



Aalborg Universitet

AALBORG UNIVERSITY  
DENMARK

## Towards sustainable energy consumption

*Challenging heating-related practices in Denmark, Finland, and Hungary*

Laakso, Senja; Jensen, Charlotte Louise; Vadovics, Edina; Apajalahti, Eeva Lotta; Friis, Freja; Szöllőssy, Anita

*Published in:*

Journal of Cleaner Production

*DOI (link to publication from Publisher):*

[10.1016/j.jclepro.2021.127220](https://doi.org/10.1016/j.jclepro.2021.127220)

*Creative Commons License*

CC BY 4.0

*Publication date:*

2021

*Document Version*

Publisher's PDF, also known as Version of record

[Link to publication from Aalborg University](#)

*Citation for published version (APA):*

Laakso, S., Jensen, C. L., Vadovics, E., Apajalahti, E. L., Friis, F., & Szöllőssy, A. (2021). Towards sustainable energy consumption: Challenging heating-related practices in Denmark, Finland, and Hungary. *Journal of Cleaner Production*, 308, Article 127220. <https://doi.org/10.1016/j.jclepro.2021.127220>

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal -

### Take down policy

If you believe that this document breaches copyright please contact us at [vbn@aub.aau.dk](mailto:vbn@aub.aau.dk) providing details, and we will remove access to the work immediately and investigate your claim.



## Towards sustainable energy consumption: Challenging heating-related practices in Denmark, Finland, and Hungary

Senja Laakso<sup>a,\*</sup>, Charlotte Louise Jensen<sup>b</sup>, Edina Vadovics<sup>c</sup>, Eeva-Lotta Apajalahti<sup>d</sup>, Freja Friis<sup>b</sup>, Anita Szöllőssy<sup>c</sup>

<sup>a</sup> University of Helsinki, Centre for Consumer Society Research, P.O. Box 24 (Unioninkatu 40), 00014, University of Helsinki, Finland

<sup>b</sup> Aalborg University, Center for Design, Innovation and Sustainable Transitions, A.C. Meyers Vænge 15, A, A2, 2450, København SV, Denmark

<sup>c</sup> GreenDependent Institute, 2100, Gödöllő, Éva U. 4, Hungary

<sup>d</sup> Helsinki Institute of Sustainability Science, 00014, University of Helsinki, Finland

### ARTICLE INFO

Handling editor: Cecilia Maria Villas Boas de Almeida

#### Keywords:

Energy consumption  
Households  
Indoor space heating  
Intervention  
Social practices  
Comfort

### ABSTRACT

This article presents the process and results of a practice-based intervention aimed at facilitating the time and space required to experiment with and change home heating in households, to promote socially and environmentally sustainable ways of practising thermal comfort. A central feature of the intervention, called ENERGISE Living Labs and conducted across eight European countries, was that social practices were targeted, resulting in a focus on what ‘heating is for’ rather than the process of heating in and of itself. In this article, we concentrate on the three countries with the highest reported expectations of thermal comfort and describe how 113 households in Denmark, Finland and Hungary completed a set of challenges to reduce their indoor temperature to 18 °C for four weeks in the late autumn of 2018. To facilitate alternative ways of keeping warm, the participants were supported by reflexive interviews and group discussions, and aided by tips and materials. The results demonstrate how changes in skills, competences, norms, and expectations related to indoor thermal comfort (in addition to other daily practices) are essential for more sufficient energy use. Generally, the temperature level at which people felt comfortable was reduced by an average of 1 °C, and, more importantly, participants became aware of their heating-related practices, including the underlying elements of these practices, and learned how to challenge them. The results clearly indicate the potential of practice-based interventions to promote deliberation on and change in existing socially shared expectations of comfort.

### 1. Introduction

In Europe, home heating accounts for a significant proportion of both household energy and total energy use. On average, indoor space heating constitutes approximately 67% of residential energy usage in Europe (Odyssee, 2019). Besides shifting to renewable energy sources, radical reductions in energy used for heating are necessary to meet the EU’s climate and energy goals (Labanca and Bertoldi, 2018; Thomas and Rosenow, 2019). Sufficiency, referring to absolute reductions in resource use, has been proposed as a new strategy to complement energy efficiency efforts (Lorek and Spangenberg, 2019). Indeed, while much attention has been directed to renewable energy technologies, information provision, and the energy efficiency of buildings and appliances, only recently has interest grown towards disrupting mundane ways of

energy use, finding alternative means of achieving thermal comfort, as well as simply using less energy – despite their apparent importance (see Genus and Jensen, 2017; Madsen and Gram-Hanssen, 2017; Sherriff et al., 2019; Jensen and Friis, 2019).

In this article, we ask *how practice-based interventions can support a change of heating-related practices in countries with high expectations of thermal comfort*. By practices, we refer to mundane, habitual performances of everyday actions guided by shared norms and conventions, skills and competences, as well as materials and technologies (e.g., Gram-Hanssen, 2011; Shove, 2003; Warde, 2005). To answer this question, we use data from ENERGISE Living Labs (ELLS) – a practice-based intervention aimed at challenging mundane practices and thereby supporting the normalisation of less resource-intensive alternatives (Vadovics and Goggins, 2019). Central to the intervention

\* Corresponding author.

E-mail addresses: [senja.laakso@helsinki.fi](mailto:senja.laakso@helsinki.fi) (S. Laakso), [cjensen@plan.aau.dk](mailto:cjensen@plan.aau.dk) (C.L. Jensen), [edina@greendependent.org](mailto:edina@greendependent.org) (E. Vadovics), [eeva-lotta.apajalahti@helsinki.fi](mailto:eeva-lotta.apajalahti@helsinki.fi) (E.-L. Apajalahti), [frf@sbi.aau.dk](mailto:frf@sbi.aau.dk) (F. Friis), [anita@greendependent.org](mailto:anita@greendependent.org) (A. Szöllőssy).

<https://doi.org/10.1016/j.jclepro.2021.127220>

Received 14 January 2020; Received in revised form 12 April 2021; Accepted 18 April 2021

Available online 5 May 2021

0959-6526/© 2021 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

design is the targeting of social practices rather than people or technologies, resulting in a focus on ‘what heating is for’ rather than the process of heating in and of itself, much in line with similar practice-based approaches to energy use (Shove and Walker, 2014). Compared with technology- or behaviour-oriented approaches, which often do not fully engage with practices or meet the requirements in relation to energy savings (see Kuijer and Bakker, 2015), practice-based interventions hold novel potential for shifting mundane energy use towards sustainability (Laakso et al., 2021).

To discuss the potential of practice-based interventions to achieve reductions in residential energy use, this article presents the results from ELLs in Denmark, Finland and Hungary, three countries with relatively high notions of thermal comfort (see Sahakian et al., 2021). The aim of the intervention was to utilize a practice-theoretical approach to enable households to rediscover and innovate ways to ‘heat people, not spaces’ and thus to question their existing practices while developing and experimenting with new ways of achieving thermal comfort that require less energy. By exploring practices related to heating in households across the three countries, this article demonstrates the various ways materials, meanings, and competences are linked together in the performance of daily practices. Moreover, it provides examples of what are considered normal and appropriate ways of practising thermal comfort. Unlike previous studies on practice-inspired interventions in heating, our aim is to capture both the shifts in *and* the stickiness of the norms, conventions, and skills maintaining current heating practices, and to scrutinize the longer-term and cross-cultural effects of interventions that have yet to be studied in detail (see Jensen et al., 2018).

The article proceeds as follows. We introduce the theoretical background in section 2, and the materials and methods used in the study in section 3. Then, in section 4, we present our findings, focusing on changes in meanings, skills, and materiality, all of which underpin the notions of comfort in heating-related practices in the three countries. Finally, sections 5 and 6 conclude the study and discuss the potential of practice-based interventions to promote change towards more sustainable energy use in European households.

## 2. Intervening in heating-related practices

Practice theory has become an established means of avoiding methodologically individualist accounts of ‘the consumer’, focusing instead on consumption as a moment in practice (Warde, 2005). People do not use energy as such; rather, we perform daily activities such as showering and laundering as a way of achieving cleanliness and presentability, and heat our homes for the sake of comfort. Hence, patterns of energy use stem from mundane practices that are performed to take care of ourselves and others, participate in society, and conform to socially shared understandings of ‘the good life’.

Following this line of thought, heating is not about transforming electricity, water, or other resources into a source of heating; rather, it essentially concerns feeling comfortable and being able to perform all the other daily practices in the home. Similar to other interlinked daily practices, practices related to heating are comprised of and reproduced by a range of elements, such as infrastructures, technologies, bodies, rules, ideas, meanings, conventions, and social norms, which together define what we experience as normal, acceptable, and appropriate ways of keeping warm (Shove, 2003).

Practices are inherently social; research suggests that we learn the skills and competencies of heating over the life course, starting from the childhood home, and meanings related to thermal comfort stem from collective conventions and expectations concerning what is seen as ‘normal’ (e.g., Gram-Hanssen, 2011; Greene, 2018; Hansen, 2018). Understandings of normal indoor temperature extend as far as to the design standards of and material arrangements in offices and other workplaces, steering indoor thermal environments and thus the temperatures to which we become accustomed (Cass et al., 2019). Thus, policies and collective rules play an important role in the constitution of

normality in interlinked practices (Fahy et al., 2019; Greene, 2018; Greene and Fahy, 2020).

Enjoying the same stable indoor temperature throughout the year is a rather recent expectation in the Western world (Luo, 2016; Shove, 2003). Air conditioning and electrified cooling represent one of the newest examples of energy-intensive comfort provisions and the co-evolution of technologies and escalating expectations, where the use of these appliances has shifted from a ‘luxury’ to a perceived ‘necessity’ (Chappells and Shove, 2005). What is interesting is that this ‘technologisation of daily life’ actually results a rather narrow definition of thermal comfort (Sherriff et al., 2019). Thus, despite thermal comfort being a highly negotiable socio-cultural construct, the strong normative commitments involved in reproducing present standards of living and related building codes allow little space for elaborating alternative ways of life and may ultimately do quite the opposite by ‘locking-in’ current carbon-intensive ways of life (Kuijer and de Jong, 2012; Wilhite, 2008).

Hence, for society to move towards carbon neutrality, we must understand how energy-consuming practices are structured and can be transformed in everyday life and how needs such as thermal comfort can be achieved with less energy (Shove, 2012). Instead of understanding comfort as a universal physiological construct or a property offered by the surroundings, an ‘adaptive thermal comfort approach’ recognises the co-evolution of technology, building design, meaning and routines, and norms and expectations that has resulted in the unsustainable demand for heating (Sherriff et al., 2019). Furthermore, it acknowledges the inter- and intra-personal variation existing in the (thermal) conditions that are considered comfortable (Kuijer and de Jong, 2012). Such an approach thus offers the opportunity to offer people a variety of alternatives to achieve thermal comfort and to challenge the notion and level of comfort required.

Our practice-based intervention approach is rooted in practice-oriented design studies (e.g., Kuijer and de Jong, 2012; Scott et al., 2012) and in a living lab methodology embracing transdisciplinarity and co-creativity (Heiskanen et al., 2018). Living labs are situated arenas driven by two main ideas: involving households, researchers, and other stakeholders on equal terms, and intentional experimentation in real-world settings (Hasselkuß et al., 2016). Following Scott et al. (2012), the aim of practice-based design is to allow participants to identify, understand, and challenge the norms and structures promoting unsustainable practices while revealing how these norms are created, recreated, and undone in the course of the performance of practices. Unlike approaches focusing solely on behaviour, practice-based approaches thus recognise the socio-material framework of everyday life and provide participants with the means to understand and question that framework (Kuijer and Bakker, 2015). Moreover, as practices are situated, practice-based interventions allow researchers to identify a variety of material and institutional infrastructures, ideas about a normal and ‘good’ life, as well as the competences and skills related to performing these practices (Laakso and Heiskanen, 2017).

Some examples already exist of living lab approaches employing a practice-theoretical approach within households (see Devaney and Davies, 2017; Scott et al., 2012); however, they have mostly been small-scale and local. In the next section, we situate and extend our study within the current body of research by presenting our methodology for challenging the normalised, contextualized ways of performing heating-related practices within a larger set of households across several countries.

## 3. Intervention design, methodological approach, and empirical foundation

In the following, we present the ENERGISE Living Labs (ELLs). The ELLs were organised within the framework of the ENERGISE project in eight European countries and focused on challenging energy-intensive practices in two domains of household consumption: heating and laundry, of which this article focuses on the heating challenge.

### 3.1. Intervention process and participants

In the heating challenge, households were encouraged to reduce their indoor temperature either to 18 °C or to their own target<sup>1</sup> by challenging the underlying assumptions of heating-related practices and by developing and experimenting with alternative ways to achieve the preferred level of thermal comfort. Importantly, the main focus of the intervention was not on whether the households achieved their targets, but rather on co-creating knowledge on how and why practices are performed as they are and how practices change (or fail to change). In terms of deconstructing the practices, experimenting with alternative practices, and deliberating on the experiences (see Laakso et al., 2017), our intervention design methodology was founded on the work of Scott et al. (2012) and Kuijer and de Jong (2012). The theoretical orientation of our intervention design primarily builds on the seminal work of Shove (2003) on practice-theoretical accounts of everyday life, which specifically describes practices as interlinkages between meanings, competences, and materials, as well as on the conceptual work of Shove et al. (2012), which suggests that change indeed occurs through transformations in these interlinkages between elements and interconnections between practices. Consequently, enabling changes in heating, for example, means targeting the meanings, competences, and material conditions that comprise a particular heating-related practice, as well as recognising the practices to which heating is interlinked and interconnected.

Researchers in each country recruited participants 'to challenge their routines'. Recruitment occurred through public announcements, social media, and participation in local events. The applicants completed recruitment surveys, and the participants were selected on the basis of three criteria: (1) engagement in the practices under study (i.e., the possibility to adjust and manage their heating), (2) representation of various socio-demographic groups in each country, and (3) inclusion of so-called 'hard-to-reach' groups (i.e., those not previously engaged in sustainable consumption initiatives). As shown in Fig. 1, each household completed a baseline survey that included more detailed questions about their existing heating-related practices. Researchers visited households in August–September 2018 to provide more detailed information on the intervention and to install thermometers, which allowed households to observe and researchers to record the indoor temperatures. Households then monitored their actual and preferred indoor temperatures for a four-week baseline period in October.

After the baseline data collection, half the households were visited again for an interview, while the other half were invited to focus-group meetings. In these interviews and meetings, we discussed the participants' heating-related practices, as well as the meanings, competences, and material arrangements that co-produce the performances of such practices. While both interviews and group discussions exposed inconspicuous and embedded routines for reflection and engaged participants in the reconfiguration of practices (Scott et al., 2012), the group discussions also revealed the diversity of the performance of practices and enabled reflection on those differences among the participants (Browne, 2016). During these second meetings, and in order to facilitate the change, households received 'challenge kits'. Similar to Akrich (1992), here the intention was to introduce material arrangements that held the potential for co-scripting new practices of keeping warm; the challenge kits included tips and somewhat familiar products that the participants knew how to use either from other domains of daily life or from alternative experiences with keeping warm, such as warm socks and hot beverages (Kuijer and de Jong, 2012). The intervention was thus 'low-tech' in the sense that the material elements provided were simple thermometers and products in the challenge kits. Nevertheless, it is

important to stress that the challenge kits included material manifestations of new meanings and skills (such as tips and tricks for exploring and defining thermal comfort in new ways), just as much as they included material products in and of themselves (such as socks). The challenge kits thus assisted a co-scripting of whole practices instead of solely relying on the introduction of a new product.

The heating challenge lasted for four weeks in November 2018. During the challenge, households aimed to find new ways to achieve thermal comfort at the reduced indoor temperature (such as wearing more layers and warmer clothes and heating unused rooms less than used rooms). Thus, instead of being issued with specified comfort conditions, households were 'provided opportunities' for making themselves comfortable (Chappells and Shove, 2005). Throughout the challenge, participants reported their experiences through weekly surveys and diaries.

After the challenge, the households were visited a third time, this time with the aim of offering the participants an opportunity to reflect on their experiences and allowing the researchers to enquire about the influence of the intervention on the participants' everyday lives. As the actual experiment occurred between two interviews or group discussions, the participants were able to analyse and negotiate their practices more deeply in the latter meetings (Hitchings, 2012). Households also completed a closing survey to capture changes relative to the baseline. To observe longer-term changes in practices, a follow-up survey was conducted in March 2019, approximately three months after the end of the challenge (for more details of ELLs, see Vadovics and Goggins, 2019).

Thus, in line with Shove (2003), the intervention aimed to cover all elements of the practice – materials (e.g. technologies, bodies, appliances), meanings (shared understandings of what thermal comfort is), and competences (skills of keeping warm) – and to embed notions of sufficiency in heating-related practices. The challenge kits and thermometers helped participants link the notion of comfort with energy use and the material elements of the practice, while the discussions supported reflection on the meanings of thermal comfort and what could be considered 'sufficient'. The actual experimentation supported the learning of skills and competencies in 'heating people instead of space'.

The ELL cases selected for analysis in this paper are drawn from Denmark, Finland, and Hungary because the participating households from these countries had the highest average indoor temperatures, both in terms of measured *and* preferred temperatures. Moreover, despite this, these households achieved only small reductions in temperatures – thus households in these countries seem the least likely to compromise on their expectations of comfort.<sup>2</sup> Therefore, these three countries can be approached as a critical case (Flyvbjerg, 2006), as scrutinising experiences from participants in these particular countries might provide findings on the *challenges* of changing practices related to heating and energy use more generally.

Altogether 113 households (out of 122 recruited) completed the intervention in Denmark, Finland, and Hungary. Attention was paid to recruiting a diverse group of participants in all countries, but, in the sample of households, participants who had completed higher education and lived in detached houses are nevertheless overrepresented (see Table 1).

Our sample included a diverse selection of building and heating-system types, as they were not part of the selection criteria (see above). In Denmark, approximately half the participants lived in detached houses with gas heating. Several of these houses also had a fireplace or wood stove that were sometimes used. The other half of the participants lived in terraced houses with district heating. Most of the terraced houses with district heating were equipped with floor heating.

<sup>1</sup> The households were able to set their own target if 18 °C proved to be too low due to a specific circumstance (e.g., an ill family member or small children).

<sup>2</sup> The ELLs were organised in eight countries: Denmark, Finland, Germany, Hungary, Ireland, Switzerland, the Netherlands and the UK (for the analyses of results from all eight countries, see Kajoskoski, 2019; Sahakian et al., 2021).



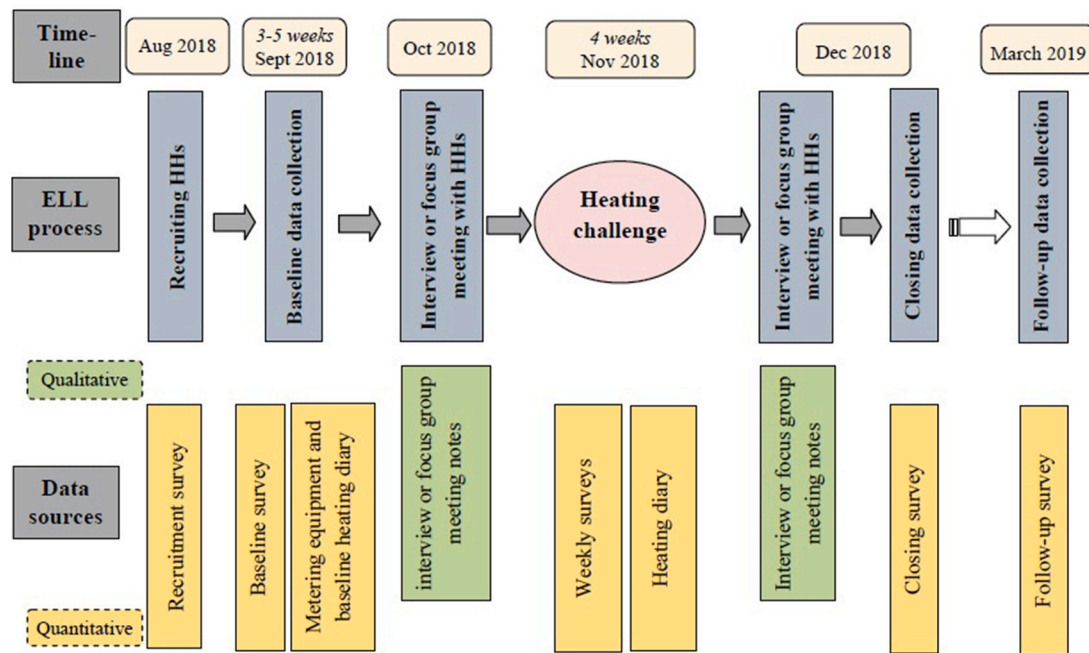


Fig. 1. The intervention process.

Table 1  
Description of recruited households.<sup>3</sup>

	Denmark	Finland	Hungary
<b>Number of recruited households</b>	38	43	41
<b>Household size</b>			
1–2 persons	17	27	12
3–4 persons	19	12	17
5 or more persons	2	4	12
<b>Contact person age</b>			
25–34	3	9	4
35–44	7	8	11
45–54	13	10	15
55–64	9	9	8
65–	6	7	3
<b>Contact person education</b>			
Higher education	20	25	34
Secondary education	13	4	6
Vocational education/training	4	10	1
Other	1	1	0
<b>Housing type</b>			
Detached	19	20	30
Semi-detached or terraced	19	1	10
Apartment building	0	22	1

<sup>3</sup> For detailed data on participants and energy systems in each country, see Heiskanen et al. (2019); Jensen and Friis (2019); Vadovics and Pap-Szuromi (2019).

There were only a very few cases of Danish households heated with electric heating powered by solar cells. In Finland, half the participants lived in apartment buildings with district heating and half in detached homes with various heating types, from (mainly oil-based) central heating to (combinations of) fireplaces, electric radiators, and heat pumps. In Hungary, three out of four participants lived in detached houses and the remainder in terraced/semi-detached houses, and thus these participants had full control over their heating systems (Vadovics and Pap-Szuromi, 2019). As for the energy source, gas heating was the most typical, followed by biomass heating.

### 3.2. Data collection and analytical approach

This study is based on both qualitative and quantitative data

collected during the intervention (Fig. 1; see also Heiskanen et al., 2019; Jensen and Friis, 2019; Vadovics and Pap-Szuromi, 2019).<sup>3</sup> The combination of qualitative and quantitative methods and the actual experimentation by the households allows us to capture both ‘doings and sayings’, which is essential for practice-theoretical research (Warde, 2005).

The qualitative data consists of interviews and focus group discussions organised before and after the challenge. The interviews and group discussions were conducted as similarly as possible, based on guidelines that included questions related to changes in routines, learning new skills and competences, changes in material arrangements, and representations of social norms. All the interviews and groups discussions were recorded. The quantitative data includes four surveys: the recruitment survey, baseline survey completed before the challenge, closing survey completed right after the challenge, and follow-up survey sent to the households three months after the end of the challenge to assess the persistence of the changes. In the baseline, closing, and follow-up surveys, we asked participants about their preferred temperature (i. e., the participants’ own estimation of the indoor temperature at which they considered they would feel the most comfortable) to allow for comparison with measured values as well as to analyse any changes in preferences occurring due to the intervention. In addition, a temperature diary and weekly surveys supported the data collection by enabling the researchers to monitor the temperatures, progress of the challenge, and the participants’ feelings. In the diaries, participants recorded the temperature in their living-room and bedroom on the same day of every week, preferably between 5 and 9 p.m. when the heating was on and household members were likely to be home. Logging thermometers were used by the researchers to track the changes in indoor temperatures in more detail.

Analysis of the extensive data proceeded in two steps. It began by writing summary forms from each interview and focus group discussion. The summaries were compiled as similarly as possible in each country,

<sup>3</sup> All ENERGISE Living Lab materials, including detailed descriptions of interview and focus group processes and surveys, are available as supplementary material as well as on the ENERGISE website at [http://www.energise-project.eu/livinglab\\_materials](http://www.energise-project.eu/livinglab_materials).

including a description of materials, meanings, and competences and any changes in these elements. In this phase, representative quotations on how households experienced the challenge, reflected upon their practices, and found alternative ways to stay warm were selected to illustrate the stability and change of these practices. Quantitative analysis was performed to capture the changes in indoor temperatures and the ways of keeping warm reported in the surveys. Extensive country reports were written in each country (see Heiskanen et al., 2019; Jensen and Friis, 2019; Vadovics and Pap-Szuromi, 2019). Second, we distributed the summaries from each country and organised a workshop to discuss the findings.<sup>4</sup> For the purposes of identifying heating-related practices in Denmark, Finland, and Hungary (the countries with the highest average indoor temperature and relatively small temperature reductions), we continued with qualitative content analysis on the notions of thermal comfort within these countries, identifying both common and context-related themes that would explain how the competences and meanings of and materials for keeping warm changed (or failed to change) in the course of the intervention. In the next section, we present our findings.

#### 4. Results

The methods used in the intervention provided insights into how heating-related practices, and the expectations of comfort, meanings, skills, and materialities that hold these practices together, can be understood, challenged, and changed. In the following, we describe the changes in indoor temperatures in relation to shifts in practices of keeping warm (Sections 4.1 and 4.2) and changes in the meaning and skills of keeping warm, the complexities of material and infrastructural arrangements for keeping warm as well as changes to notions of remaining comfortable (Sections 4.3–4.5).

##### 4.1. Changes in indoor temperatures

Our results show that collectively established indoor temperature standards (Wilhite, 2008, and as discussed in Section 2) indeed played a strong role in the understanding of desirable indoor temperatures prior to the intervention. Moreover, the preferred indoor temperatures were often within the range of official recommendations (Table 2). Nevertheless, these preferred temperatures differed from the measured temperatures, signalling a mismatch between preferences and actual practice. This demonstrates that challenging heating-related practices must begin with the self-reflection and acknowledgement of the starting point: expectations of thermal comfort are partly based on beliefs about temperature rather than the actual temperature.

Most of the participants in Denmark and Finland agreed to challenge themselves to meet the target of 18°, whereas in Hungary the majority of participants (67%) decided to set their own targets. This was partly due to the higher temperature recommendations in Hungary (Table 2), but it is also a reflection of Hungarians especially valuing freedom of choice (see Section 4.3). As a result of the intervention, the average reduction in temperatures was quite similar across the three countries: approximately 1 °C (Table 2). Importantly, this reduction occurred in both actual (measured) and preferred temperatures, and participants in all countries managed to maintain the temperature reduction even after the intervention phase or reduce it even further, especially in bedrooms.

Across all countries, very few participants reached the 18 °C target and most of them only for a short time (Table 2). The reasons for struggling to reach the target were multiple; For example, automated heating systems, for instance in apartment buildings and also in terraced houses, were often difficult to control, indicating the key role of material

**Table 2**

Official indoor temperature recommendations, average temperatures, and temperature changes: measured and preferred (in parentheses) temperatures and number of households managing to achieve the 18 °C target (Data source: Heiskanen et al., 2019; Jensen and Friis, 2019; Vadovics and Pap-Szuromi, 2019; calculations using thermologger data).

Indoor temperatures (°C)	Denmark	Finland	Hungary
<b>Officially recommended indoor temperatures</b>	19–22 °C depending on the type of the room <sup>b</sup>	20–21 °C living rooms; 18–20 °C bedrooms <sup>c</sup>	20–25 °C min. 20 °C winter in mostly used rooms <sup>d</sup>
<b>Before the challenge (T1)</b>			
Living room	21.2 (21.6)	21.7 (21.2)	21.4 (22.0)
Bedroom	19.7 (18.5)	21.2 (20.2)	20.9 (20.3)
<b>Right after the challenge (T2)</b>			
Living room	20.8 (20.9)	20.7 (20.2)	20.7 (20.7)
Bedroom	19.5 (18.8)	20.2 (19.2)	20.2 (19.2)
<b>3 months after the challenge (T3)</b>			
Living room	20.8 (20.8)	20.6 (20.3)	20.6 (20.6)
Bedroom	18.2 (18.3)	19.7 (19.1)	19.6 (19.3)
<b>Average reduction (T1–T3)<sup>a</sup></b>			
Living room	–0.5 (surveys) –1.4 (thermologger)	–1.2 (surveys) –0.8 (thermologger)	–0.8 (surveys) –1.2 (thermologger)
Bedroom	–1.5 (surveys)	–1.5 (surveys)	–1.3 (surveys)
<b>Largest reduction in average temperature between baseline and challenge period</b>	–2.65	–2.71	–2.57
<b>No. of households</b>			
Achieving ≤18.5 °C	0	1	4
Achieving ≤18.5 °C at least on one occasion between 5 and 9 p. m.	13	17	14

<sup>a</sup> The data provided by thermologgers differs slightly from the thermometer data, based on which the households filled in the surveys (this might be due to, e.g., thermologgers being placed higher in rooms).

<sup>b</sup> source: Bolius (2018).

<sup>c</sup> Based on decree 545/2015 by the Ministry of Social Affairs and Health, source: Motiva (2019).

<sup>d</sup> Based on the decree July 2006 by the Ministry of Innovation and Technology, source: TNM, 2006.

arrangements in scripting how practices unfold or fail to unfold (e.g., Akrich, 1992). Further, strong notions of comfort and ‘the right to comfort’ played a key role in whether participants felt it possible to adjust practices, as reflected by the views of a Danish participant:

*Basically, if we are doing something [moving around], then I don't think it has been a problem. But the moment you sit down in the living room, for example, I think it gets too cold. So I don't want to continue with that. It would be something else if we were less well-off. I don't want to sit there, wrapping myself in blankets ... and when you have guests over, you cannot say 'here are some slippers' – or actually we did mention it ... but they [the participant's daughter and son-in-law] had forgotten, so he had to borrow a sweater, and you don't really want to do that. (interview, DK248<sup>5</sup>)*

Some participants thus reached comfort thresholds that could not be crossed, as also illustrated by a participant from Hungary:

*As for heating, the more we turn it down, the more wallet-friendly it becomes. However, there is a point of comfort which we do not want to cross; we do not want to go under this point. We tested this with the*

<sup>4</sup> The research team met altogether two times after the data collection in all countries and organised bi-monthly online meetings to discuss the findings in each country.

<sup>5</sup> HU for Hungary, FI for Finland, DK for Denmark.

challenge, and for us it is okay to be around 20 degrees. (interview, HU106)

These illustrations demonstrate that a temperature drop is also considered in economic terms, be it a matter of saving or a matter of feeling entitled to particular levels of comfort if one can pay for it.

Some participants also noted that changing the indoor temperature was a gradual process. Nevertheless, many participants were motivated to attempt to reduce the indoor temperature, and some continued to use alternative ways of keeping warm even three months after the challenge, as described by another Hungarian participant:

*We agreed to the common [heating] challenge, to reduce to 18 °C, which was quite a brave decision for us. So far, we have not reached it, but we are not giving up, we will get there by the end of January. Now [right after the challenge] we are at 19.5–20°C, but there is still some potential. The challenge period was too short for us to reach 18°C. (focus group, HU42)*

#### 4.2. Changes in practices of keeping warm

Households already utilised a number of ways to keep warm before the challenge, the most common being wearing warm socks or slippers and extra clothing (Fig. 2). These remained the most popular measures throughout the challenge, with extra blankets becoming an important part of staying warm. Using blinds and curtains to prevent draught was most common in Hungary despite the fact that most windows are double- or even triple-glazed, and less so in Denmark or Finland. In addition, it should be noted that many of the participants employed several of these alternative techniques for keeping warm in parallel. Moreover, alternative practices of keeping warm generally increased in all three countries, even after the challenge ended. This may be partly due to the weather becoming colder during the course of the winter, causing the participants to employ their previous skills and competences or those gained during the challenge.

As Fig. 2 shows, some participants also took hot baths and showers to achieve thermal comfort, which might have increased their hot water use. This illustrates that while allowing households a ‘free hand’ to experiment and find the most suitable ways to keep warm by ‘heating bodies instead of space’ is generally an effective approach, it may also lead to less desirable practices that are rather energy-intensive, thereby causing some reduction in energy gains.

Another important result was that several participants in all countries simply became accustomed to slightly lower indoor temperatures and some did nothing ‘additional’. Many participants even expressed

surprise at how well they could cope with reduced temperatures: ‘It was a surprise for me to feel good at 19 degrees. I’m happy to have this experience’ (interview, HU100). These findings suggest some interesting aspects of the adaptability of the human body and the bodily sensing of temperature. Some participants identified very strongly with having a warm home, whereas others simply adapted. The reasons for some of this variance can be found in differences in the meanings associated with keeping warm.

In the following, we explain the formation of meanings, competences, and materials in heating-related practices and how these elements were reconfigured in the intervention.

#### 4.3. Continuities and changes in meanings and skills of keeping warm

The deliberative discussions, together with the action of lowering temperatures, revealed that meanings and skills related to heating are largely explained by the joint histories of people and material arrangements (Hansen, 2018). Several participants were already more skilled at living with lower temperatures than others because they associated it with frugality and the virtue of not wasting energy, which was especially common among participants living in detached homes. Some of these participants were even discouraged by the seeming ‘ease’ of the challenge, which primarily activated and reconfirmed already available skills and competences. However, during the intervention, they attached new sustainability-oriented meanings to these practices in addition to those related to, for example, frugality.

The discussions also revealed more in-depth historical attachments, as the intervention foregrounded experiences of saving energy during the 1970s oil crisis, which particularly the older participants in Denmark and Finland remembered. In turn, Hungarian participants reflected on the heating system during Communist times, when housing blocks had district heating that could be ‘regulated’ only by opening windows and wearing light clothes in winter – practices now considered wasteful and illustrated by sayings such as ‘heating the street’. Adjusting the heating individually and setting one’s own targets for heating reduction reflected a sense of freedom, while also underlining the skills required to adjust the heating system. Many Hungarian participants indeed turned down their heating for the night, in unused rooms, or when they were not at home, making their heat management more active compared to participants in other countries. These findings highlight the importance of ‘paths’ of practices in the effort to change (Kuijer and de Jong, 2012) as well as the variety of meanings and reasoning behind seemingly similar practices.

The challenge also nurtured new combinations of skills to keep warm

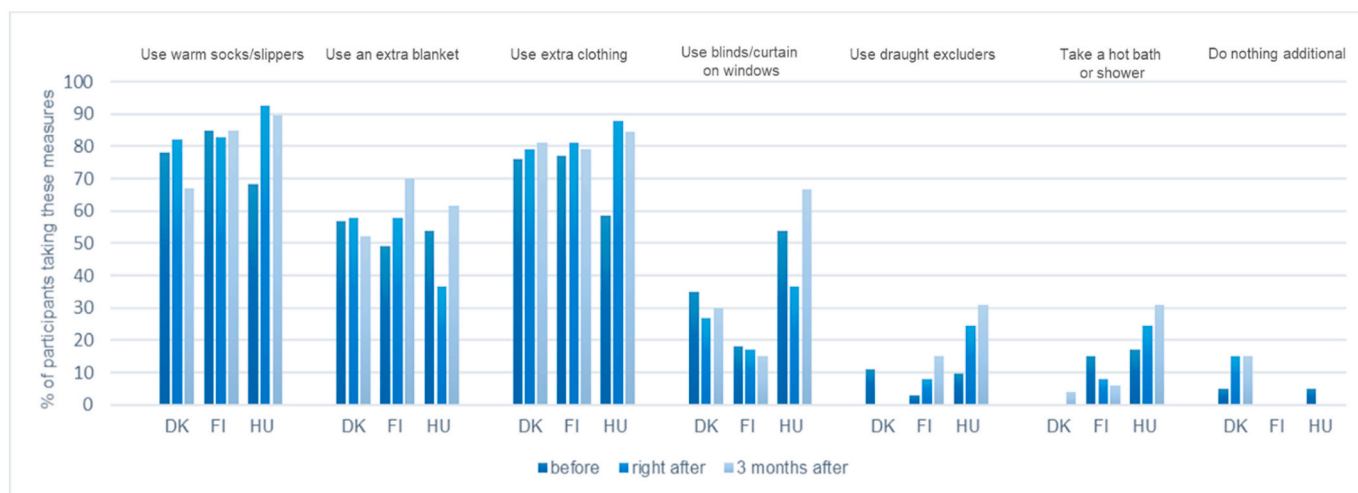


Fig. 2. Changes in the ways of keeping warm before, immediately after, and three months after the challenge (Data source: Heiskanen et al., 2019; Jensen and Friis, 2019; Vadovics and Pap-Szuromi, 2019).

with less heating and increased participants' awareness of the temperature. Some participants who had been less conscious of their heating mentioned that they had begun to question their present practices of heating spaces instead of people: 'Why should it be like this [wearing light clothing]? What is stopping me from putting on the woollen socks?' (interview, FI26). For them, the challenge was an opportunity to consider assumptions that had become self-evident over the years, also highlighting the importance of discussions for reflecting upon these aspects of practices with peers and researchers. However, as mentioned earlier, there was also resistance among some participants to abandoning existing levels of comfort, as described by a Finnish participant for whom the bodily experience of feeling cold triggered childhood memories and the desire to avoid a similar situation in the present:

*I thought it was cold here. It was not fun anymore and made me think of my childhood when all of us used to sit there and mum and dad said that it didn't need to be so warm in the winter. Then I thought, I have really become so modern that I don't want to live in such a cold temperature anymore.* (interview, FI25)

For this participant, thermal comfort and not having to actively adjust the heating or even consider it was linked to ideas of 'modern' life over which she was not ready to compromise. Some participants indeed found it laborious to ponder, and even question, these 'normalities' in their everyday life. These findings explain how long-term experiences and the normalisation of practices lock-in thermal expectations, making it difficult to lower them despite participants' engagement in the intervention (see also Luo et al., 2016).

#### 4.4. Socio-materiality of heating systems and their (in)active management

The participants' heating systems varied between household types, and during the experimentation period it became evident how practices were bounded by these material arrangements in many ways. The socio-material arrangements of the heating system largely explained why participants living in detached houses had a 'closer' relationship with their heating systems and possessed the skills to manage them. By contrast, participants living in apartment buildings struggled to understand the system, due, for example, to the slow response of floor-heating system in Denmark or feeling unable to influence centralised system in Finland.

Indeed, during the challenge, it became evident that both the building and the interface of the heating system were crucial not only for explaining the variation in how the participants engaged with the heating challenge, but also how they experienced it (see also Madsen and Gram-Hanssen, 2017). In Finnish apartment buildings, it was difficult to reduce the temperature in individual apartments below the collectively determined temperature (which in the buildings investigated here varied from 19 to 21 °C). Participants living in these apartments explained how this caused their management of heating to be extremely inactive: 'We rarely turn on the radiators even during winter because our apartment is so warm all the time' (focus group, FI09). These are strong examples of how materiality (products as well as infrastructures) scripts practices in many ways. The group discussions empowered these participants to actively question the set temperatures and seek ways to provide residents with more opportunities for managing heating in apartments. This demonstrates how the intervention helped link the practices within homes with technologies, rules, and broader systems of provision and decision making (Gram-Hanssen, 2011).

Although the majority of households living in detached homes enjoyed greater opportunities to manage their heating systems, a few of these participants admitted lacking the knowledge to do so. For them, the intervention supported socio-material learning, but it also caused distress. In Denmark, several participants thought heating systems lacked transparency in terms of how to regulate them, and some

Hungarian participants mentioned how it might take two or more heating seasons to become fully accustomed with a renovated or newly installed heating system.

Other socio-material elements at home were fireplaces and stoves as well as usage of rooms. In some cases the fluctuations in indoor temperatures caused by fireplaces and stoves were seen to hamper the regulation of heating, but in other cases they justified cooler overall temperatures due to having a warmer spot in the house. As an outcome of the intervention, many participants changed the ways they used their rooms: some rooms were used less, bedroom doors were closed during the day to keep them cooler, and more attention was paid to heat flow around the house. These strategies to limit the need for heat were illustrated by a Finnish mother of two:

*If we'd felt really cold, we surely would've done so that the space where we and the kids were in, we would've closed it. We would've preserved the heat from the people in the smaller space so it wouldn't have spread around the apartment.* (focus group, FI14)

The material provided within the intervention, such as thermometers, significantly enhanced changes in heating-related practices. For example, many Hungarian participants lacked an indoor thermometer prior to the challenge, causing them to be unaware of how warm their homes actually were. These low-tech solutions provided new information and enhanced the connection between changes in practices and changes in temperatures. Many households, especially in Hungary, also reported that the challenge motivated them to learn more about smart meters and alternative energy solutions and provoked them to initiate concrete plans for performing energy retrofits and renovations, such as building a winter garden to capture passive heat or a tile stove to gather around. Participants thus became more skilful in linking their practices and expectations of thermal comfort to the performance and characteristics of the dwelling (see also Rinkinen, 2019).

#### 4.5. Finding new ways of being comfortable

The challenge caused participants to consider the link between indoor temperature and comfort, and many used more bodily senses while adjusting what they considered comfortable, highlighting the importance of experimentation with temperature in relation to the body, senses, and emotions (see also Kuijter and de Jong, 2012). Some participants were rather surprised about the previous temperatures of their homes and actually experienced greater comfort at temperatures cooler than those they had maintained for years, as highlighted by a Danish participant: 'It is funny, now that I think of it, I haven't needed to go outside to cool off [during hot flushes] in this period' (interview, DK247). Instead of lowering comfort expectations in general, participants thus learned to find comfort from other aspects than high indoor temperatures.

What also changed for some households during the challenge was appreciation of the contrast between cooler rooms and warm clothes. Comfort provided by warmth thus became comfort provided by the contrast (see also Madsen and Gram-Hanssen, 2017), as illustrated by a Finnish participant:

*You just sleep so well already when it's a bit cooler, and when you go under the feather duvet you have like goose bumps, and then you truly have a good night's sleep ... then it somehow feels so nice in the winter to create a bit like a hygge situation for yourself, when you put on a jumper and wool socks and a bit like that.* (interview, FI32)

However, by contrast, some participants described feeling 'anxious' if they had to wear warm clothes inside. For example, some Danish participants resisted wearing many extra layers indoors, also because they felt it was difficult to cook or perform other daily tasks when wearing so much clothing, which also highlights the interlinkages between practices of heating and other practices in daily life. Many participants also emphasised that they were not the only ones whose



comfort needed to be taken into account. There was a tendency, especially among Danish participants, to report difficulties in surrendering the ‘right to a warm home’, not only for their own comfort, but also for guests or other family members, thus flagging the (social) expectations of a warm home: ‘When we have guests, we turn the heating up ... people expect that you know ... they come wearing thin blouses’ (interview, DK244). In Finland and Hungary, however, most of the participants did not adjust the heating while having guests; if the guests felt cold, they were provided with wool socks and blankets, and it was explained to them that the hosts were participating in a challenge. These experiences illustrate how the notion of thermal comfort is not only personal but also socially negotiated and part of a wider understanding of being comfortable at home.

## 5. Discussion

It is clear from the results that changing the way we use energy entails changing the practices that generate energy use. However, for several reasons, reconfiguring practices is a complicated process. The study demonstrates that households, policymakers, and practitioners invested in designing and engaging with change processes must explicitly acknowledge that ‘what people do’ goes beyond the individual.

Our research contributes to the existing literature by elaborating on practice-based interventions as a method for changing expectations of comfort and by revealing, across various contexts, the meanings, materials, and competences that hold heating-related practices together. The *meanings* attached to thermal comfort extend beyond simply feeling warm; they are tied to ingrained understandings of freedom and well-being based not only on personal experiences and beliefs but to a large extent on historical identities (such as those connected to the oil crisis or to rebelling against political dictatorship) and standardizations in building regulations. The *competences* related to practising heating-related comfort also extend beyond merely maintaining the heating system; we already learn some of the skills and competencies of heating and keeping ourselves and others warm in our childhood home and later in life in other contexts, and practising thermal comfort is thus intertwined with the ways we have learned to maintain a comfortable physical environment just as much as it is interconnected with collective conventions and expectations about what is experienced as ‘normal’ (Greene, 2018; Hansen, 2018). The *materials* related to the practising of heating-related comfort also extend beyond the immediate heating source; the intricacy of heating systems and the distributed agency that they entail (Wilhite, 2008) are extremely important contributors to the stickiness of resource-intensive ways of heating. If the heating system is built to maintain standardised thermal comfort without ‘bothering’ the user (the householders), it becomes very difficult for householders to regain the agency to control their own indoor climate (Rinkinen, 2019).

Unlike approaches focusing on individual behaviours, our findings thus highlight that shifts towards sufficiency in energy use are a collective effort requiring action also from actors outside the home. Pro-environmental motivations and values are insufficient if one’s community and the prevailing social norms surrounding thermal comfort, hospitality, or proper ways of practising care are unfavourable to change. Our results also underline the inadequacy of mere technological changes; instead, expectations towards indoor comfort must change, and the skills of using technologies efficiently must be learned to achieve the expected energy savings.

A practice-based approach such as the one employed in this study also steers attention to the interlinkages between practices, such as those of heating and hosting guests, which can significantly affect ideas of the appropriate indoor temperature. Moreover, our approach suggests how practices co-evolve (see also Shove, 2003); policy, economic, health care, and construction practices, among others, have all impacted the evolution of heating-related practices, leading to rather narrow standards of thermal comfort and certain indoor temperatures being seen as

a manifestation of modernity. Challenging existing practices takes time, but one of the first steps is to reflect upon and question these underlying conventions and interlinkages.

While this study does not represent a comparative analysis, it nevertheless highlights the expression of aspects within and across these dimensions and reveals how they can be opened for deliberation and reflection through a practice-based intervention design. However, it also highlights the difficulty of achieving changes in practices when these practices are interconnected with many factors outside the immediate realms of the individual – a consideration that is frequently neglected in most behavioural change programmes and which, thus, needs constant reiteration (Jensen et al., 2019). Nevertheless, providing *time* and *space* for people to deliberate on and challenge the practices with which they engage may be particularly beneficial for experimentation with socially shared conventions of what is ‘normal’ and ‘appropriate’. Our practice-based intervention method contributes to this by demonstrating that when participants themselves challenge these notions they become equipped and empowered to question ingrained socio-material structures that lock-in particular ideas of normal, such as technologically enforced standardizations of thermal comfort, socially shared ideas about what is comfortable and acceptable, and – to some extent – the their own embodied habits and feelings of entitlement. Moreover, low-tech solutions made our approach easily accessible and feasible in various contexts.

The present study contributes to the understanding of both the nuances and generalities of heating-related practices and notions of comfort across countries. In the countries studied here, both the actual and preferred temperatures were quite high, suggesting that heating plays a large role in thermal comfort across Europe. Nevertheless, it was surprising to note how particular aspects of keeping warm differed between the countries. The reasons for accepting or rejecting the set challenge of 18° seemed to stem from the same general rationale and thus cannot be tied to the individual; however, this rationale varied in form both within and between the countries. In Hungary, most participants wished to set their own targets, in line with their independent and active approach to the management of heating, while in Denmark most participants agreed to the common target, preferring to have ‘experts’ set the challenge, showcasing a sort of delegation of decision-making. To some degree, heating-related practices were more similar among participants living in detached homes, as they shared notions of frugality and an active relationship with the heating system, than they were among participants who lived in the same country but in different types of dwelling. This illustrates the variety of contexts in which practices are performed and highlights the importance of addressing this variety in change efforts (Laakso and Heiskanen, 2017). The question of living space (i.e., the space to be heated) is important, and in detached homes even small reductions in temperatures can lead to significant savings in energy use. However, due to global urbanisation, it is particularly essential to support sufficiency in heating in apartment buildings.

Finally, and importantly, the study presents specific ways of incorporating the notion of sufficiency into attempts to change heating-related practices (Lorek and Spangenberg, 2019). Because practice-based interventions allow for a deliberative process of taking stock of existing heating-related practices, their resource intensity, and certain ‘limits’ (e.g. the lowest comfortable temperature), they can reveal what a sufficient level of energy usage might be. Several participants ended up reflecting on why certain practices were enacted in the way they were, and whether they could be performed differently, and some of these deliberations were tied to ideas about an adequate level of heating and even frugality.

### 5.1. Limitations of the study

It is evident from the study that practice-based interventions hold potential and thus merit. However, the study also contains limitations that should be addressed.

An eternal issue for practice-theoretical studies is the fact that data is often based more on 'saying' (interviews and self-reported answers to surveys) and less on 'doing' (observations). However, this is less of a problem when participants actually discuss their practices (Hitchings, 2012), particularly when interviews and reporting are contextualized within a deliberative and reflective process where participants are provided with the time and space to experiment. Moreover, detailed measurements on energy use for heating in homes would have supported our analysis even further. This was the case in Hungary, where it was found that the average energy saving amounted to 10% by the end of the intervention, and continued to increase to 15% by the time of the follow-up survey (Vadovics and Pap-Szuromi, 2019).

In addition, there is always a danger of recruiting participants to projects on energy saving and sustainability who are already 'green'. A practice-based intervention design, however, enables both researchers and participants to reflect and deliberate on aspects of energy use that are not usually considered or challenged in more conventional behaviour-change programmes that focus on 'efficiency' (Labanca and Bertoldi, 2018). In our study, participants realized that improving the efficiency of existing behaviours was far from enough; rather, the socio-material underpinning of these behaviours must also be challenged. Practice-based intervention processes create a larger space for transformation than efficiency-oriented programmes, thereby enabling attention to be focused more on sufficiency-based change (Jensen and Friis, 2019).

Lastly, even if deliberate change processes are designed to allow participants to experiment with their own practices over time and space, such processes between participants and researchers are to some extent 'artificial', and thus it is uncertain that the changes will be maintained after the space for deliberation is dissolved, or after the follow-up period. Although these questions are discussed in detail in the intervention design (see Laakso et al., 2017), observing the permanence of changes is beyond this temporally bounded project.

## 6. Conclusions

This paper investigated a practice-based intervention that challenged heating-related practices and notions of comfort in countries with high actual and preferred indoor temperatures. The participants succeeded in reducing both temperatures by an average of 1 °C through learning new ways to 'heat people instead of space' and by feeling comfortable at cooler temperatures. This was despite the many intricate aspects of the participants' practices of thermal comfort, including opaque heating systems that were difficult to control, 'sticky' social conventions about colder indoor environments being inhospitable, and historically and culturally conditioned ways of understanding thermal comfort as a right and a sign of modernity and sovereignty.

The results provide several opportunities for learning across fields of research, practitioners and policy.

Our research approach could motivate further research on practice-based interventions involving a larger set of actors. Although such research is emerging, few examples exist of intervention processes that allow for experience-based deliberation and experimentation across extended time and space. Our approach could be complemented with existing frameworks (e.g., Hoolohan and Browne, 2020) for deliberating on and facilitating practice change with practitioners and policy makers, for which real-life experiences could provide a valuable input.

For practitioners implementing practice-based interventions, it is important to understand and address the differences both between and within countries during the intervention design phase. Practice-based interventions provide room for contextual adaptations as well as opportunities for the co-creation of knowledge with households and other local actors, adding valuable information on the aspects of practices specific to each context. A low-tech methodology allows a design that is inclusive and realisable in many contexts and applicable to various socio-economic groups. Moreover, designers and builders could utilize

the findings to extend their thinking towards how buildings can provide flexibility and sensitivity in achieving preferred levels of thermal comfort (Sherriff et al., 2019). However, there are some methodological challenges related to temporally bounded initiatives. As the experiences of participants illustrate, becoming accustomed to cooler temperatures requires time and occurs gradually, highlighting the importance of longitudinal research, embedding initiatives locally, and connecting them to similar projects, thereby providing an opportunity for participants to continue their transformation and ensuring a continued flow of resources and follow-up and evaluation processes.

The policy recommendations of this study stem from the entanglement of social, material, and cultural aspects of reducing energy use. As important as it is to support the renovation and retrofitting of buildings to lower their environmental impact, of equal significance is the alternative policy pathway of transforming comfort expectations and related practices (Luo et al., 2016). The findings of this study highlight that reconfiguring practices related to heating, challenging norms, and thus reducing residential energy use is a task that cannot be left solely to households by means of information provision or technological innovations. Climate change mitigation policies should address practices and their social, cultural, and material foundations.

The norms around thermal comfort are the result of official recommendations, the images created by commercial media, and expectations of temperatures in workplaces, day-care centres, and other spaces, among others. Practice-based interventions may reveal the areas that must be addressed in order to achieve appropriate and long-lasting changes, but they lack the mandate to realise these changes in all such areas. Thus, there is a need to include stakeholders and policy-makers in the process who can translate the findings into actionable legislation and to provide a space for this kind of deliberation in boardrooms and the corridors of power as much as in households (Watson, 2012). Public discussion that explores and challenges the justification for stable indoor temperatures and escalating expectations of thermal comfort could be one way to address these norms. Similarly, ideas related to sufficient energy or avoiding excess heating that are common in detached houses could be transferred to apartment buildings by, for example, increasing the visibility of energy use and heating systems in these dwellings. Moreover, if sustainability aims are to succeed, it is important to address material conditions such as increases in living areas.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgements

We are grateful to all the households who participated in this study as well as to the Danish, Finnish and Hungarian research teams for contributing to the data collection. We would also like to thank the anonymous reviewers for their detailed and constructive reviews. The research presented here received funding from the European Union's H2020 Research and Innovation programme under grant agreement number 727642. The sole responsibility for the content of this article lies with the authors.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jclepro.2021.127220>.

## Credit author statement

Senja Laakso contributed to the original study, analysis of the findings, theoretical conceptualization, and writing of the article. Charlotte

Louise Jensen contributed to the original study, analysis of the findings, theoretical conceptualization, and writing of the article. Edina Vadovics contributed to the original study, analysis of the findings, methodology, writing of the article, and visualisations. Eeva-Lotta Apajalahti contributed to the original study, analysis of the findings, and writing of the article. Freja Friis contributed to the original study, analysis of the findings, and writing of the article. Anita Szöllösy contributed to the original study and analysis of the findings.

## References

- Akrich, M., 1992. *The de-scription of technical objects. Shaping technology/building society* (Cambridge MIT Press, MA, pp. 205–224).
- Bolius, 2018. *Undersøgelse: Så varmt har danskerne det i deres hjem*. Online. <https://www.bolius.dk/undersogelse-saa-varmt-har-danskerne-det-i-deres-hjem-39458>. (Accessed 4 August 2019).
- Brown, A.L., 2016. Can people talk together about their practices? Focus groups, humour and the sensitive dynamics. *Area* 48 (2), 198–205.
- Cass, N., Faulconbridge, J., Connaughton, J., 2019. The Office. How standards define 'normal' design practices and work infrastructures. In: Shove, E., Trentmann, F. (Eds.), *Infrastructures in Practice. The Dynamics of Demand in Networked Societies*, pp. 77–89.
- Chappells, H., Shove, E., 2005. Debating the future of comfort: environmental sustainability, energy consumption and the indoor environment. *Build. Res. Inf.* 33 (1), 32–40.
- Devaney, L., Davies, A.R., 2017. Disrupting household food consumption through experimental HomeLabs: Outcomes, connections, contexts. *Journal of Consumer Culture* 17 (3), 823–844. <https://doi.org/10.1177/1469540516631153>.
- Fahy, F., et al., 2019. *Energy Demand Challenges in Europe: Implications for Policy, Planning and Practice*. Palgrave-Macmillan.
- Flyvbjerg, B., 2006. Five misunderstandings about case-study research. *Qualitative Inquiry* 12, 219–245. <https://doi.org/10.1177/1077800405284363>.
- Genus, A., Jensen, C.L., 2017. Beyond 'behaviour': the institutionalisation of practice and the case of energy-efficient lighting in Denmark. *J. Consum. Cult.* 19 (3), 340–358.
- Gram-Hanssen, K., 2011. Understanding change and continuity in residential energy consumption. *J. Consum. Cult.* 11 (1), 61–78.
- Greene, M., 2018. Socio-technical transitions and dynamics in everyday consumption practice. *Global Environ. Change* 52, 1–9.
- Greene, M., Fahy, F., 2020. Steering demand? Exploring the intersection of policy, practice and lives in energy systems change in Ireland. *Energy Res. Soc. Sci.* 61, 101331.
- Hansen, A.R., 2018. 'Sticky' energy practices: the impact of childhood and early adulthood experience on later energy consumption practices. *Energy Res. Soc. Sci.* 46, 125–139.
- Hasselkuß, M., Baedeker, C., Liedtke, C., 2016. Social practices as a main focus in living lab research. In: *Living Labs: Design and Assessment of Sustainable Living*, pp. 23–34.
- Heiskanen, E., Laakso, S., Matschoss, K., et al., 2018. Designing real-world laboratories for the reduction of residential energy use: articulating theories of change. *GAIA* 27 (S1), 60–67.
- Heiskanen, E., Laakso, S., Matschoss, K., Apajalahti, E.-L., 2019. *ENERGISE living lab country report - Finland*. Online. <http://doi.org/10.5281/zenodo.3354053>.
- Hitchings, R., 2012. People can talk about their practices. *Area* 44 (1), 61–67.
- Hoolohan, C., Browne, A.L., 2020. Design thinking for practice-based intervention: Co-producing the change points toolkit to unlock (un)sustainable practices. *Des. Stud.* 67, 102–132.
- Jensen, C.L., Goggins, G., Fahy, F., et al., 2018. Towards a practice-theoretical classification of sustainable energy consumption initiatives: insights from social scientific energy research in 30 European countries. *Energy Res. Soc. Sci.* 45, 297–306.
- Jensen, C.L., Friis, F., 2019. Experimenting with resource-intensive practices and related energy consumption levels. In: *Eceee Summer Study Proceedings: Panel 1: the Dynamics of Limitin (Energy) Consumption*, vol. 2019, pp. 47–54. *ECEEE Summer Study*. [http://energise-project.eu/sites/default/files/content/1-116-19\\_Jensen.pdf](http://energise-project.eu/sites/default/files/content/1-116-19_Jensen.pdf).
- Kajoskoski, T., 2019. *Effects of Contextual Factors on the Outcomes of Household Energy Use Interventions*. Master's Thesis, University of Helsinki. Online. <https://helda.helsinki.fi/handle/10138/307803>.
- Kuijter, L., Bakker, C., 2015. Of chalk and cheese: behaviour change and practice theory in sustainable design. *Int. J. Sustain. Eng.* 8 (3), 219–230.
- Kuijter, L., de Jong, A., 2012. Identifying design opportunities for reduced household resource consumption : exploring practices of thermal comfort. *J. Des. Res.* 10 (1/2), 67–85.
- Laakso, S., Heiskanen, E., 2017. *Good practice report: capturing cross-cultural interventions*. *ENERGISE. Deliverable 3.1*. Online: [http://www.energise-project.eu/sites/default/files/content/ENERGISE\\_D3.1\\_Good%20practice%20report%20capturing%20cross-cultural%20interventions\\_0.pdf](http://www.energise-project.eu/sites/default/files/content/ENERGISE_D3.1_Good%20practice%20report%20capturing%20cross-cultural%20interventions_0.pdf).
- Laakso, S., Heiskanen, E., Matschoss, K., 2017. *ENERGISE Living Labs background report*. *ENERGISE, Deliverable 3.2*. Online: [http://www.energise-project.eu/sites/default/files/content/ENERGISE\\_D3.2\\_141117\\_FINAL\\_0.pdf](http://www.energise-project.eu/sites/default/files/content/ENERGISE_D3.2_141117_FINAL_0.pdf).
- Laakso, S., Heiskanen, E., Matschoss, K., et al., 2021. The role of practice-based interventions in energy transitions: a framework for identifying types of work to scale up alternative practices. *Energy Res. Soc. Sci.* 71, 101861.
- Labanca, N., Bertoldi, P., 2018. Beyond energy efficiency and individual behaviours: policy insights from social practice theories. *Energy Pol.* 115, 494–502, 2018.
- Lorek, S., Spangenberg, J.H., 2019. Energy sufficiency through social innovation in housing. *Energy Policy* 126, 287–294. <https://doi.org/10.1016/j.enpol.2018.11.026>.
- Luo, M., de Dear, R., Ji, W., et al., 2016. The dynamics of thermal comfort expectations: the problem, challenge and implication. *Build. Environ.* 95, 322–329.
- Madsen, L.V., Gram-Hanssen, K., 2017. Understanding comfort and senses in social practice theory: insights from a Danish field study. *Energy Res. Soc. Sci.* 29, 86–94.
- Motiva, 2019. *Hallitse huonelämpötiloja*. Online: [https://www.motiva.fi/koti\\_ja\\_aminen/hyva\\_arki\\_kotona/hallitse\\_huonelampotiloja](https://www.motiva.fi/koti_ja_aminen/hyva_arki_kotona/hallitse_huonelampotiloja).
- Odyssee, 2019. *Energy consumption by end-use*. Online: <http://www.odyssee-mure.eu/publications/efficiency-by-sector/households/energy-consumption-by-end-use.html>. (Accessed 15 May 2019).
- Rinkinen, J., 2019. Chopping, stacking and burning wood: rhythms and variations in provision. In: Shove, E., Trentmann, F. (Eds.), *Infrastructures in Practice: the Dynamics of Demand in Networked Societies*. Routledge.
- Sahakian, M., Rau, H., Grealis, E., et al., 2021. Challenging social norms to recraft practices: a Living Lab approach to reducing household energy use in eight European countries. *Energy Res. Soc. Sci.* 72, 101881.
- Scott, K., Bakker, C., Quist, J., 2012. Designing change by living change. *Design Studies* 33 (3), 279–297. <https://doi.org/10.1016/j.destud.2011.08.002>.
- Sherriff, G., Moore, T., Berry, S., et al., 2019. Coping with extremes, creating comfort: user experiences of 'low-energy' homes in Australia. *Energy Res. Soc. Sci.* 51, 44–54.
- Shove, E., 2003. *Comfort, Cleanliness and Convenience: the Social Organization of Normality*. Berg, Oxford/New York.
- Shove, E., 2012. *Energy Transitions in Practices: the case of global indoor climate change*. In: Verbong, G., Loorbach, D. (Eds.), *Governing the Energy Transition*, pp. 51–74.
- Shove, E., Walker, G., 2014. What is energy for? Social practice and energy demand. *Theor. Cult. Soc.* 31 (5), 41–58.
- Thomas, S., Rosenow, J., 2019. *Energy Consumption in Europe: why is it increasing and what are the policy implications*. Policy and Governance, ECEEE Summer Study Proceedings.
- TNM Decree No. 7, 2006. (V. 24.) az épületek energetikai jellemzőinek meghatározásáról (on determining the energy performance of buildings in Hungary). Online: <https://n.et.jogtar.hu/jogszabaly?docid=A0600007.TNM>. (Accessed 10 July 2019).
- Vadovics, E., Goggins, G. (Eds.), 2019. *ENERGISE Living Labs – Methodology, Experience and Lessons Learned*. *ENERGISE, Deliverable 7.12*. Online: [http://www.energise-project.eu/sites/default/files/content/D7.12\\_ENERGISE\\_LivingLabs\\_spread.pdf](http://www.energise-project.eu/sites/default/files/content/D7.12_ENERGISE_LivingLabs_spread.pdf).
- Vadovics, E., Pap-Szuromi, O., 2019. *ENERGISE living lab country report - Hungary*. Online: <https://zenodo.org/record/3345849#.XT8kflzbDc>.
- Warde, A., 2005. Consumption and theories of practice. *J. Consum. Cult.* 5 (2), 131–153.
- Watson, M., 2012. How theories of practice can inform transitions to a decarbonized transport system. *J. Transport Geogr.* 24, 488–496.
- Wilhite, H., 2008. New thinking on the agentive relationship between end-use technologies and energy-using practices. *Energy Effic.* 1, 121–130.