Energy Efficiency (2024) 17:50
https://doi.org/10.1007/s12053-024-10231-y

ORIGINAL ARTICLE

What can we say about the longer-term impacts of a living lab experiment to save energy at home?

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Received: 25 January 2024 / Accepted: 10 May 2024

Abstract There is a wide evidence base on various interventions to change energy behaviours in households, but limited evidence on their long-term effects. It is argued that interventions in individual behaviours are subject to attrition over time following the withdrawal of the intervention. Evaluation of these arguments is difficult since the conditions and composition of households change over time, making it hard to isolate the effects of a behavioural intervention several years later. Social practice theory argues for interventions that do not target individual attitudes or behaviours but focus instead on household practices (such as laundering and heating homes), and the underlying notions of cleanliness and comfort that are the causes of energy use in households. In contrast to behaviours, practices are also seen as socially shared, bundled with other practices, and embedded in social structures and processes. Practices are durable entities that persist over time; true practice change would hence entail durable intervention impacts. Our paper qualitatively investigates the long-term effects (2018–2023) of a practice-based living lab intervention that aimed to influence laundry and heating practices in Finnish households. We compare how the new or changed practices of 21 households, learned during the intervention, have persisted through societal changes (i.e., the Covid pandemic and the energy crisis), and whether these new or changed practices helped households to deal better with these crises. In this way, we contribute to, and also reframe, the problem of evaluating long-term effects, and critically consider the persistence of small-scale interventions in practices.

Keywords Energy efficiency · Everyday behaviour · Household · Living lab intervention · Long-term change · Social practices

Introduction

The need for sustainability transitions in the energy sector has long been recognised and became even more prevalent during the energy crisis in Europe starting in 2021, during which, for example, the IEA and EU outlined key energy saving actions to help Europeans to reduce dependence on Russian fuels (EC, 2022). Action to reduce energy use has been expected from all actors in the society but especially from households, with homes being some of the key

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Published online: 23 May 2024

sites of everyday energy use, as well as sites where much of the energy-saving potential remains unfulfilled (Ivanova et al., 2020). The household sector used circa 65 GWh of energy (18%) in Finland in 2022 and heating indoor spaces formed approximately two thirds of it (Statistic Finland, 2023a). The problem is that households' energy use is related to meeting various kinds of needs such as the need to stay warm or the need to take care of one's family, steered by shared notions of e.g. thermal comfort, representability, and hospitality that may conflict with energy conservation actions (e.g. Laakso et al., 2021b, 2022; Shove & Walker, 2014). Saving energy in homes hence requires not only opening the performance of these highly routinised and inconspicuous practices for reflection, but also finding ways to meet the needs in alternative ways. While practices are not unchangeable, and research has shown that for example the expectations towards suitable indoor temperatures have changed dramatically in the past decades, the trend has rather been towards more resource-consuming practices of thermal comfort (e.g., Luo et al., 2016; Shove, 2003). For example, evolving technologies have allowed the detailed management of indoor temperature independently of the outdoor temperatures or the time of day or year, making it unnecessary to adjust for varying temperatures by other means. Similar patterns of co-evolution, which counteract the potential of energy efficiency, have been identified in many areas, from practices of cleanliness (Shove 2003) to practices of storing food (Rinkinen et al., 2019).

There is a growing field of research that focuses on interventions in the escalating expectations that have led to ever-increasing use of energy and other resources despite technological innovations and efficiency measures. Known either as practice-based interventions (Laakso et al., 2021a), or practice-based design (Kuijer & de Jong, 2012; Scott et al., 2012), the idea of these approaches is to understand the current situation, co-create knowledge with experts and households on the ways to change practices to be less resource-consuming, and then test these solutions in real life. However, the evidence-base of the longer-term impacts of these practice-based approaches is missing since most interventions are organised within the time limits of a single project. In the meanwhile, there is a wide evidence base on interventions designed to change energy behaviours in households where it is argued that such temporally-bounded interventions in individual behaviours are subject to attrition over time following the withdrawal of the intervention (e.g. Allcott and Rogers, 2014; Composto & Weber, 2022; Khanna et al., 2021).

To fill this knowledge gap, we investigate the longer-term effects of a practice-based intervention, ENERGISE Living Labs. In these Living Labs (LLs), conducted as part of the European ENERGISE project in eight countries in 2018, the participating households developed new ways of keeping warm and doing laundry, with the goal of reducing indoor temperatures and laundry wash cycles to save energy (e.g. Matschoss et al., 2021; Sahakian et al., 2021). In Spring 2023, we organised a follow-up survey in Finland, and in this article, we qualitatively analyse the survey responses to examine whether the LLs have longer term impacts. We focus on *how the new or changed practices that households learned during the intervention have persisted through societal changes* (i.e., the Covid pandemic and the energy crisis), and on *whether the new or changed practices helped households to better deal with these crises*. The impacts of the pandemic on energy and sustainability have been previously discussed for example by Greene et al. (2022), Kanda and Kivimaa (2022), and Rouleau and Gosselin (2021). Here, we contribute to, and also reframe, the problem of evaluating long-term effects, and critically consider the persistence of small-scale interventions in practices.

In the following section, we introduce the literature on energy-related living labs and practice-based interventions, with discussion on persistence of intervention effects. In the third section, we describe the living lab intervention, methods for collecting data and analysis. In the fourth section, we present the findings of the analysis and show that some of the learnings have persisted even through exceptionally difficult times. In the fifth section, we discuss the findings in light of persistence of practices and provide conclusions.

Persistence of effects of practice-based household interventions to save energy in a living lab setting

In this section, we first introduce the notion of living labs and how social practice research has used them as an intervention method. We then explain the

problems related to understanding the longer-term effects of such interventions, which only very few interventions are even set to examine.

Living labs as an intervention approach in social practice research for sustainable consumption

In the 2000s, the notion of 'experimentation' has occupied a central position within the academic field that investigates transformations towards sustainable socio-technical systems. Experimentation in this sense can be defined as conducting inclusive, real-life and challenge-led initiatives, which are designed to promote system innovation through social learning under conditions of uncertainty and ambiguity (see Sengers et al., 2016). Living laboratories, or living labs, (LL) have proliferated as a particular form of experimentation and as a transition governance tool to drive sustainable development (Bulkeley et al., 2016).

The concept of living labs can be seen as an approach/methodology, an organisation, a system, an arena (i.e. geographically or institutionally bounded space), or an environment involving systemic innovation (Bergvall-Kåreborn et al., 2009; Schliwa et al., 2015; Voytenko et al., 2016). While the range of initiatives that call themselves living labs is diverse, some core characteristics can be identified. Almirall et al. (2012) note that living labs are driven by two main ideas: (1) involving *users as co-creators* on equal grounds with the rest of the participants, in order to work together to frame research that delivers more effective solutions, and (2) intentional *experimentation in real-world settings* that make social and/or material alterations. LLs are not just focused on services or technologies, but also on how various technologies and practices interact in the context of consumption and lifestyles. As other forms of social experimentation, they are initiated by research organisations and universities, as well as by communities, firms, and grassroots organisations (Evans et al., 2015; Mastelic et al., 2015; Voytenko et al., 2016). An important characteristic is that the LL approach is founded on the idea of uncertainty, as well as on the need to act despite gaps in knowledge (Karvonen & van Heur, 2014).

Social practice theories (SPT) have also gained prominence in studies of (especially mundane) consumption and sustainable consumption since the early 2000s (see, e.g., Keller et al., 2016; Welch & Warde, 2015). SPT argue for interventions that do not target individual attitudes or behaviours but focus instead on practices, such as laundering and heating homes, as well as the underlying notions of cleanliness and comfort that are the reasons for energy use in households. In contrast to behaviours, practices are also seen as communally- and socially-shared, bundled with other practices, and embedded in social structures and processes. Recent years have seen some practice-based suggestions for how to reduce household energy use. With regards to space heating and cooling, these are often linked to the notion of heating or cooling people rather than space (Kuijer 2014; Strengers, 2014). Some studies have investigated practice-based approaches to reduce hot water use by new, energy-conserving bathing practices and adaptive washing skills, supported by the use of social benchmarking information, suggestions for culturally appropriate forms of washing, and automatic adjustments to flows of water-using devices (Kuijer, 2014). Interventions around laundry practices have challenged the conventions of cleanliness by engaging people to wear the same pair of jeans for months without washing them (Jack, 2013). A practice-based intervention thus aims "to disrupt, relocate, innovate, redirect or otherwise reorient" the practices in question (Strengers et al., 2014: 74).

The challenge is that these kinds of initiatives are often laborious because they aim to address mundane, inconspicuous routines that are considered as 'normal', and thus might be hard to identify, question, and break. In addition, these interventions are often small-scale and short-term due to their hands-on nature, and the challenge lies in transforming individual performances of a limited number of people to sustainable mainstream practices. Thus, we examine the problems related to the persistence of effects targeted with interventions and to their evaluation in the next section.

Persistence of intervention effects

Interventions focusing on energy behaviours via information (e.g., by providing tips and feedback) commonly struggle with attrition of effects over time (Composto & Weber, 2022; Khanna et al., 2021). This means that they may have significant effects in the short term, but these effects fail to

persist once the intervention is withdrawn. Interventions that involve changes in physical infrastructures might have better persistence over the duration of the equipment or investment (Allcot and Rogers, 2014; Bergquist et al., 2023), but these effects are often lower than predicted, and may degrade as the equipment ages (Vine et al., 2014). Commitments and other team-based methods have been found to render relatively persistent results (Burns & Savan, 2018), but overall, the evidence on persistence of energy interventions is quite patchy (Vine et al., 2013).

Practice-based interventions are expected to render more persistent effects, since they do not target simple energy behaviours, but underlying patterns of consumption that result in energy use, influencing material, meaning and competence elements in the performance of practice. Using behavioural terms, this could include habit-formation, changes in physical infrastructures, changes in self-perception and identities, and changes in social reinforcement – which are all more persistent than behavioural responses (Frey & Rogers, 2014). Moreover, as the interventions are often executed among a group of people and include forms of collective deliberation and experimentation to address the social nature of consumption, they can be said to ultimately target 'practices as entities', i.e., socially-shared understandings of the practices, in addition to individual performances of practices (e.g. perceptions concerning appropriate levels of cleanliness, Shove et al., 2012).

However, it can be very difficult to assess the long-term effects of any kind of energy interventions in experimental settings. Problems in evaluating persistence include attribution errors, where people are more likely to attribute changes to an intervention even when the changes might be due to other factors (Howell, 2014). As time passes, there are many factors that can influence practices, from changes in household composition and situation to broader, societal changes (Howell, 2014; Vine et al., 2013). Vine et al. (2016) propose that when evaluating long term and persistent effects of interventions a key point is hence to identify other developments that might influence behaviour (or practices) over time.

Research context and methods

In this section, we explain how we have set out to analyse the longer-term effects of a practice-based living lab intervention organised in 2018. We first present the intervention as a context of the study. Then we describe the research data and methods.

The context of research: the ENERGISE living labs

The ENERGISE project aimed to solve some of the challenges described above by implementing living labs (LLs) in an experimental setting in various contexts in eight European countries, and with a particular focus on the longer-term effects of the experiment. Furthermore, the collective elements employed in the LLs aimed at supporting the scalability and stability of the novel ways of heating and washing laundry (Matschoss et al., 2021; Sahakian et al., 2021). The design and process of executing the LLs are described in detail in the project's webpage (www.energise-project.eu; see also Laakso et al., 2021b).

The Finnish LLs examined in this paper were implemented at two different sites: in the Porvoo region, about 50 kms from the capital city of Helsinki and engaging 19 households living mainly in single-family homes, and in Merihaka, in a capital city district close to Helsinki city centre with 18 households living in apartment buildings. The immediate findings of the Finnish LLs (i.e. the short-term effects right after the LL) are described in detail in previous publications (Heiskanen et al., 2019; Laakso et al., 2022). Moreover, there are several publications, in which the Finnish findings are compared or combined with other countries (e.g. Godin et al., 2020; Laakso et al., 2021b; Matschoss et al., 2021; Sahakian et al., 2021).

The LLs were designed so that participants faced a heating and a laundry-related challenge and had to adjust their everyday lives accordingly (Heiskanen et al. 2018). Most of the LL participants in Finland took on a challenge to halve the number of wash cycles in laundry and reduce indoor temperatures to 18 °C for seven weeks. The households, on average, reduced the number of wash cycles by one-third, and the room temperatures by one degree (Sahakian et al., 2019). In terms of practice change in Finland, Heiskanen and colleagues (2019) report that households used more alternative ways of keeping their clothes clean, such as washing and brushing stains

from clothes instead of washing the whole piece, and simply wore clothes for longer without washing them. Many also separated their work and home clothes, with home clothes being washed less often. Warm clothes such as woollen socks were used quite commonly already before the heating intervention, but their use was shown to increase during the LL intervention. The participants also got used to slightly cooler indoor temperatures, and some even found that they slept better in new, cooler temperatures (Heiskanen et al., 2019).

The societal context of participating households has changed significantly since 2018, owing to the Covid-19 pandemic. Finland has been considered a country that survived the pandemics in a good manner (EURACTIV, 2020; Kinnunen, 2021). Digital services were well developed already when the pandemics started and switching to home office or homeschooling did not cause much difficulty (Andere, 2021; OECD, 2020). Some experts believe that the pandemic has changed working practices permanently as remote work has now become more of a rule than an exception in many professions (Erdsiek & Rost, 2022). This also has major implications for energy use in homes, as people use more energy in homes but also have more opportunities to cook, wash laundry and dishes, and cook at different times of the day.

The second shock was caused by the impacts of the Russian invasion of Ukraine and its energy war against Europe (European Council, 2023). Finnish imports of electricity and wood from Russia were abruptly and completely cut off during 2022, which led to fears of energy shortages during the winter season of 2022–2023 (Statistics Finland, 2023b). Energy prices rose in an unprecedented manner, and many struggled to pay for their electricity bills. The authorities warned about blackouts and encouraged people to save energy with a conservation campaign called "Down a degree" (MEAE, 2022). Consequently, energy use was reduced by eight percent in October 2022 compared to the year before (Fingrid, 2022), largely thanks to the actions of citizens in their everyday lives, and Finland did not suffer any blackouts. In a survey conducted in Spring 2023, 87% of respondents reported having saved energy, with most popular measures being reducing the use of electric appliances, indoor heating, and showering times (Motiva, 2023).

Research data and methods

Data was collected in several stages prior, during and after the intervention. A baseline survey was executed four weeks before the start of the intervention, in August 2018, and a closing survey was sent seven weeks after it had started in December 2018. The first follow-up survey was executed three months after finishing with the LLs, in March 2019. To capture the longer-term effects of the Finnish LLs, we conducted another follow-up survey four years after the end of the intervention. The most recent follow-up survey was sent to 25 out of 37 households, those who had participated in the LLs and who could still be reached by email in April 2023, which coincided with the end of the heating season in Finland due to the colder than average weather. We received 21 responses. The survey questions followed the structure of the previous follow-up survey conducted in 2019, with additional questions regarding the impacts of the Covid-19 pandemic and the energy price crisis for heating and washing laundry. We also asked whether the respondents considered their participation in the project had turned out to be useful for meeting these crises in terms of the lessons learned for less energy-using practices regarding cleanliness and thermal comfort. This research compares the average results of the two follow-up surveys to see if practice changes have persisted from 2019. We also examine the responses related to the questions on Covid-19 and energy crises to understand whether having taken part in the intervention has given participants competences that they could use during exceptional times.

There are some important limitations to consider. There may be some bias in those who answered towards being more interested in these topics and thus perhaps more active in their everyday lives towards energy saving than the average of the original sample. In addition, we cannot combine the datasets from 2018/19 with 2023 to match respondents as responding was anonymous. We also wish to point out that the numbers of temperature or of laundry cycles from prior, at the end and three months after the LL cannot be directly compared with the numbers from the survey in 2023. This is due to differences in measurement and reporting. The average numbers for temperatures and numbers of laundry cycles in 2023 are based on the self-evaluation of the respondents, whereas the numbers from 2018–2019 are based on

temperature measurement with temperature saving loggers and the laundry cycles on diary data that the respondents kept each time they washed laundry. Therefore, the numbers from 2023 should be treated as more indicative and not as exact as those from 2018–2019. Due to the qualitative difference of the data between datasets and small number of responses, we cannot calculate any statistical significance. We complement the quantitative, comparative examination of the survey data with the qualitative content analysis and present quotes from the responses as an illustration of typical responses.

Findings

In this section, we present the key findings from the follow- up survey compared to the results from the LL. First, we report how the indoor temperatures and heating-related practices have changed and then we report changes related to laundry cycles and practices. Finally, we examine the results from the perspective of the energy crisis and Covid-19.

Changes in indoor temperatures and heating-related practices

15 out of 21 respondents stated that the temperature in their homes has remained at the reduced level that they had set as a target during the project. The respondents assessed their 2023 living room temperature as 19.7 °C, on average (Table 1). Prior to the LL in 2018, the average living room temperature was 21.1 °C and during the intervention, the temperatures reduced on average by 0.9 °C to 20.1 °C (Heiskanen et al., 2019). In the home of one respondent, the temperature was even colder than right after the intervention, while the indoor temperature had risen in one home only. Many respondents explain the reason for keeping the lower temperature with experiences gained during the project: "*Lowering the temperature has been a conscious choice that the project initiated*" (R18), that 18 degrees at home is doable, that they can manage the lower temperatures quite well: "*We noticed during the project that we can do well even in cooler indoor temperatures*" (R7), and that the project provided novel understanding of reasons for heating, which is why the change is permanent: "*The goal of the project was to understand why, and that is why the change is permanent*" (R12). Further explanations for keeping temperatures low were the price of energy: "*The price of oil is quite a big variable*" (R16), the overall temperature reduction of the central heating in the housing company, and a new home in which it is possible to control the temperature better: "*In the new apartment, we will be able to influence the temperature better*" (R2).

Table 1 Living area temperatures and numbers of laundry cycles from prior to LL to four years after

	Average before, August 2018 ($n=40$)	Average directly after, December 2018 ($n=36$)	Average 3 months after, March 2019 ($n=33$)	Average, April 2023 ($n=21$)*
Living area, °C	21.2	20.2	20.3	19.7
Numbers of laundry cycles per week	3.7	2.6	2.4	2.4

Source: Heiskanen et al. (2019) and novel calculations for 2023. (*The numbers cannot be directly compared as the average numbers in 2023 were measured as described above.)

The respondents were asked a set of questions regarding their heating practices. The questions included a list of practices, concerning which they were asked whether they now engaged in them more or less than before the LL intervention. Figure 1 presents the change in practices as reported by the respondents right at the end of the LL, three months after closing of the LL, and in 2023. The findings show that the share of respondents engaging more in the given practices four years later is higher in all practices than right after the LL. Altogether missing is the use of hot water to keep warm; the respondents did not take more hot showers, and more than half of respondents reported having taken hot showers less frequently.

The observations in Fig. 1 suggest that the participants have adopted and retained a repertoire of ways to stay warm without turning up the heat. These include extra blankets, extra clothing and adjusting the temperature in different rooms, which has not traditionally been a standard practice in Finland (Karjalainen, 2009).

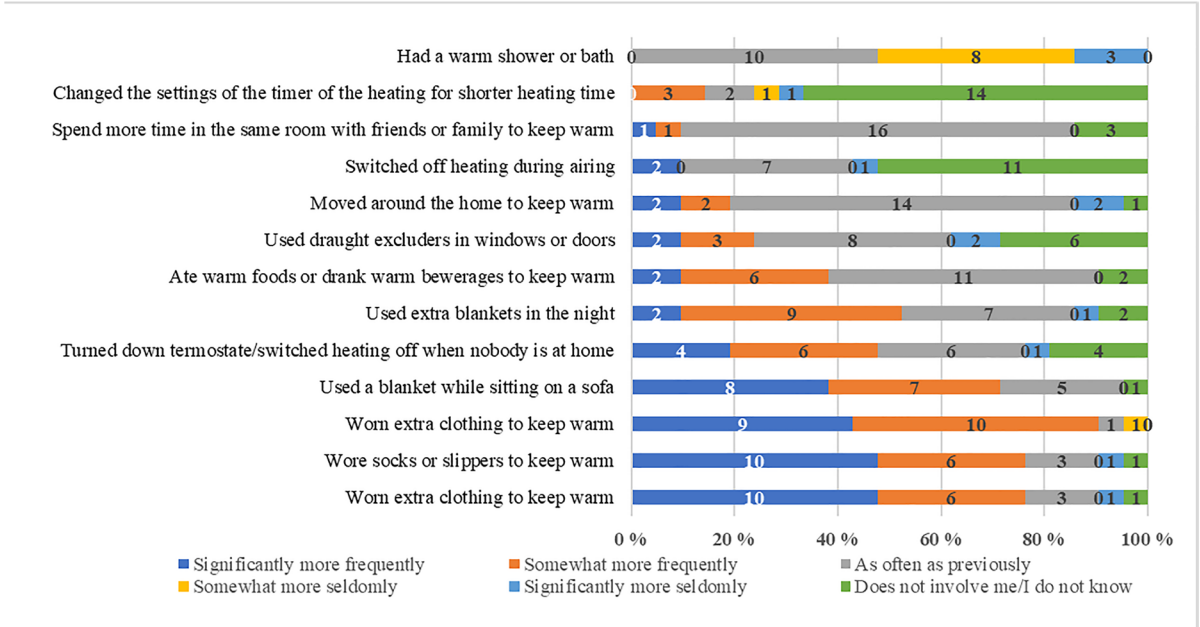

Fig. 1 Change in heating-related practices compared to time before and after the LL experimentation

Changes in doing laundry

Related to the laundry intervention, respondents reduced the number of their daily laundry cycles from 0.52 to 0.38 (a reduction of 0.15) per day during the intervention (Heiskanen et al., 2019). In the follow-up survey in 2023, the respondents evaluated the number of their laundry cycles as 0.34 per day (Table 1). 15 out of 21 respondents stated that the number of their laundry cycles is the same as during the intervention, and 4 out of 21 respondents reported having reduced the number of cycles even further. One respondent explained several ways in which they had attempted to reduce the amount of laundry purposefully further: "*Awareness. Taking care of clothes, adding smart materials such as wool. Cleaning the closet for clothes, reducing clothes, and dressing smarter*" (R12). None of the respondents had increased the number of laundry cycles (even though one family had had another child).

Also related to laundry, survey questions listed a set of practices, and the respondents were asked whether they now engaged in the practice more or less frequently than before the LL intervention. Figure 2 presents the change in practices as reported by the respondents. As in the case of heating, many practices were performed more often than before the LLs: the respondents examined clothes carefully to see if they needed washing, aired clothes, and removed stains to postpone washing the whole piece, and washed fuller loads. These were also the main ways to reduce washing laundry listed by one of the respondents: "*The understanding that emerged during the project is that laundry does not need to be washed so often. Removing stains, airing clothes, using separate work clothes*" (R5). However, slightly used clothes were not stored to be reused before washing as often as during the LLs, and colder wash temperatures and eco programmes were used less often.

Impact of the energy crisis and Covid-19 on heating and washing laundry

Given the overall rise in energy prices following the energy crisis, we asked whether the price hikes had motivated the households to reduce their room temperatures or the number of laundry cycles washed. 12 respondents out of 21 reported that they had reduced their room temperatures, 8 that they had reduced washing laundry, and 8 responded that they had done nothing as a reaction to the rising energy prices.

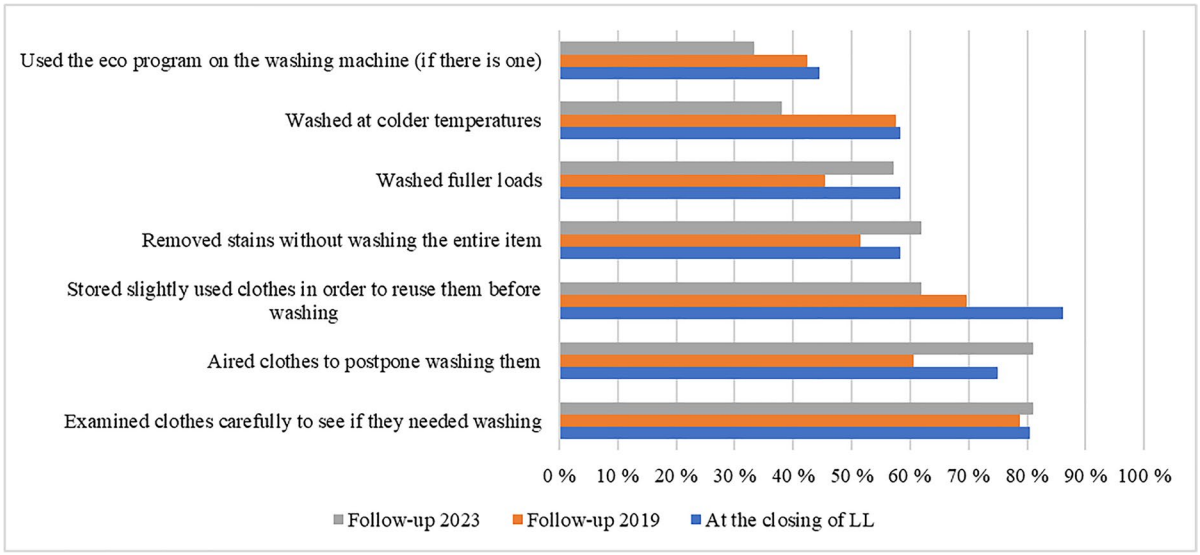

Fig. 2 Change in laundry related practices compared to time before the LL experimentation

Based on this survey, 8 had reduced indoor temperatures and 13 had washed full laundry loads.

Regarding *heating*, the respondents explain the changes in their energy use by saying that they lowered the temperatures in some spaces such as in the bedroom and in rooms less used, for example on the upper floor or in outside spaces. (In Finland, isolated outside storage rooms or garages are often heated, especially if they contain a water source, otherwise the pipes would freeze and break during winter.) Because of the energy crises, many respondents had also tried to avoid using electricity for heating and instead used wood stoves and fireplaces: "*The use of electrical energy has decreased by approx. 70–80%, mostly because electric heating has not been used at all this past winter, except for the floor heating in the bathroom. It has largely been replaced by the heating energy obtained from burning wood. Bathroom floor heating is on only 1 day/week. Overall, energy use has decreased*." (R5).

The Covid pandemic seems to have impacted energy use for heating less than the energy crisis (Appendix Fig. 3). Statistics Finland has assessed the overall energy consumption during the Covid-19 pandemics and found that there was a slight increase in use of electric appliances (1%) but as car heating is also included and people did not use their cars as much to travel to work, this reduction somewhat cancelled out the increase of other appliances (Statistics Finland, 2021). There are, however, some changes to be seen caused by both crises. During the pandemic people had to stay at home more, which could be expected to increase the need for indoor heating in homes. In Finland, the heating of indoor spaces is usually not reduced while people are away for work, so the impact of increased remote work on indoor heating is generally not large. The respondents stated that because they were more at home, they could better control heating for example with the fireplace: "*Remote working made it possible to heat the fireplace more effectively…*" (R12), and the increased home cooking provided indirect heat from the stove and oven, as well as the heat from using other appliances more, such as the computer.

Related to *laundry*, one third of the respondents reported changes in the number of laundry cycles during the pandemic, but it did not have much influence on the washing temperature (2 out of 21 stated changes). The most frequent washing temperature was 40 °C, as it had been also before the pandemic. The changes related to laundry had to do with the consequences of working from home: 3 respondents out of 21 worked full time at home, 2 at the workplace and 12 in a hybrid mode (part time at home and part time at work). For those working from home, there was less need to change clothes and less need for working clothes that needed to be kept clean, which reduced the need to wash as often as before. Some also stated

that working from home enabled washing laundry also during the daytime, which saved time for other activities in the evening.

The energy crisis changed the number of laundry cycles of one third of the respondents. It had more influence on the washing temperature: 4 out of 21 stated changes towards colder wash temperatures. Other changes include washing laundry less frequently or during the times when electricity is cheaper, such as during the night. The electricity price thus influenced practices despite only 3 respondents stating that the energy crisis had caused them financial difficulties during the previous nine months (as from July 2022).

When asked if the respondents had discussed energy saving with others, the results are strikingly similar compared with the follow up survey from 2019, where the respondents were asked if they had shared their experiences from LLs with others (Table 2). As many as 71% of the respondents have discussed with their friends and more than half with their relatives, followed by colleagues and other household members (38%), while the shares were 73%, 48%, 39% and 33% in the previous survey, respectively.

Discussion and Conclusions

Our aim in this paper was to examine whether the living lab intervention, which took place in 2018, had longer-term impacts for the energy use of participating households. Based on our findings from the 2023 follow-up survey, several participating households showed persistent practice changes. Survey respondents explained that participating in the LL had brought them a novel understanding of their energy use and taught them various ways to live in colder temperatures without having to compromise their comfort. Similarly, people reported having learned adaptive practices to avoid doing laundry as frequently and having changed their ways of thinking about cleanliness.

Table 2 Share of households having shared experiences from the LLs

	2019	2023
Friends	73%	71%
Relatives	48%	52%
Other household members	33%	38%
Colleagues	39%	38%
In social media	-	33%
Neighbours	21%	19%
Members of my associations	6%	10%
Others	3%	5%
Children's school or e.g. sports club	3%	0%

An important issue to note in our study is related to the timing of the follow-up survey of 2023. Although our findings indicate that reductions in indoor temperature are persistent, our survey took place immediately after the energy crisis with a public national campaign warning people about potential energy shortages and urging them to reduce their indoor temperatures, among many other energy saving measures (see MEAE, 2022). The respondents also indicated that their energy use for heating has changed somewhat due to the energy crisis, and therefore we cannot claim that the temperature reductions were solely due to the lessons learned in the LL intervention. Nevertheless, we directly asked the respondents whether they had kept the reduced temperatures that they adopted during the LL, and the majority responded "yes". We also asked them to reflect upon why they think that their indoor temperatures have changed after the LL, and the responses highlighted the respondents' increased understanding of their energy-using practices and positive experiences with the LL intervention, while no one indicated the energy crisis as the sole cause for reduced indoor temperatures. This points towards the conclusion that the LL had a long-term influence on the way the participants experience a suitable indoor temperature and enabled them to accept lower temperatures than before the intervention, and that the energy crisis led them to reduce temperatures even further—potentially with the help of experiences from the LL, as the respondents reported having engaged more in various alternative practices to keep warm than during the previous follow up in 2019.

Moreover, and related to practices to keep warm, shorter and colder showers were also discussed as ways to save energy during the energy crisis (MEAE 2022). This was also seen in our survey responses, as none of the respondents reported having taken more hot showers, and more than half of respondents

reported having taken hot showers less frequently, compared with the responses from 2019 survey, in which some respondents still reported having taken hot showers more to keep warm in their colder homes (Heiskanen et al., 2019). However, also during the LL, those respondents who had taken more hot showers reflected on its impacts on energy use and called it a "sin" (Heiskanen et al., 2019: 21).

In addition, the impacts of the Covid-19 pandemic for energy use cannot be ignored (cf. Greene et al., 2022; Kanda & Kivimaa, 2022; Rouleau & Gosselin, 2021). It has permanently changed the way of working and most of the respondents reported working both at home and at the workplace, which reduces the need to wash work clothes as frequently but has different kinds of implications for indoor heating, as described in the previous section. Nevertheless, we can assume that the changed practices of keeping warm and clean supported less energy-intensive living during and after the pandemic. However, the responses also show a decline in the usage of colder wash temperatures and eco-programmes, of which the former could be explained with the increased expectations of hygiene gained by washing in high temperatures to kill viruses during the pandemic, while the latter is somewhat surprising as the respondents also reported how they could wash laundry during the daytime when working from home, so using longer eco-programmes should not have been a problem at least from a time-use perspective.

A limitation related to the persistence of practices indicated by this research relates to the small number of respondents. Unfortunately, we could only reach 68 percent of the LL participants and only 57 percent of them responded to the survey in 2023. We could thus make no statistical analysis of significance because the sample was much smaller than in 2019. In addition, those who did respond in the survey may also be more interested in energy issues than those who did not respond. Despite these and the shortcomings mentioned in the methods section, the responses received show how participation in a practice-based living lab had long-term impacts at least among those who we could reach, and that many of these respondents had also discussed energy issues with others, thus potentially increasing the impact of the LLs by the participants serving as exemplars of energy-saving practices.

In light of these findings, we can thus conclude that organising such experimental practice-based living labs is not a futile exercise as they can indeed teach citizens novel ways to organise their everyday life and adopt persistent practices contributing towards sustainability. Nevertheless, the practice-based living lab initiatives are often laborious due to the intense interaction with the participants and the need to keep the participating households engaged for the whole time (see e.g. Sahakian et al., 2021), but it may also be one of the reasons for why we could still identify persistence in the changed practices several years later. A further problem with such interventions is that they often are rather short-term and remain small-scale—a problem that still remains unsolved. However, the findings show that the participants exchange experiences with several others, so there is some upscaling potential and an indication that the lessons learned in an intervention may have broader influence. Engaging media and local communities in living lab projects is also suggested to help upscale the lessons further (Sahakian et al., 2021). The interventions also point out the importance of addressing and reflecting on social norms and conventions underlying mundane energy use on a broader scale. As we experience the effects of global warming, unexpected situations and further crises are more and more likely to arise. The types of low-energy practices that households adopted in our LL may help the participating households adapt to changing circumstances and live well, or at least better, through various kinds of crises. In this way, they can enhance households' flexibility and resilience, and perhaps, one day, also the resilience of the entire energy system.

Acknowledgements We would like to thank the participating households for their commitment and excellent cooperation throughout the Living Lab project and responding to the follow-up survey so many years after the project. We also thank Research Council of Finland for the funding (GA 333556, 358439).

Funding Open Access funding provided by University of Helsinki (including Helsinki University Central Hospital). This work was supported by Research Council of Finland (GA 333556, 358439).

Data Availability The data is not openly accessible as the participants of the living labs were not notified about further sharing their data at the time of data collection.

Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

Appendix

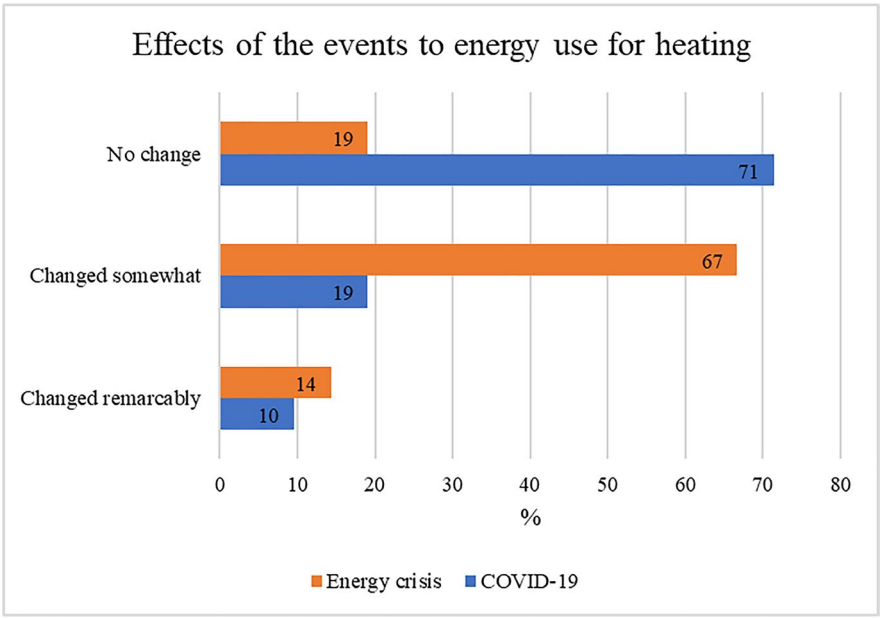

Fig. 3 Effects of energy crisis and COVID-19 to energy use for heating

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