest.

As a general observation, raising energy awareness requires a long time and HEAs can only go forward in small steps to change entrenched energy consumption habits. As an example, electricity consciousness is mainly restricted to buying energy efficient lightbulbs, but many families do not connect it with switching lights off when they leave the room.

**Home visits** are also served with important methodological lessons. First, it was really hard to overcome the prejudice that Maltai is generally regarded to be engaged with only people at the edge of society. However, energy advisory could be also very useful for families with proper energy supply, with adequate knowledge and finances to reconsider consumption patterns and initiate potential changes. These families were the hardest to engage in STEP-IN program.

Local presence and contact network was a key influencer for effective energy advisory work and has developed parallel to STEP-IN program. Until the local people did not have some information about HEAs or related social programs, they were not open towards the survey. Second and third round survey results reflected the acceptance of HEAs presence in the settlements.

Prior to the survey and energy advisory sessions, it took considerable time to build good relations with the respective local social workers, respected local people, to get their support for STEP-IN field work. Without this time-consuming work in the background, HEAs would have struggled to involve people in STEP-IN.

The housing and living conditions were really bad in the area. According to our baseline survey, more than half of the local households were struggling with some problem with their dwelling. The most common problem (32%) is that dwellings are not comfortably cool during the summer. Nearly the same number of respondents said (28%) that their dwellings were not comfortably warm during the winter. The lack of good quality insulation could be the cause of this. 19% noticed condensation on the windows and the walls during the winter, 15% said that there was dampness on the walls or floors, and another 15% said there was mold in the house. A leaking roof presented as a problem in 8% of households. These numbers were even higher for those who participated in the STEP-IN home visits. We had a lot of discussion with the project team, and with the home advisors about the ethical dimension of the home visits: if the comfort level is very low, is it ethical to suggest consumption reduction? To support our advisors, we estimated the ideal/normal energy consumption of the given household based on their home visit survey answers. This helped the advisors to decide what is fair to suggest to a household. If we found massive under-consumption, we tried to find schemes to improve the situation of the household instead of asking them to reduce their bills (energy consumption).

The **proper measurement of energy consumption** was really challenging. In the first Living Lab iteration we asked participant household to provide indicators of the amount of money they spent on different energy sources, and we also asked them to estimate their energy consumption in kWh (electricity) $M^3$ (gas), or kg (wood). We received very little information regarding the latter question. And the statistical correlation between the money and volume measures was zero. We discussed this issue with the home advisors and based on their experiences we used the money measures as primary information source and estimated the consumption in kWh/ $M^3$ /Kg based on that. The situation was even more complex where people use firewood. In some cases, participants know how much money they spent on firewood. But in other cases, we only have information about the quantity (kg or $m^3$), and this information is very unreliable. Households buy firewood several different times and from several vendors. Sometimes they buy it in kg, sometimes in m3, and sometimes just from a trailer. And the heating value of the firewood heavily depends not only on the species of the tree, but also on the humidity level of the firewood. So even if we know the proper amount of money, we still have a problem to estimate the quantity and at the end the heating value in kWh. And we can add a further layer to this problem. Local municipalities sometimes give firewood to the citizens as subsidies. And it is also frequent that people collect firewood from the local forest. In most cases this is not illegal, as they got this "free" firewood as a "payment" for their work. So, at the end, it becomes very difficult to estimate the firewood consumption of a household.

Smart-meter data could help solve some of the above-mentioned problems. Smart-meter penetration is very low in Hungary, but E.ON deployed pole-meters in many settlements, which works like a smart-meter, as It records the electricity consumption of the household every 15 minutes. But it was also challenging to include this data source. As E.ON doesn't use this data in its core service, the quality of this data is far from perfect. We observed many missing patterns, which caused by data transmission problems. But the most problematic part was not the data quality, but the legal complexity of data access. Consumers own this data, but the utility stores it. So when we are doing the first home visit, we also need to ask the participants to fill a special consent form (above the general one), which gives a permission to E.ON to share the participant data with a third actor (in this case Ariosz). And then Ariosz could use this data to create unique energy reports or to measure the program effectiveness.

The developed **energy diary** was not a useful tool and we did not get any useful data from them as participants didn't fill it properly. It was too much time and effort for them, and because they did not get any remuneration for that, they were not motivated enough.

**The ICT app** created by LIST in collaboration with the Labs, was very useful for our advisors. In the first iteration we used our own survey tool for recording the questionnaires and a different tool for creating the PEAS. The tool integrated these features and advisors could also recorded all the contacts they had with the participants. In the third round we add a new feature to the Hungarian version of the tool – the smart-meter based personal energy report. The tool was also useful for the project team, as we could monitor the actual situation of the field work.

The **COVID-19** pandemic had an impact on our project as well. We could not finish the second LL round before the restriction came into force in March, so part of the second LL round was carried out after the restriction were lifted in the summer period. What is more important: all the impact assessment questionnaires were conducted after the COVID outbreak. When we are calculating our impacts, we have to consider how it was affected by COVID-19. People stayed at home longer, used their electricity appliances more frequent, some of them lost their job. In a crisis situation, energy awareness is not the most important issue for the households. We tried to minimize the f2f contacts. We spent less time with the involved households, so we had less time to understand their needs. We tried to substitute the f2f meetings with telephone calls, but the efficiency of this channel was much worse.

At the start of STEP-IN, we had to develop efficient advisory services almost from scratch. Efficient advisory services require multiple conditions: adequate circumstances, professional and material preparedness and efficient communication. It is very important what HEAs say, how they form the message and how they act at the field. Although HEAs were experienced social workers, advisory skills had to be adjusted and new ones to be incorporated during the first phases of field work. In contrast with social support work when clients initiate contact, HEAs had to address the population and convince them of the usefulness of energy advisory services. They had to learn how to screen the homes to locate potential energy issues and had to constantly pay attention to select proper advice that targets the unique conditions of the house and which is acceptable and feasible to the family concerned.

### 6.4.3 Ethics and Data Protection

All project documents and procedures were strictly in line with the GDPR regulation and the Hungarian data protection law. This included consent procedures, as well as data collection, sharing, and storage provisions. The avoidance of stigmatization and the maintenance and promotion of participant well being featured prominently throughout all project processes and activities.

The Hungarian law protects personal data heavily. Personal data or information about special attributes (like health status, belonging to ethnic minority, etc.) can only be saved/stored, if the respondent agrees to it. The response is voluntary in every case (except a few special cases). In all stages of the data processing, full anonymity of the respondent needs to be assured. All personal data needs to be anonymized immediately, when it is possible by the research design. All personal data, which makes the identification of the respondent possible, has to be saved/stored separately from the data, which contains other kinds of answers of the respondents. A scientific report cannot contain anything, which makes the identification of the respondents possible. Based on the answers and personal data of the respondents, it is not allowed to create any action, which targets a specific respondent.

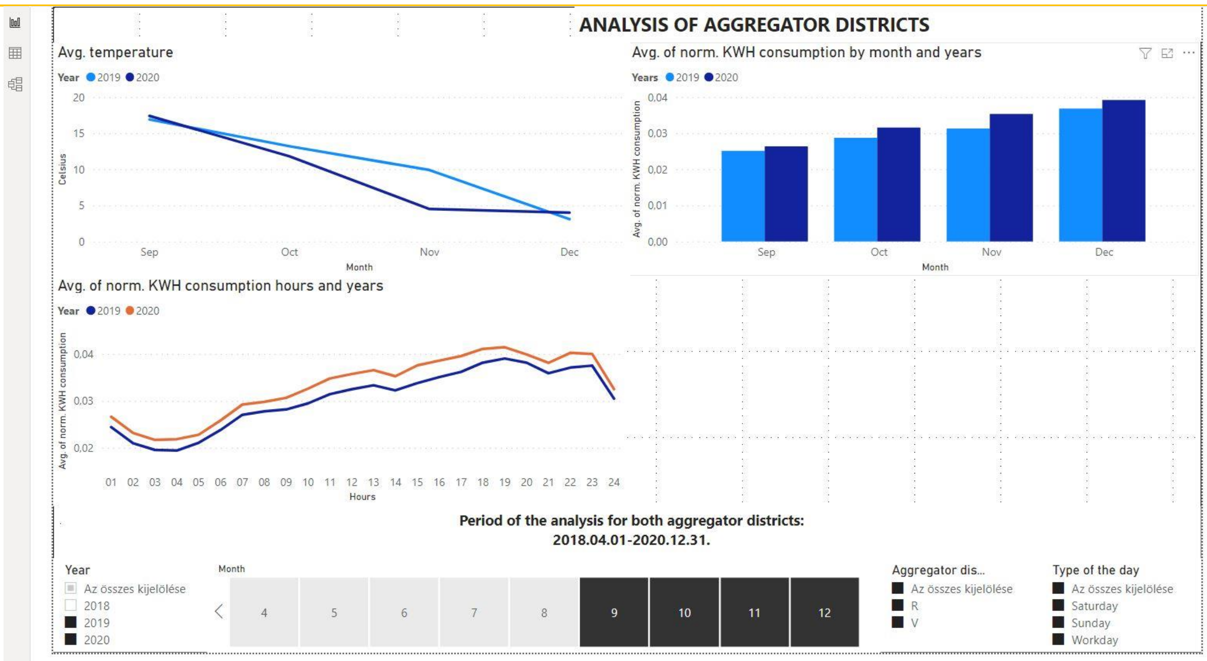
We provided an information sheet to all the participants at the beginning of the home visit. Participants also had to sign a consent form. Without this consent form, we could not record/store their personal data. The establishment survey contains several sensitive questions (health condition, belonging to ethnic minority). In order to keep this information secure, personal data is stored separately from survey data. All the participants have an identity code. This code contains the first two letters of the settlement, the initial letters of the advisors and a 3-digit number. Only the HEAs had access to personal information. For them, this was necessary, as they had to recontact the participated households several time. Ariosz, as a partner in the local project, had access only to the survey data.

We added a new service to the third LL round. Where smart-meter data was available we could generate a detailed energy consumption report. This implied new data management protocols. The three Hungarian partners signed a new agreement that regulated the data sharing between them. An extra consent form had to be signed by those participants who asked for a smart-meter based energy report. When the consent form was signed, Ariosz got access to the raw data through a secure and encrypted channel, without any personal information. The STEP-IN id was linked to the data, so Ariosz could upload it to the tool. The ICT tool generated the energy report, which immediately became available for the HEAs. The HEAs didn't have access to the raw data, they only had access to the report.

As a consequence of COVID-19 pandemic, the Hungarian government had to introduce several restrictions. We organized all the events and home visits in total respect to all sanitary and hygienic measures enforced by the Hungarian Government in order to fight against the COVID-19 virus.

### 6.4.4 Other Findings

Within the project framework E.ON gave access to aggregated energy consumption data of Nyírbéltek. Nyírbéltek was one of the settlement's we involved in LL round 3. We organized an Energy Café there, and we also conducted there some limited number of home visits. We have data from two aggregator districts. Around 100-150 households live within an aggregator district. These two districts cover that part of the settlement, were most of the deprived households live. This aggregated data helped us to understand better how people use electricity. We can use this data to draw the within day curve of consumption, compare the different day types or even check the impact of COVID-19 on consumption. We used this data for the latter purpose.



Period of the analysis for both aggregator districts:
2018.04.01-2020.12.31.

*Figure 22 Electricity consumption comparison: 2019 vs 2020 (aggregator data in Nyírbéltek)*

In order to better understand the impact of COVID-19, we compared the electricity consumption of 2020 with 2019 (Table 15). We selected the September-December period. The second wave of COVID-19 started at end of August in Hungary, and new restrictions came into force from September. The electricity consumption was higher in 2020 compared with 2019 in all the analyzed months. The overall difference was 9%. We measured the smallest difference in September - 5%. The COVID-19 numbers were not so high in this month and people lived a close to normal life. The highest difference was in November when the pandemic had a major impact on Hungry. But this big difference could be partly explained by the lower temperature too (Figure 22 left top). The daily load curve is also very instructive. There was a constant consumption increase all day, not just in specific hours. But the extra consumption was more typical in the morning and in the afternoon hours. But the load curve of this area was already atypical even in 2019. Usually there is a peak consumption in the morning period and lower consumption in the afternoon. But here we can observe a continuously increasing consumption during the day. This is a typical consumption pattern of pensioners or households where people are unemployed or stay at home.

We calculated the same measurements for the weekdays, and all the trends were the same. We can draw the conclusion: due to the restrictions people stayed at home, used more appliances and used more electricity. This was a heavy burden on those households who were already deprived.

The dissemination actions of the project also contributed to the achievement of ***Objective 4*** (‘***Engaging with the Energy Poverty Community***’), ***Objective 3*** (‘***Supporting Best Practices***’) and ***Objective 5*** (‘***Define Future Policies, Strategies and Research Areas***’). The main dissemination activities were, as follows:

The STEP-IN project was featured in the local television three times:

- Before the first LL, the project leader of Maltai, Gábor Major, gave an interview to the local TV. https://www.youtube.com/watch?v=ONi3C78t2Wo – 500 views just in Youtube
- One of our home energy advisor (Bea Pálóczi) was also interviewed by the local TV, after the first Energy Cafe. https://www.youtube.com/watch?v=XN_Sa75yp5Y – 276 views just in Youtube
- During the winter school visit, our advisor was also interviewed. https://www.youtube.com/watch?v=MxWxrqsgbQs – 430 views just in Youtube

We disseminate the project in conferences and expert meetings:

- We organised a meeting with the experts of Regional Centre for Energy Policy Research (REKK) in 6.11.2019 – 10 participants
- We presented our project in a Conference about Energy Poverty hosted by the Hungarian Academy of Science in 25.11.2019 – 50 participants
- A winter school was organized from November 26th to November 28th, 2019 with the support of ARIOSZ, MALTAI and E.ON. The first two days of the Winter School were dedicated to interactive workshops with the participants while the third day was dedicated to visiting the Nyírbátor region, which holds the Hungarian Living Lab of our project. Approximately 15 social workers attended the Winter School and 12 students attended the dedicated University session. On the third day of the Winter School, a visit to Nyírbátor was organised with the participants. Presentations were given to explain what was being done at the Living Lab, and discussions with local home energy advisors were held. Small groups home visits were also organised in order to grasp the global situation.
- Ariosz hold an oral presentation in the "Right to Fair Energy Access" Conference organized by Adiconsum in 18.02.2021 – 100 online participant + 500 Facebook views
- We organized a webinar in 24.03.2021 for colleagues and experts to present the main findings of the Hungarian Living Lab. – 40 participants (https://www.youtube.com/watch?v=zY19UJipElQ&list=PLusWqiSEpuT5HnRCAf0l4FQyO4A19QCk_&index=1)

We distributed the general advice booklet and the project leaflets in the energy cafes and in the home visits. 602 home visits were carried out in the rural LL and 149 people participated in the energy cafes. Energy Cafes served as an excellent channel for engagement. 42 people who participated in Energy Cafes signed up for home visits. We directly engaged 709 households throughout the Living Lab lifecycle. Overall, these households were estimated to contain 1829 people.

The Hungarian Facebook page of the rural LL followed by 116 people. We released more than 100 posts in the project period. The total number of impressions was 23,919 (01-09-2021). Further information on social media performance can be found in D4.3.

Considering the above-mentioned figures, the total number of people that the LL engaged with in face-to-face communication was 709 and the engagement through information material, dissemination of the results, round tables, etc. was over 3800.

The rural STEP-IN program was cited in **two documents.** At the European level, it was cited in the ESPN report: Access to essential services for low-income people – Hungary country report (https://ec.europa.eu/social/BlobServlet?docId=22811&langId=en)

On the national level, the project was cited in a Cooperation Agreement between the Hungarian government, E.ON and Máltai – related to a new program in Tiszabő.

| Event title | Event location | Event dates | Attendee(s) | Details/URL | Type of audience | Method of presenting | Audience size |
|---|---|---|---|---|---|---|---|
| Conference about Energy Poverty | Hungary, Budapest | 25.11.2019 | Zoltan Kmetty | Participant and presenter<br>https://szociologia.tk.hu/esemeny/2 | Scientific community, civil society, policymakers, media, | Oral | 50 |

| Event title | Event location | Event dates | Attendee(s) | Details/URL | Type of audience | Method of presenting | Audience size |
|---|---|---|---|---|---|---|---|
| | | | | 019/10/energiaszegenyseg-haztartasok-nehezsegeitol-a-klimavalsagig | | | |
| Webinar about Hungarian LL results | Hungary (online) | 24.03.2021 | Zoltán Kmetty, Berndadett Tóth, Gábor Major | Organizers and presenters<br>https://www.step-in-project.eu/last-meeting-of-the-hungarian-project-team/ | Scientific community, civil society, policymakers, | Oral | 40 |
| **TOTAL ESTIMATED ATTENDANCE** | | | | | | | **90** |

Table 23 Hungarian Living Lab Dissemination Activities

### 6.4.5 Summary

| Type of activity | Total number of participants reached |
|---|---|
| Focus groups | 13 |
| Advisor visits | 602 |
| Energy cafés | 49 |
| Dissemination activities (e.g. energy advice booklet, FB page, energy advice videos, conferences & workshops, etc.) | <3,800 |
| **Total** | **<4,500** |

Table 24 Total number of people that the Living Lab directly engaged (virtual or physical).

The Hungarian rural Living Lab program met all the objectives which were set in the project.

- We held 7 energy cafes, 2 focus group discussions, 2 expert meetings and we also organized a school visit in Nyírpilis.
- We trained three Energy Advisors. They visited 602 households in the three LL rounds.
- We developed special strategies to deal with those households who didn't have (formal) electricity access. One of the major success of our lab, that we were able to support 14 households in the reconnection process.
- 67% of the participating households did some refurbishment or bought new energy efficient appliances. Based on these actions we could estimate a 5.3% possible reduction in energy bills and 5.9% reduction of energy usage in kWh. If we project this number to our whole sample, we could estimate an annual 0.66 GWh energy saving.
- But it is important to highlight, that we could not measure significant change in the consumption based on the energy bills. We can assume that, some of the above calculated estimated energy savings were partly turned back to improve the comfort level of these households. On top of that, as a consequence of COVID we measured a 9% energy consumption increase in Nyírbéltek. This is alone enough to diminish the savings we measured.

- 13.2% of the households had better conditions regarding housing problems (mold, damp, condensation on the wall, leaking roof, ideal temperature) and 15.3% felt improvement in arrears and 18.8% of the households had an improvement on life quality. 36.8% of those who took part in the impact assessment questionnaire had improvement in at least one area. Based on our results we managed to improve the life of 793 people in the project period, despite the negative impact of COVID-19.
- Overall 45% of the respondent changed their behaviour as a result of counselling and 70% said that they understood better their energy expenses: 970 people changed their behaviour and took better decisions than before.
- We directly engaged with 709 households throughout the Living Lab lifecycle. Overall, these households were estimated to contain 1829 people.
- Through other dissemination channels we were able to reach further 2000 people.

## 6.5 Discussion

The following section outlines the results achieved during the STEP-IN living labs. For a detailed discussion on the methodological aspects, please see chapter 4.

**COVID-19 Pandemic**

The Covid-19 pandemic heavily influenced the results of the living labs. This is initially because less face-to-face operations could take place and engagement via online means was not always as successful as expected. From a results perspective, people were spending time at home, which resulted in higher energy costs. This problem was further amplified by the drop in income experienced by many of the citizens involved. In Manchester, the number of people unable to pay their bills doubled during the pandemic. This would point to the welfare system not addressing the needs of all citizens, despite the UK Government rolling out a range of schemes. There were some notable exceptions to these changes, for example those who were prior to the pandemic not going out to work as e.g. senior citizens. This means that looking at long-term effects is problematic, although certain measures for example insulation, maintenance and tariff switching remain relevant both during and after the pandemic situation.

**Positive Impacts on Citizens**

Across all the living labs, it became clear during the project that asking individuals who are already under consuming energy (relative to the average) to consume less would be problematic. Therefore, energy saving advice must go hand-in-hand with improving the quality of life of the citizens involved. As noted in chapter 5, rebound effects were quite high in the UK and Greece, and also existed in Hungary. However, while increases in consumption or spending on other goods may on the face of it seem negative overall, within this group of citizens, it should be viewed positively. For example, in Hungary for some people the choice is between medicine or energy. Avoiding forcing people to make this choice is clearly highly undesirable. At a higher level, improved access to heating and hot water should also lead to improved health outcomes in all the households concerned. While improved lighting may reduce accidents and allow a child to do homework or an adult to work after dark. Therefore, increased energy consumption without increased total energy costs is clearly desirable from a health and educational perspective of the individuals concerned.

STEP-IN had a positive impact on many of the citizens who took part in the project. Across all the living labs, the feedback from the citizens who took part was positive, with a large number indicating that STEP-IN had improved their quality of life. One interesting point is that this figure rose from 30% to

60% when people had energy monitoring equipment installed in their home (Greece). This would point to improved energy issues, awareness and being able to monitor consumption more easily as having a strong impact on perception. Monitoring equipment also provided a useful way to identify faulty or old appliances, which could then be replaced with more energy efficient ones.

In terms of specific impacts these ranged from overall improved awareness of energy bills, switching to lower-cost tariffs and providers and a reduction in bill arrears. In Manchester, for example, the average bill saving was 8.47% (pre-Pandemic). While in Greece, we calculated energy savings at between 3.9 and 9.2% (with maintenance of diesel heating burners alone resulting in a 4-7% savings in Greece). In contrast, it became apparent in Hungary that lack of a safe and reliable energy supply was a critical aspect. Therefore, in many cases connecting people to the energy supply has one of the single most positive impacts on their lives. In total, STEP-IN connected 14 people to the electricity grid and supported them with advice and referrals (when required) to grant schemes. It should be noted that for many this replaced burning rubbish or wood, which in many households were the primary sources of energy. Wood being more expensive than gas, which is often not available in their locality.

Improvements to overall comfort levels were noted with reports that people were experiencing less or no condensation, mould and dampness in their homes. While these are clearly beneficial from a comfort perspective, they also should lead to improved health outcomes in the future.

Besides those taking part directly in the living labs, STEP-IN provided general information awareness campaigns in all three locations. We estimate that More than 13,000 people received advice via STEP-IN campaigns. These ranged from leafleting to social media. In addition, the leaflet has distributed the information to all 331 municipal authorities in Greece, thus further widening the reach of the STEP-IN project. Estimates undertaken by partners point to these information campaigns, also assisting people and providing positive outcomes.

**Assessment, Benchmarking and Market Segmentation**

As noted in the methodological section, assessment and benchmarking were key parts of the project. This also provided a basis upon which we identified specific market segments and was a method to tailor the advice. For example, in Hungary those taking part ranged from pensioners through to the Roma community. While in the UK, the demographic comprised those on low incomes, the recently bereaved, people who are at risk of homelessness, migrants and asylum seekers. In the UK the referrals to the STEP-IN matched the initial market segment analysis, while in Greece there did not seem to be any link between market segment and referrals or consumption patterns. In Greece, there were variations in success and patterns depending on the market segment.

**Types of Advice and Interventions**

STEP-IN initially placed a significant emphasis on behaviour change approaches (e.g. turning off lights etc), however as the project progressed a range of other interventions were provided to the citizens involved. These ranged from referring people to financial schemes (e.g. reconnection grants) through to referring people to heating maintenance/boiler replacement and minor upgrade programmes.

Smaller scale interventions, including behavioural changes or minor home upgrades, were also an important part of the mix. Although it should be noted that more commonly known pieces of advice such as "turning off unwanted lights" were largely ignored in Manchester, while in Hungary this advice was more successful. Whereas reduction in the heating level by one degree or reduction in shower times proved more successful. In Greece, reducing the thermostat by one degree was estimated to lead to a saving of approximately €1,000 per year, which is clearly significant. The lighting example is one which perhaps requires further investigation as it points to behaviour changes being context dependent.

Major retrofitting and refurbishments remain one of the few ways to reduce carbon emissions and improve the quality of life of the citizens. However, for many citizens, larger refurbishments may not be possible. For example, they may not be able to afford the additional costs, they may not be the property owner or the housing stock itself may not be suitable for an upgrade. Often certain interventions also require general upgrades, such as making a roof suitable for PV cells. This further adds to the cost. Care also needs to be taken that any refurbishments have long-term benefits. For example, replacing a gas boiler for someone in need may bring immediate financial and comfort benefits to them and be more energy efficient. However, there is a risk that overtime the cost of gas may increase above that of electricity, thus leaving the citizens with higher costs and worsening their situation.

### Connections to Local and National Programmes

STEP-IN did not provide direct financial help, its primary role was to connect the citizens with the relevant financial and non-financial programmes which could assist them. These ranged from referring people for reconnection grants in Hungary to arranging for people to take part in the ECHO programme in the UK. At a local level, certain small interventions were paid for via funds from local and national NGOs. Other schemes involved pointing people toward subsidies, bill caps and special tariffs. Registering people with protective/monitoring schemes was also used.

More costly national programmes such as PV installation are inaccessible to the vulnerable consumers involved in STEP-IN, this is due to costs and that in many cases they are not the property owner. This means has a negative impact not only for the consumers, who may end up in long-term saving money but also wider society.

### Providers of Advice and Services

As noted in many living labs, "who" provides the advice, levels of trust and the perception of that organisation are important. In all the living labs it was essential to work with local organisations who were seen as being impartial. Sometimes these organisations were STEP-IN partners, in others they worked alongside the project. There are important caveats, however, some NGOs are seen as offering advice only to those in a totally desperate situation. This can put some citizens off asking for help if they are not in that particular situation themselves. While STEP-IN overcame this problem, it was initially a problem within the Hungarian living lab. Resolving energy poverty problems also often relies on working with the relevant providers. Again, consumers may initially be reluctant to engage in this, especially where they are not currently using stable energy supplies or are experiencing other social issues. Our experience shows that when an energy provider (in this case E. On) engages actively with the community and is seen to be supportive of consumers in need, rather than resorting to enforcement actions that the citizens in need will take on board the advice. As noted earlier, several citizens were reconnected. Also, when trusted local individuals are involved, participation rates increase and results are more likely to be positive. Trust also played an important role in the installation of monitoring equipment, with citizens preferring to trust local people/organisations to undertake the work. Also, those advising must understand the local context and schemes available for the consumers involved. In many cases, the advice moved beyond energy issues to providing social work type help for the citizens.

**Reduction in Environmental Impacts**

Due to the COVID-19 pandemic, it is not possible to give a clear sign on this point as comparable data is not available. However, it should be noted that several positive environmental impacts were indicated. At a high level, the reduction of burning of wood and rubbish due to electricity reconnections in Hungary should have a positive environmental impact. In the UK (ignoring rebound effects) the actions taken by the citizens involved such as temperature reduction, reduction in showering time should result in longer-term benefits to the environment. While in Greece, maintenance of diesel heating supplies should reduce $CO_2$ outputs with estimates of between 17.4-32.8tn per round of the living lab per year for those who directly took part in STEP-IN with those who only received information leaflets estimated to save up to 51tn tonnes of $CO_2$ per year.

## 6.6 Impacts

A summary of how these impacts were relevant across the various labs are outlined in Table 25.

| | UK - Urban | Greece - Mountainous | Hungary -Rural |
|---|---|---|---|
| Households Adopting Measures | 534 | 123 | 270 |
| Average Bill Savings<br>Energy Reduction | Bill Savings 8.41%<br>0.135GwH | Bill savings 6.2%<br>Energy Savings 6.2%<br>0.56GwH | Bill Savings 5.3%<br>Energy Reduction 5.9%<br>0.66GwH |
| Number of people the living lab reached | 4,620<br>8,500 via information campaigns and ICT tools | 5,000+<br>(7.000+ incl. Facebook) | 3,800+ people |
| No. of people reporting improvements in quality of life | Est. 300 (direct improvements in income only) | 475<br>(est. 850 helped) | 793 |
| General Improvements to Quality of Life | • Reduction in bill arrears<br>• Improvement in thermal comfort and reduction in dampness<br>• (re-)Connection to energy supply<br>• Subjective assessment of improved quality of life | | |
| Behaviour Changes | 1121 (min)<br>• Upgrades to heating and boilers<br>• Small energy efficiency measures<br>• Sought Further advice<br>• Lowered thermostat temperature<br>• Switched energy providers | 461 people (min)<br>• Better understanding of bills<br>• Changes to everyday habits<br>• Maintenance of heating system<br>• More efficient use of heating | 970 people<br>• Better understanding of bills<br>• Changes to everyday habits<br>• Less arrears<br>• Reduced shower times |

| | UK - Urban | Greece - Mountainous | Hungary -Rural |
|---|---|---|---|
| | • Reduced shower times<br>• Washed at 30 degrees | • Plans to improve insulation | |
| Stakeholders and Community | • Worked with local and national organisations, including local government, NGOs and regulators.<br>• Demonstrated the value of using a living lab approach to tackle energy poverty, possibly leading to the adoption of similar methods later<br>• Training of those involved in tackling energy poverty | | |

*Table 25 Summary of Living Lab Impacts*

## 6.7 Conclusions

STEP-IN has delivered a range of benefits for the citizens who took part directly (e.g. reduced bills and lowered arrears), and also for those who have received information via the campaigns. Furthermore, it will provide long-term benefits in terms of energy efficiency and greenhouse gas emissions. Via connections to local stakeholders, STEP-IN was able to provide life-changing assistance for some citizens, including providing some with a safe and stable energy supply.

Our experience shows that asking those who are already under-consuming to consume even less energy is likely to result in significant direct and indirect rebound effects. In many cases these are positive for the citizens concerned. Therefore, energy efficiency policy should focus on specific market segments, with those who are better off and over-consuming being the main target for behaviour change measures. Importantly, this should offset the potential increase in consumption that some vulnerable consumers will experience.

In the longer-term large-scale refurbishments including PV cells, are likely to have a significant positive impact on energy vulnerable consumers as it will allow them to increase their levels of energy consumption to levels which improve their quality of life, without increasing greenhouse gas emissions. However, vulnerable citizens often do not own their home. Therefore, there needs to be funding programmes which can target this group of citizens and the relevant property owners.

# 7 Sustainability of our Approach

## 7.1 Manchester – United Kingdom

The institutional structure and learning practices established within the Manchester Living Lab vouch that its activities will continue to proceed in a modified format. There is certainly significant interest among all relevant stakeholders to ensure that advice is provided to vulnerable energy consumers in the context of low-carbon transitions. One of the lasting benefits of STEP-IN is the development of knowledge on the immediate and direct improvements in the lives of highly vulnerable residents, especially in terms of new ways of identifying vulnerabilities 'at the doorstep' that can subsequently be addressed through referrals to energy efficiency programmes. Another important consideration in this regard is the provision of analytical tools to evaluate the effectiveness of existing schemes, and develop new methods of helping energy poor households.

## 7.2 Metsovo – Greece

In Metsovo, the Greek Living Lab's activities raised the interest of the local community and it's envisaged that the good practices established during the project will continue to exist after its completion. The Living Lab proved that simple and low-cost measures, such the regular maintenance of the heating systems, the replacement of defective thermostats or even setting the thermostat in the right temperature, can save a significant amount of money. More importantly, the reduction in energy costs can be achieved without jeopardising (and in some cases by improving) the quality of life. As a means to sustain these benefits and develop knowledge on energy usage issues, the Living Lab prepared and disseminated information and awareness material in both electronic and paper format. In this regard, an energy advice booklet, an online energy app and animated energy advice videos are available for helping all citizens in the area and beyond.

## 7.3 Nyírbátor - Hungary

In the Hungarian Living Lab, Maltai was the leading service provider. They did all the home visits and all the local engagement actions. Maltai is one of the biggest charity service providers in Hungary, they are operating several programs, and they have solid local embeddedness in many settlements. They are also involved in the program '300', aiming to help the 300 most disadvantageous settlements in Hungary. The developed STEP-IN methodology is an effective new tool for Maltai to tackle unique aspects of poverty that they did not tackle before: energy vulnerability. They are planning to add the energy advice framework to their existing tools. Some of the program elements are already transferred into new projects. Energy Cafes will be organized in Tiszabő to discuss the possible deployment of a small-scale social solar powerplant with the local community. Maltai and E.ON also continue their joint work to reconnect as many households to the energy grid as possible. After we finished writing the d4.3 report, another household was successfully reconnected to the formal electricity grid. The high social responsibility of E.ON is an excellent example for other utilities, how a big company needs to help consumers in need.

# 8 Discussion and Recommendations

## 8.1 Recommendations

The following recommendations are not an exhaustive list of what is required within a living lab structure and they should be read alongside the relevant sections of this deliverable. However, below we have summarised some of the key points and issues identified.

### 8.1.1 Market Segments and Assistance Identification

As the STEP-IN project progressed it became clear that the nature and impact of energy poverty on citizens varied significantly. These ranged from those who were at risk of disconnection, need for insulation and maintenance through to those with no energy supply and in some cases unsafe energy supplies. This resulted in a limited rethink at project level on the nature and types of assistance to be provided, for example with for example in Hungary one objective being to connect people to safe energy supplies. Critical to understanding these problems are clear assessment and benchmarking steps, coupled with a direct feedback loop with the consumers involved. We therefore me the following recommendations.

1. Understand the market segments and the nature of energy poverty in the area.
2. From the benchmarking phase understand the key issues which need to be addressed (examples, bill payments, energy supply, safety).
3. Identification of programmes which can address these needs.
4. Align the goals of the living lab to the particular citizen needs, this can vary and can consist of many aspects e.g. energy efficiency, reduction in environmental damage or bill management.

## 8.2 Partner Skills Required

When STEP-IN was being developed, the coordinator was clear that the construction of the consortium and living labs should be based around which partners or supporting organisations filled a specific need. This policy proved successful, and while a one size fits all model is not appropriate some general recommendations can be made. In STEP-IN organisations operated either as direct partners or as supporting organisations. For the purpose of the recommendations below we do not distinguish between these roles, instead it is whether they are the organisation delivering that service. The precise entity can also vary, it could be (but is not limited to) a municipal authority, university, consultancy, regulator, consumer advocate or NGO. It should be noted that an organisation can fulfil various roles.

5. A Benchmarking and assessment partner who has experience of thorough data analysis.
6. Partners who are trusted in the community who can provide the underlying advice.
7. Partner who has experience of recruiting participants.
8. A single management and co-ordination partner.
9. Service delivery partners or external providers e.g. small or large upgrade providers, energy suppliers.
10. Experienced dissemination partners for developing materials and engaging via social and traditional media
11. Efforts should be made to ensure that materials produced e.g. leaflets are relevant for those who do not take part directly in the living labs. This will increase their relevance, distribution and impact.
12. Partners who are involved in regulatory and consumer advocacy who can influence policy.

### 8.2.1 Reflexive and Co-Creative Process

The living labs operated in three rounds with a clear feedback loop between each one. This approach was used in part due to need to have a method of comparison. However, when operating outside of a project, the living labs should operate continuously with improvements made as they progress. With this in mind, we would recommend the following processes. Certain aspects such as focus groups provide a good way to obtain feedback from improvement from a range of stakeholders. STEP-IN started with a blueprint methodology which was designed to be adapted for local circumstances, this approach worked well but of course also requires some flexibility at the start in order to make these adaptations.

13. It is advisable to start with a blueprint of ideas based on proven approaches which can then be adapted, this allows for schemes to start reasonably quickly.
14. The living lab should operate continuously with a clear feedback loop.
15. Focus groups which consist of all stakeholders, including citizens should be used. These can be used to not only obtain advice but also to restructure and adapt plans accordingly.
16. Feedback should be obtained regularly from the citizens, this can be done via energy cafes, questionnaires, advisors visits or other appropriate methods.
17. Home advisors should be with the living lab from the start to the end, this allows them to feedback their experiences and make adaptations as the living lab operates.

### 8.2.2 Data Collection Techniques

Across the living labs a variety of data collection techniques were used, these ranged from monitoring equipment and questionnaires, through to data collected by advisors. ICT tools and energy diaries were also employed, although we would advise against the latter. Aggregated energy data also provides information at a higher level which can be used to look at overall trends in particular localities. Based on our experiences we would recommend the following issues are taken into account.

18. The use of long-term data collection techniques such as energy diaries probably requires payment for participating.
19. Energy, temperature and humidity monitoring equipment should be deployed. It generally improves awareness and can also be used to identify problems and energy consumption patterns.
20. The installation of equipment requires careful monitoring in itself, so as to avoid issues with damage, breakdown or removal.
21. ICT tools are a useful way to collect data from citizens, they can also be used to provide advice. They can be used by both consumers and advisors.
22. The events e.g. energy cafes are also a way to collect data from citizens.
23. Home visits are essential to understanding the situation of the individual citizen involved, collect meaningful data and to provide advice.

### 8.2.3 Ethical and Data Protection Issues

STEP-IN provided an ethical approach to tackling energy poverty, as part of this we tried as far as possible to avoid issues relating to stigmatising individuals and communities. Procedures were also put in place to ensure that the citizens were informed of the ethical and data protection issues which surrounded their involvement. One problem area is also the use of terms with respect to particular audiences, for example materials for the community involved should not use negative terms which cause stigmatisation as this may discourage uptake. Whereas often documents designed for policy makers and other groups may need to use more direct terminology. A full list of ethical matters can be found in D1.2. With these aspects in mind we make the following high-level recommendations:

24. Those taking part must receive formal consent documents in a language they can understand, with appropriate verbal explanations also provided.
25. Sharing identifiable information except when required to assist people should be avoided. For example, avoiding the use of faces, names or other data which could lead to the identification of individuals.
26. Materials circulated in communities should avoid using stigmatising terms e.g. “are you energy poor?” rather it should use more inclusive statements e.g. “Energy Saving Measures”.
27. Materials circulated to other individuals and organisations should use language appropriate for the problem being identified and should only use terms which may lead to stigmatisation when absolutely required. Where this is the case, naming specific localities should be avoided (if possible).

### 8.2.4 Energy Advice Measures

Trying to persuade vulnerable citizens that they may become “greener” by taking up energy efficiency measures is (based on our experience) unlikely to result in many positive outcomes. The citizens involved in STEP-IN are those who are already under-consuming (some had no energy supply) and for them ***higher energy consumption may be perceived (often correctly) as a way to improve their quality of life***. Therefore, STEP-IN finds that those who are already energy poor should in the main not be asked to cut back on consumption levels unless this will improve or maintain their overall quality life. It is however entirely right to suggest energy efficiency measures, which may help to mitigate any potential direct rebound effects that may arise. Based on our experiences and data collected, we propose the following list of recommendations which provide a high-level look at the nature and type of support that should be provided. Any advice should be tailored to the location involved and assistance services available.

28. The emphasis should be on improving the overall quality of life of the citizen concerned, taking into account their personal, financial and social situation.
29. Proposed solutions should directly address areas where potentially desirable rebound effects are an outcome e.g. ability to pay for more healthcare.
30. Holistic solutions should be proposed with (if needed) the citizen being encouraged to obtain assistance in other areas e.g. via social services.
31. Low barrier solutions should be proposed which have a relatively high payoff e.g. reduction in temperature of one degree or other low or zero cost behaviour changes.
32. Other low barrier solutions such as tariff and supplier switching should be suggested where possible.
33. Referrals to appropriate funding mechanisms for higher cost interventions should be provided e.g. reconnection grants or grant to repair/replace boilers.
34. Low cost interventions such as LED bulbs, heating maintenance, radiator foil and small-scale window insulation measures should be provided.
35. Efficiency measures should be suggested as they are still worthwhile and generally reduce the energy consumption and/or improve the quality of life for poor households.
36. For the most impoverished it is imperative that energy providers move from seeking legal sanctions for non-payment and informal energy supply to one of supporting vulnerable citizens.

## 8.3 Future Considerations

The overall green energy strategy needs to recognise the issue of energy poverty more clearly and accept that for many members of society reduction in consumption is not possible or desirable. Green energy programmes such as PV, are one area with potentially high payoffs for individuals (reduced bills) and society (reduction in emissions). Yet the current schemes do not address those who are energy vulnerable. In our view this needs to change, as the relative improvement in their disposable incomes and quality of life would be far greater than that of middle and upper income members of society. Some attempts have been made in this direction e.g. in Hungary where a Roma community received PV cells via a crowd funded programme (https://www.facebook.com/fenyhozok and https://www.elosztoprojekt.hu/wp-content/uploads/2019/12/FÉNYHOZÓK-PPT.pptx.pdf). However, crowd funding while desirable should not be the only source of funding available.

STEP-IN has provided an early indication of the role of rebound effects within energy poor communities, it has shown there is a vast variation in direct and indirect rebound effects. There needs, to be a close examination of potentially desirable rebound effects and how these can be harnessed in a way to encourage greater energy savings and/or lower bills. In effect trying to provide citizens with a positive "other benefit" which may arise as a result of any particular action they may take. However, we would caution against the current popular trend of viewing behaviour change as the panacea. Instead, it can form part of a package of solutions proposed to the citizens concerned.

Where energy providers move from seeking legal sanctions, to one where they offer support to vulnerable citizens levels of trust in the community increase and people start to seek (re)connection. In STEP-IN we were pleased to have a provider which took this enlightened view. However, it is clear that the providers themselves should be assisted in taking this path perhaps via Government support.

# 9 Conclusions

Energy poverty transcends the populace and often its impacts are hidden from wider society. These impacts range from lack of energy, through to health issues and potential fatalities from unsafe energy supplies. While inability to pay bills may seem like the cause, it is often the symptom of underlying problems such as poor housing stock, mental health issues or being a member of a marginalised group e.g. Roma, immigrants or the ill. Therefore, while energy advice is critical so is the ability to address these underlying problems.

From an energy transitions perspective, the market segmentation approach used within STEP-IN clearly points to a major challenge facing energy policy makers. That is how to develop emissions reduction policies that take into account energy poor consumers who are by nature often under-consuming. For many, increased energy consumption would vastly improve their quality of life, in some cases simply letting them have lights on after dark and in other cases, potentially saving them from death due to unsafe energy supplies. While others who adopt efficiency measures may significantly reduce their bills and improve their financial situation. As a result, there needs to be an acceptance that consumption may increase as energy poverty is alleviated and therefore policies should focus in sharper reductions in consumption for those that are not energy poor. Locally based renewable sources may have a significant impact on energy poor communities, for example providing them with cheaper energy while at the same time lowering emissions. Refurbishment programmes also provide a potential route out of energy poverty for many. However, the householders often rent their properties and therefore are left behind when such schemes are announced.

The living lab approach rolled out within STEP-IN had a range of positive impacts on energy vulnerable citizens. Many reported that the approach and the associated advice improved their quality of life. Specific benefits including lowering bills, in some cases by up to €1,000, reduction in bill arrears through to the provision of a safe and stable energy supply. The benefits and take up of behaviour change advice varied, with measures such as switching off light bulbs varying per country. Whereas, shortening showering/bathing times or lowering temperatures by one degree was more successful. Other advice which tackled the overall situation and not just technical responses yielded positive results, for example referring people to other support services and providing bill awareness advice. Whatever advice is provided, it has to focus on the needs of the individual concerned and relate to their personal situation.

From a methodological perspective, the key findings are that advice must come from trusted organisations/individuals and face-to-face is referred over remote services (e.g. online). Over and above these living labs must have a clear co-created and reflexive approach which allows the specific elements to evolve. This can be explicitly via feedback provided, or by allowing home energy advisors to work with the same consumers and community over a period of time. This long-term approach allows them to adapt not only how they deliver advice but also what advice is delivered. It also improves trust. The overall methodology used in STEP-IN was successful, this was as much due to having a common approach as it was to allow each lab to adapt it to local circumstances.

Covid-19 had an impact on the operation of the living labs and the results obtained. Many citizens served by STEP-IN suffered a drop in incomes and an increase in energy costs. The pandemic also allowed us to compare the effectiveness of remote vs face-to-face advice provision, the latter being the more successful option.

In conclusion, STEP-IN has provided 36 recommendations for the operation of living labs, which encompasses not only their operation but different forms of advice that can be offered. The overall approach is designed to fit in with existing eco-systems and therefore should be relatively low cost to implement and provide significant impacts for the citizens involved. It is also designed to be adaptable to local circumstances. As a result, there is currently interest in taking forward the approaches used after the project.

# 10 Bibliography

Arendt, H., & Kohn, J. (2006). *Between Past and Future: Eight Exercises in Political Thought.* London: Pengiun Books.

Avelino, F., & Grin, J. (2017). Beyond deconstruction. a reconstructive perspective on sustainability transition governance. *Environmental Innovation and Societal Transitions, 22*, 15-25.

Balezentis, T., Butkus, M., Streimikiene, D., & Shen, Z. (2021). Exploring the limits for increasing energy efficiency in the residential sector of the European Union: Insights from the rebound effect. *Energy Policy*, 149.

Ballon, P. (2010). Open Innovation by Living Labs Across Border: the APOLLON Project. APOLLON.

Bouzarovski, S., & Haarstad, H. (2018). Rescaling low-carbon transformations: Towards a relational ontology. *Transactions of the Institute of British Geographers*, 265-269.

Bouzarovski, S., & Herrero, S. (2017). The energy divide: Integrating energy transitions, regional inequalities and poverty trends in the European Union. *European Urban and Regional Studies, 24*(I), 69-86.

Brown, J. I. (2005). *The World Café: Shaping Our Futures Through Conversations That Matter.* Berrett-Koehler Publishers.

Chitnis, M., & Sorrell, S. (2015). Living up to expectations: Estimating direct and indirect rebound effects for UK households. *Energy Economics, 52*, 100-116.

Chitnis, M., Fouquet, R., & Sorrell, S. (2020). Rebound effect for household energy services in the UK. *The Energy Journal, 41*(4), 31-59.

Chitnis, M., Sorrell, S., Druckman, A., Firth, S., & Jackson, T. (2013). Turning lights into flights: Estimating direct and indirect rebound effects for UK households. *Energy Policy, 55*, 234-250.

Chitnis, M., Sorrell, S., Druckman, A., Firth, S., & Jackson, T. (2014). Who rebounds most? Estimating direct and indirect rebound effects for different UK socioeconomic groups. *Ecological Economics, 106C*, 12-32.

Copernicus. (2019). *E-OBS data.* Retrieved from Copernicus: http://surfobs.climate.copernicus.eu//dataaccess/access_eobs.php

ELSTAT. (2011). *Cencus of population – residences 2011.* Retrieved from Hellenic Statistical Authority: http://www.statistics.gr/el/2011-census-pop-hous

European Commission. (2019, 1). *Ethics.* Retrieved from Ethics: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/ethics

European Commission. (n.d.). *Global Code of Conduct for Research In Resource Poor Settings.* Retrieved from European Commission: http://ec.europa.eu/research/participants/data/ref/h2020/other/hi/coc_research-resource-poor-settings_en.pdf

European Commissoin. (2018). *Data Management.* Retrieved from Participant Portal H2020 Online Manual: http://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/open-access-data-management/data-management_en.htm

EuroScientist. (2017, 2 17). *The Brussels declaration on Ethics and Principles for science and society policy making.* Retrieved from www.euroscientst.com: http://www.euroscientist.com/wp-content/uploads/2017/02/Brussels-Declaration.pdf

Flood, R. L. (1999). Knowing of the Unknowable. *Systemic Practice and Action Research, 12*, 247-256.

Fressoz, J. (2014). Pour une histoire désorientée de l'énergie. *25èmes Journées Scientifiques de l'Environnement - L'économie verte en question.* Retrieved from https://hal.archives-ouvertes.fr/hal-00956441/document

Hills, J. (2012). *Getting the measure of fuel poverty - Final Report of the Fuel Poverty Review.* London: Department of Energy and Climate Change (UK).

Jaglin, S. &. (2017). Emerging countries, cities and energy. Questioning transitions. In S. S. Bouzarovski, M. Pasqualetti, & V. Cástan Broto, *he Routledge Research Companion to Energy Geographies* (pp. 106-120). London: Taylor & Francis.

Katsoulakos, N., & Kaliampakos, D. (2014). What is the impact of altitude on energy demand? A step towards developing specialized energy policy for mountainous areas. *Energy Policy, 71*, 130-138.

LILAN. (2009). *A Nordic-Baltic Research and Innovation Programme on Living Labs (Programme Description)*.

Longhurst, R. (2003). Semi-structured interviews and focus groups. In C. N. G., *Key Methods in Geograph*. London: Sage Publications.

Loorbach, D. F. (2017). Sustainability Transitions Research: Transforming Science and Practice for Societal Change. *Annual Review of Environment and Resources, 42*, 599-626.

Marlyne Sahakian (UNIGE), L. D. (2018). *ENERGISE Living Lab evaluation and assessment manual. ENERGISE – European Network for Research, Good Practice and Innovation for Sustainable Energy, Deliverable No. 3.5.* University of Helsinki.

Morgan, D. (1998). *The Focus Guidebook*. London: Sage Publications.

Observatory, E. E. (2019, 5 24). *Indicators and Data*. Retrieved from European Energy Poverty Observatory: https://www.energypoverty.eu/indicators-data

Saheb, Y., Calcagno, S., Kostov, P., Bodis, K., Vondung, F., & Thema, J. (2019). *European Energy Poverty Index (EEPI)*. Openexp. Retrieved from https://www.openexp.eu/sites/default/files/publication/files/european_energy_poverty_index-eepi_en.pdf

Santamouris, M. (2018). *Minimizing Energy Consumption, Energy Poverty and Global and Local Climate Change in the Built Environment: Innovating to Zero*. Amsterdam, The Netherlands: Elsevier.

The European Parliament and the Council of the European Union. (2016). *General Data Protection Regulation*. Retrieved from Official Journal of the European Union: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32016R0679&from=EN

The European Parliament and the Council of the European Union. (2016). *General Data Protection Regulation*. Retrieved from Official Journal of the European Union: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32016R0679&from=EN

The World Cafe. (n.d.). *World Cafe Method*. Retrieved from The World Cafe: http://www.theworldcafe.com/key-concepts-resources/world-cafe-method/

Thomson, H., Bouzarovski, S., & Snell, C. (2017). Rethinking the measurement of energy poverty in Europe: A critical analysis of indicators and data. *Indoor and Built Environment, 26*(7), 879–901.

University of Maribor. (2017). *Deliverable: 4.1.1 Living Lab Approach for GRASPINNO*. GRASPINNO Project.

Vicini, S. B. (2012). How to co-create Internet of things-enabled services for smarter cities. *The First International Conference on Smart Systems, Devices and Technologies*, (pp. 55-61).