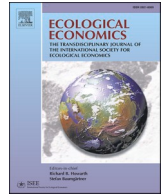




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Methodological and Ideological Options

The Grounded Survey – An integrative mixed method for scrutinizing household energy behavior

Maria Csutora, Agnes Zsoka, Gabor Harangozo^{*}

Corvinus University of Budapest, 8 Fovam ter, Budapest 1093, Hungary

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ABSTRACT

Sustainable energy policy and tackling climate-change-related issues require exploring energy consumption patterns. This paper proposes an integrative methodological approach called grounded survey for understanding behavioral factors behind household energy consumption. The study aims to overcome the restrictions of both quantitative and qualitative studies by combining participatory-systems-mapping (PSM) based focus group research with a quantitative survey. Focus groups were used to highlight common patterns, which helped formulate survey questions specifically into understudied areas of energy-related behavior. The survey helped validate these qualitatively grounded questions, while generating generalizable quantitative results based on a representative sample. Finally, a comparative assessment contrasted the comprehensive qualitative analysis with the survey findings. Two causal loop diagrams of common patterns are employed to illustrate the methodological model. This integrative approach deepens understanding of behavioral factors behind energy consumption and provides policy recommendations to strengthen the relationship between heating-related behavior and heating costs. The grounded survey method can be utilized in studying wicked or paradox problems in which the relationship between behavioral and technical factors are complex and possibilities for intervention are limited. The application of the model is suggested in areas where development can only be achieved through behavioral change.

1. Introduction

The international struggle to cope with climate change and national efforts to create sustainable energy policy both require an increase in our understanding of household energy consumption patterns. By doing this, we can develop more effective policies for improving energy efficiency and decreasing carbon footprints (Boardman, 2004; Ameli and Brandt, 2015). Both qualitative and quantitative techniques are used in this field; however, these methods are usually applied separately.

Quantitative tools (e.g. surveys) can create the basis for statistical analysis and increase the validity of decision preparation. However, blocks of questions related to household consumption surveys usually follow similar patterns that are mainly related to the socio-economic and technical characteristics of households (Joon et al., 2009; Ekholm et al., 2010), and fail to properly cover behavioral factors (Yun and Steemers, 2011).

Qualitative research, on the other hand (for example, focus group discussions, mind mapping, or system mapping as forms of participatory- or grounded-theory-based research), which is designed to

understand the drivers of energy behavior, can help highlight the views and ideas of stakeholders directly (Király et al., 2014; Kiss et al., 2018). However, the validity of the outcomes of such an approach may be low, and it is difficult to base policy instruments on the related results. System mapping (e.g. Sedlacko et al., 2014) puts the focus on describing systems as closed units, so it is difficult to link these with external factors.

This paper develops an integrative approach that increases understanding of household energy behavior, in which qualitative methods (system mapping, causal loop diagrams, and pattern analysis) serve as the basis for a grounded survey, the results of which are reinterpreted through a qualitative analytical process. Our approach – novel in household energy behavior research – combines the benefits of qualitative and quantitative methods, and can better serve the needs of stakeholders and policy makers, as well as deliver more valid and reliable results.

The paper is structured as follows. Section 2 provides an overview of the widespread qualitative and quantitative approaches to modeling the factors behind household energy consumption patterns and argues that

^{*} Corresponding author.

E-mail addresses: maria.csutora@uni-corvinus.hu (M. Csutora), gabor.harangozo@uni-corvinus.hu (G. Harangozo).

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integrative methods can combine the benefits of these two approaches and improve decision making. Section 3 describes the background of pattern analysis and the grounded survey, while Section 4 introduces the case study and research design. Section 5 and 6 present and discuss results, while Section 7 concludes.

2. Literature review: using quantitative, qualitative, and integrative methodologies to assess the behavioral factors behind household energy consumption

The following chapter includes a summary of the main methodologies which have been used so far to assess the behavioral factors associated with sustainable consumption; more specifically, household energy consumption. The focus is on the methodologies themselves (their scope, application, limitations, and the potential for combining them with each other). The authors review the literature, complemented by their own research experience, with a view to promoting the more conscious use of integrative analyses.

The literature agrees that behavioral factors are crucial for promoting sustainable consumption (see Carragher et al., 2017 for a comprehensive summary). “As lifestyles improve throughout the world CO₂ emissions are rising whereby a doubling of income leads to 81% more CO₂ emissions” (UNEP, 2010, quoted by Carragher et al., 2017, p.1.). In terms of combating climate change, behavioral interventions prove to be one of the most effective methods due to their high level of efficiency and thus high internal rate of return on investment.

2.1. Quantitative methods

Quantitative tools (e.g. surveys, or analyses based on large national databases) that assess the factors behind household energy consumption are typically the basis for statistical analysis and increase decision preparation validity. When modeling household-level energy consumption, three major groups of parameters are usually studied (often separately, and not necessarily in each field): i) the socio-economic characteristics of respondents; ii) the technical parameters of dwellings; and, iii) the attitudes and behavioral factors involved in energy consumption.

Regarding *socioeconomic factors*, income has been found to be both a major driver of energy consumption (Xiaohua and Zhenming, 1996) as well as a significant driver of energy-related awareness (Joon et al., 2009). Additionally, Ekholm et al. (2010) found the presence of financing, subsidy schemes, and low interest rates are significant in terms of energy-conscious household-level consumption patterns. Yu et al. (2013) studied the rebound effect in relationship to income, finding it to be relevant for some product groups (air conditioners, cars, washing machines), and irrelevant for others (refrigerators, electric fans, computers, etc.). Alberini et al. (2016) claim that financial incentives may result in both free-riding (households may have been intending to improve their energy efficiency prior to any stimuli) and upscaling (increasing energy efficiency through financial incentives may increase consumption, causing a rebound effect) and thus decreasing gains. Interestingly, Chen et al. (2013) found occupants' age to be the most important driver of household energy consumption, with younger occupants tending to consume more energy, although income level was also found to be relevant. Fong et al. (2007) focused on lifestyle-related variables, finding that energy consumption is positively linked to family size (although per-capita energy consumption is lower in larger families), while pensioners and housewives consume more energy than employed persons and students. Among the employed, Fong et al. (2007) find that consumption increases in line with age, in opposition to the findings of Chen et al. (2013).

A quantitative methodological approach is also applicable for evaluating *technical factors*. Zheng et al. (2014) and Tonooka et al. (2006) analyzed a variety of the former related to dwelling characteristics, kitchen and home appliances, space heating and cooling options, types

of residential transportation and electricity billing, metering and pricing options. Results show that these technical options (especially the geographical location of the dwelling – urban or rural) play a major role in energy consumption patterns. Druckman and Jackson (2008) found the type of dwelling, tenure, household composition, and rural/urban location to be significant for the UK. Pachauri and Jiang (2008) and Hu et al. (2017) investigated socio-economic and technical factors in a study involving India and China, finding both groups of factors to be relevant.

Only a smaller fraction of quantitative studies cover *attitudes and behavioral factors* in relationship to household energy consumption. In an early study, Seligman et al. (1979) modeled energy consumption using attitudinal factors and found that related variables (such as the individual's role in energy saving, belief in science, attitude to the energy crisis, and efforts to conserve energy) affected as much as 42–55% of total household energy consumption. Yun and Steemers (2011), from a study of household-cooling-related energy consumption patterns, found that behavioral factors (e.g. number of rooms cooled, or the frequency of use of air conditioning) were more decisive than the role of other (technical or socio-economic) factors. Steemers and Yun (2009) state that socioeconomic factors do not fully explain energy consumption patterns, thus understanding behavioral factors is also essential, even though the most important factor influencing consumption is climate. Poortinga et al. (2004) approached household-level energy consumption from an attitudinal and quality-of-life perspective, albeit concluding that these factors are less significant drivers. In a German study, Oberst et al. (2019) detected no difference between the household energy consumption of prosumers and non-prosumers.

The main limitation of quantitative methodologies (e.g. surveys) is the difficulty of predicting individual behavior. This hinders the building of models that incorporate the interrelationships related to the behavioral component of energy consumption. The latter is often significantly underestimated in surveys, as question blocks related to household consumption often follow a similar pattern to commonly used questionnaires, covering apartment characteristics, financial options for refurbishment/insulation, income, education, etc. (factors which are difficult to influence using policy measures, unlike behavioral elements). Even when behavioral aspects are covered, researchers may find it difficult to imagine themselves in the situation of respondents and identify relevant measures.

2.2. Qualitative methods

Research using *qualitative methodologies* aims to close this gap and provide deeper insight into behavioral patterns of household energy consumption. Abrahamse et al. (2005), Whitmarsh et al. (2013), Karlin et al. (2015), Milfont and Markowitz (2016), as well as Carragher et al. (2017) suggest that, beyond measuring energy consumption in kWh, further information related to the subjective experience of respondents is necessary for understanding the most effective behavior-based energy interventions. The former identified the most important factors that may enable individual- and community-level consumption behavior that can foster the sustainability transition, including the consumption of household energy. The 109 factors identified in the latter study were tested in several communities, and a comparative study about the utility of different behavior-oriented consumer policy measures was produced, supplemented by a workshop for policy makers, resource use specialists, and communities to help them design sustainability policies for behavior change.

Hendrickson (2010) also argues that, to alter consumption patterns, participatory approaches are required which can effectively be used to embed performance targets into policies that raise and deepen awareness of sustainable consumption. Vaidya (2016) illustrated different types of participatory approaches using thirteen case studies, finding that the participatory assessment approach represents a holistic method for measuring sustainability. Including local stakeholders into the assessment process has been found to help with monitoring the progress

of communities as regards sustainable consumption, to deepen understanding of socioecological systems, and to strengthen the relationship between experts and non-experts (Gibson, 2006; Fraser et al., 2006). Vergragt et al. (2018) used participatory methods to better understand the context of decoupling urban footprints from urban quality of life. Salvia et al. (2015) engaged more than 500 tenants of public housing in Milan using interview techniques to understand their energy consumption behavior with respect to four factors: i) thermal comfort, ideal temperature, ii) adaptation to routines and family needs, iii) skills and preferences with the thermo-regulating devices, and iv) expenses and perceived value attribution to the cost of renting, compared to the cost of energy. Furthermore, environmental information has been found to be an important driver of environmentally sound behavior (Solér et al., 2010).

One limitation of qualitative methodologies is the related diversity and individual nature of results. Vaidya (2016) highlights that this can make it very hard to formulate clear policy recommendations. For example, causal loop diagrams created by limited numbers of focus groups can deepen understanding of a problem, but making further generalizations about wider society from them is difficult. Although quantitative approaches have been criticized as being derived from linear, reductionist paradigms that ignore context and are inadequate for systemic research, qualitative research that provides explanations without the use of empirical data may be nonreplicable, unverifiable, and lack credibility.

2.3. Integrative methods

Considering the benefits and limitations of quantitative and qualitative methodologies related to household energy behavior, the *integration of methodologies* appears to be a reasonable approach for adding value and creating more comprehensive research results. Sells et al. (1995) criticized the practice of presenting quantitative and qualitative approaches as oppositional (involving a forced choice between the two), as both have their merits and drawbacks: the issue is rather how the approaches can be integrative, and what benefits could stem from this. The history of participatory system mapping (PSM) and the instinct of some quantitative researchers to apply qualitative techniques suggest that such integration is beneficial and could contribute to better understanding and solving complex sustainability problems like household energy behavior.

The origins of PSM, a focus-group-based qualitative technique, can be traced back to system dynamics, a strictly quantitative simulation method (which can be considered an integrative method if not only the links between variables but also the weights of causal relationships are addressed). Building on Warren (1995), Mendoza and Prabhu (2006) differentiated three types of soft system dynamics models: cognitive mapping, qualitative system dynamics, and fuzzy cognitive mapping, each involving different levels of complexity. In fuzzy cognitive mapping, even the weights of causal relationships are quantified, relying on a participatory process. Reed et al. (2013) used the method for scenario analysis, obtaining participants' opinions about the impacts and likelihood of different scenarios. Fuzzy cognitive participatory analysis was initially used to identify variables and weights of variables in simulation models whenever technical information was not available, mainly in developing countries. Participatory workshops served to produce variables and estimates of weights through educated guesswork and mutual agreement, which were then used in a similar way to weights derived from technical information. Later, the methodology was used by Mendoza and Prabhu (2006) in industrialized countries to obtain valuable insights from stakeholders as a process-based method involving soft-system dynamics. The former warn, however, that "insights from participatory models are generally broad and tend to be strategic in nature rather than operational or tactical" (p.181). Outcome models thus can be used as problem-structuring- rather than problem-solving models.

Sedlacko et al. (2014) and Király et al. (2014) used PSM in relation to sustainable consumption in order to understand and cope with the complexity of interconnections and motivations involved in formulating policies. Facilitated group process were used to develop and assess causal loop diagrams and provide insight. Videira et al. (2009) developed causal loop diagrams for Baixo Guadiana using a participatory modeling process using the insights and experiences of stakeholders. The outcome of this research was simulation models with different scenarios based on parameters that helped in the decision-making process.

Some researchers permit external effects, keeping PSM maps open (see Videira et al., 2009, Mendoza and Prabhu, 2006, Reed et al., 2013, and Inam et al., 2015), while others insist on keeping such maps closed (Sedlacko et al., 2014).

Bernardo and D'Alessandro (2019) also used integrative methodology to transform their qualitative map into a quantitative system dynamic model for evaluating the effect of strategic environmental action plans on social, economic, and environmental indicators. Lich et al. (2013) applied a similar approach, using qualitative models to frame how different variables relate to each another, followed by a quantitative one to understand and interpret the results thereof.

PSM methodology, however, is not typically combined with surveys, nor used for problems that can be mainly addressed at a national level. Our research shows that PSM and causal-loop analysis may add value even when beyond-local-level issues are addressed. When PSM is combined with the survey method, the validity of local knowledge can be broadened and generalized, helping solve problems that impact more stakeholders.

Some researchers have used qualitative techniques to support surveys and improve the quality of analysis. Bauwens and Eyre (2017) studied community-based energy projects, seeking to understand how energy cooperatives influence the behavior of their members by creating or changing social norms. The research was survey-based, but non-structured interviews were carried out with managers, employees, and members of the cooperative to better understand the underlying factors that might otherwise be missed. Webber et al. (2016) carried out a more conventional survey of household energy behavior that still involved the local community and a health authority in the development of survey questions. Jensen et al. (2018) highlight the importance of complex interactions in the energy-related behavior of households, and analyze the dynamics of initiatives targeted at behavior change.

Integrating different methods requires extra effort and resources, thus a solid strategy is needed for accomplishing this task. However, there is little consensus about how to combine these methods. While qualitative methods are associated with inductive, subjective, and contextual research goals, quantitative methods are applied to deductive, objective and general ones. Integrative research challenges how the two approaches can be combined to add extra value. Our research is motivated by what Morgan (2013) calls "sequential contributions"; i.e., using the strengths of qualitative methods to enhance the performance of survey-based methods.

3. Proposed model: the grounded survey

Earlier studies have integrated systems mapping with participatory research with no demand for more generalizable results. Thus, the related conclusions are limited to specific case studies. Our study makes the point that PSM and survey methodology can be combined to produce an outcome that has implications that go beyond those of local case studies and quantitative findings.

The benefits of combining the two methodologies are twofold. PSM can improve the quality and validity of survey tools, helping produce questions that are highly relevant from a stakeholder perspective but which might be overlooked by survey researchers whose work is fed mainly by previous studies and abstract topic knowledge.

PSM also benefits from the use of the survey tool, as the latter serves as a validity check for a broader population. Surveys may underline the

relevance of an issue that goes beyond the case study group, making it more policy relevant. According to [Martinuzzi and Scholl \(2016\)](#), greater emphasis should be placed on policymakers' needs in research strategy. Furthermore, the survey method allows for comparative assessments between groups, thus facilitating differentiation between cultural impacts, group impacts, situational impacts, and the impact of individual behavior on energy-saving patterns.

Based on these benefits, we propose the use of a "grounded survey" ([Fig. 1](#)), which:

- integrates PSM and quantitative survey methodology;
- builds on participatory system mapping, thus involves stakeholder groups in framing the survey tool;
- absorbs former knowledge from quantitative surveys, and
- is transdisciplinary research as it "aims at identifying, structuring, analysing and handling, issues in problem fields with the aspiration of 'grasp[ing] the relevant complexity of a problem (b) tak[ing] into account the diversity of life-world and scientific perceptions of problems, (c) link[ing] abstract and case-specific knowledge, and (d) develop[ing] knowledge and practices that promote what is perceived to be the common good" ([Pohl and Hirsch Hadorn, 2007](#), p.4).

Pattern analysis serves as a bridging technique that links qualitative and quantitative methods by helping identify recurring, generalizable patterns in repeated focus group studies and transforming those patterns into variables for use in surveys.

Our model is based on a number of causal loop diagrams developed by stakeholder focus groups. Such diagrams are regarded as mental models of a stakeholder focus groups that represent their reflection of reality, rather than reality per se. Accordingly, different causal loop diagrams can be developed by different focus groups that may share some recurring patterns, but which are also likely to be dissimilar in

some ways. Recurring patterns reflect general complexities that may be relevant for a wider stakeholder population. Dissimilarities reflect the specific characteristics of individual focus groups and the dynamics of the group process. None of the resulting causal loops can be used as a single system map or model of reality itself. However, recurring patterns can help build up a more robust model and their validity can be tested on a broader population.

We allow for outside effects in our model which cannot be controlled and/or captured by focus group participants. Our system is thus not closed. Participants were not forced to offer opinions on issues they were not competent about or comfortable with.

The main added value of our grounded analysis is how it facilitates the exploration of patterns which result from qualitative research based on repeated focus group discussions. Recurring patterns provide an insight into crucial challenges and recognizable strategies regarding the heating behavior of households. Patterns which were considered to be generalizable were transformed into variables and applied as survey questions for quantitative testing. The low cost of this type of research is also beneficial.

After survey implementation, pattern analysis is used in a reverse direction: the survey results are contrasted with expectations that arose in the focus group discussions, helping to test their generalizability.

4. Research design and methodologies

The case study used for the integrative approach in this paper was developed within the framework of the ENABLE.EU research project (November 2016 - January 2020), where the Regional Centre for Energy Policy Research (REKK) was responsible for the 'Heating & Cooling' case study. This was designed to increase understanding of the factors behind household heating and cooling behavior. It draws on qualitative and quantitative research findings obtained in five countries: France, Germany, Hungary, Spain, and Ukraine.

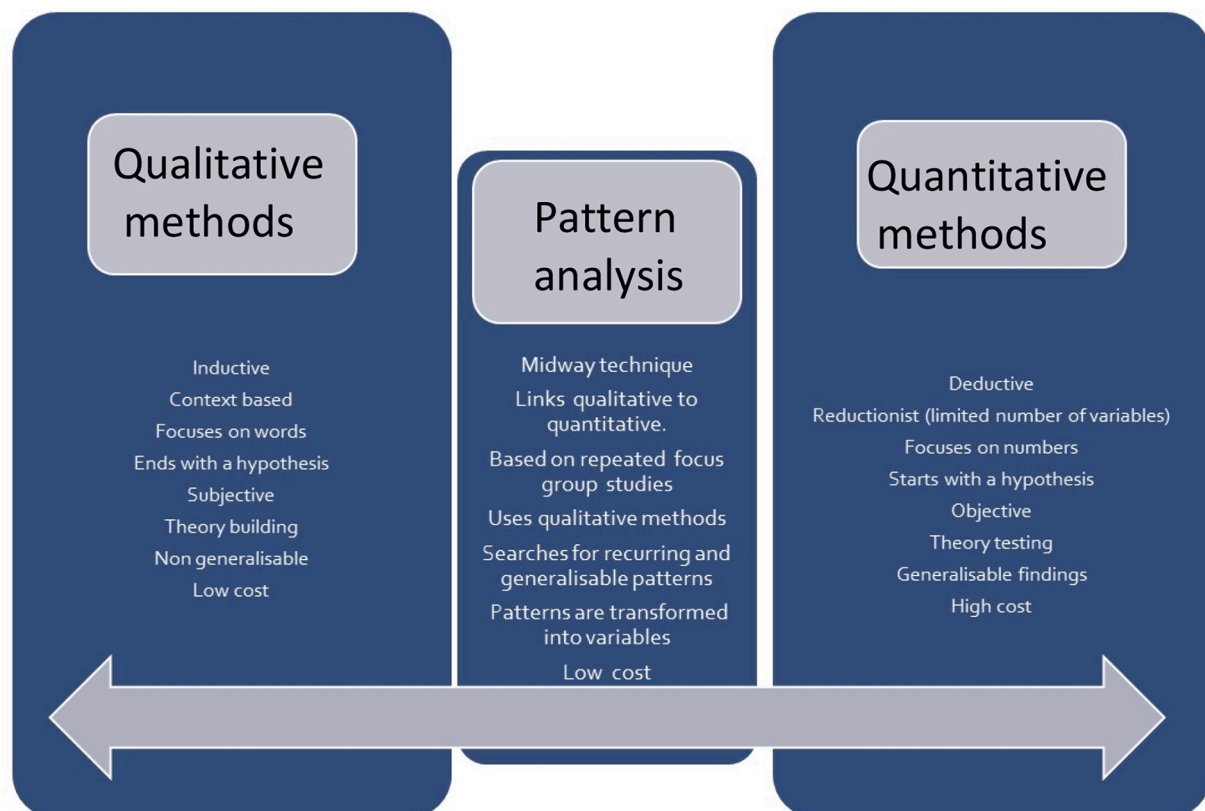


Fig. 1. Model of grounded survey (authors' compilation).

The research project was designed to reveal the economic constraints, demographic diversity, and the role of personal values in heating/cooling habits, as well as to investigate possible triple-dividend strategies for efficient low-carbon options. Triple-dividend options deliver economic, environmental, and social benefits simultaneously (e.g. a decrease in carbon footprint, utility cost, and energy dependency).

The case study channeled in citizens' perspectives regarding the behavioral aspects of energy use and saving in heating and cooling, and investigated under-researched behavioral factors that promote or hinder lifestyle changes in relation to reducing energy consumption.

The process of integrative research is illustrated in Fig. 2.

The major research steps are summarized in Table 1.

5. Results

5.1. Focus group results and pattern analysis

Using the PSM technique (e.g. Sedlacko et al., 2014), each focus group prepared a system map of challenges and potential strategies for reducing heating-related costs. During the pattern analysis phase we compared these maps and identified similar loops (causal loops) of challenges and strategies on the maps. Fig. 3 and Fig. 4 are two illustrative maps compiled in Hungary. For explanatory purposes, causal loops of four different issues (each indicated by a single color) are explained in more detail below.

The *green areas* indicate similar loops of *habit-related challenges to managing indoor room temperature*. The laypeople focus groups realized the impact of modifying expected thermal comfort on driving down heating costs, and the importance of heating habits in relation to the variable needs of people of different ages and health conditions (e.g. higher temperature for elderly and children). However, there was some disagreement about whether using a fixed temperature for the full season or adjusting the temperature according to need was more efficient way of reducing the heating bill. The answer to this dilemma was only identified in the survey. The option of heating rooms in a different way arose in both focus groups.

These assumptions were later tested in the survey. As an illustration, survey questions regarding heating habits included the following:

- What is the usual temperature in your dwelling when you are at home during i) the winter, and ii) the summer?
- Which of the following best describes the way you heat your dwelling? (Give only ONE answer)

- a) The temperature is the same in all rooms.
- b) We heat only rooms that are in use.

Brown areas indicate the *challenge of obtaining meaningful information* in relation to heating-related decisions. In most countries, interesting disagreement was identified between laypeople and experts regarding the importance of information dissemination in driving energy savings. In Hungary, laypeople groups showed strong resistance to increasing information from central sources (government, energy suppliers, etc.). They felt overwhelmed with information, and lacked trust. However, they seemed somewhat more open towards receiving word-of-mouth information and practical advice on what to do (and how) to save energy from local sources (e.g. gas fitters, general practitioners, local media, the internet). Expert focus groups, however, emphasized that people needed more easily interpretable information about energy consumption (potentially, comparisons of consumption to previous periods of time, or to the energy consumption of neighbors).

So, unlike laypeople, experts preferred to provide information rather than advice, thereby leaving the final decision to laypeople. Thus, the potential role information could play in energy saving was tested in the survey. The following related elements were formulated in the policy section of the survey:

- Please indicate on a scale from 1 to 5 how much the following factors influence your heating/cooling energy savings.

- a) I don't get frequent enough feedback about my actual energy consumption.
- b) My energy bill is too complicated, I cannot interpret it.

- How much would the following measures help you to reduce your heating and cooling energy consumption? Please indicate on a scale from 1 to 5

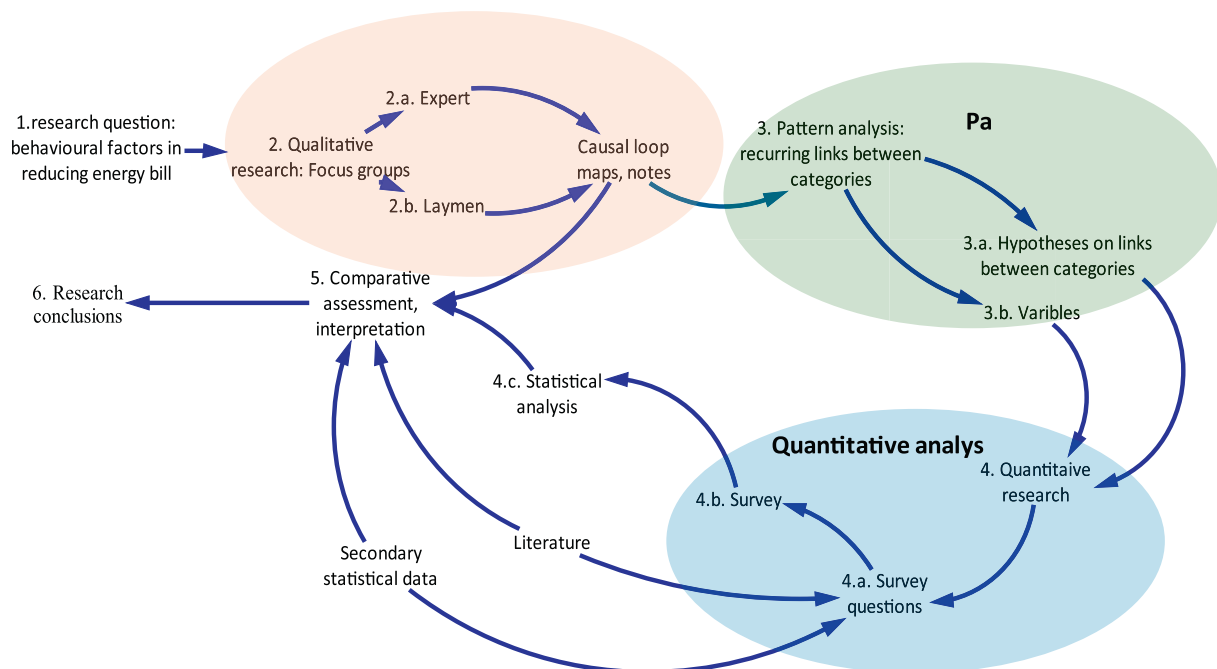


Fig. 2. Research design for the case study (Authors' compilation).

Table 1

Description of research process (Source: authors' compilation).

1. Framing focal question	The first step in the qualitative research was framing the focal research question: "How can households reduce their heating costs?" The heating bill was used as a quantitative indicator of official energy consumption. Several alternative focal issues were considered before deciding on the questions: "How can energy consumption be reduced?" and "How can CO2 emissions be reduced?" We identified questions that could be clearly interpreted by residents that involve individual behavioral change.
2. Qualitative study and analysis	A major part of the study involved laypeople and expert focus groups. Work was based on system maps, causal loop diagrams, and PSM (Sedlacko et al., 2014). Focus group participants worked on identifying the challenges they face when trying to reduce their heating costs and related energy consumption. They also identified the strategies and policy options that could help them cope with these challenges, and visualized the connections between the challenges and strategies. They were also asked about modifying factors that could catalyze or hinder those changes, such as energy price, general level of energy awareness, and level of education. Twenty-four focus groups were organized between May 2017 and January 2018, 18 with laypeople and 6 with experts (5 in France, 4 in Germany, 5 in Hungary, 2 in Spain and 8 in Ukraine).
3. Pattern analysis	Common patterns were identified and analyzed in terms of challenges and strategies, both on a national level and in the international context. The use of laypeople and expert groups in parallel also shed light on the different perspectives these agents had regarding energy-related information. Unique ideas from each focus group were distinguished from the more general patterns that were shared by several groups. Common patterns served as the basis for survey questions in the next phase.
4. Quantitative survey and analysis	Surveys were conducted in each country and then merged into a single database. The international household survey helped test the relevance of identified challenges and policy options at the national and international level, and to reveal cultural and behavioral differences across the case-study countries. The household survey was conducted in the first half of 2018, involving collecting data from 5006 households (700–1500 from different countries), representative in all subsamples.
5. Comparative assessment and interpretation	All information from the focus groups, survey, desk research, and secondary databases was fed into the comparative assessment phase. After survey implementation, pattern analysis was also used in a reverse direction: survey results were contrasted with the expectations that had previously emerged from the focus group discussions. The findings of the draft country case studies were also compared with the outcomes of statistical data analysis in all the countries involved. The comparative assessment phase revealed cultural and behavioral differences across countries, as well as the common behavioral patterns and common challenges people share. Notes, transcripts, and causal loops from qualitative research helped when statistical analysis produced unpredictable results that were difficult to interpret.
6. Research conclusions	The results of the integrative research were used to evaluate household energy behavior and became the foundation for policy recommendations.

a) Receiving feedback on your energy consumption that is comparable to that of previous periods, or to that of your neighborhood/similar households.

b) Receiving more/more easily understandable information about smart and easy techniques for lowering energy consumption.

c) Receiving regular energy-saving tips and reminders from your supplier to engage in energy-saving action.

d) Getting targeted advice about energy saving opportunities from independent experts in the frame of an "Energy-saving counselor" program.

Blue areas relate to the discussion about *how the ability to control indoor temperature affects heating costs*. Focus group results suggest that it makes a difference (in terms of heating costs) whether residents are able to adjust the temperature within their apartment or house, either manually or using a thermostat. Focus groups tended to assume that overheating would be more of an issue in houses in which room temperature could not be controlled. To test this assumption, the following question was formulated in the survey:

- How does your household control the main heating apparatus?

- a) Set one temperature, and leave it there most of the time.
- b) Manually adjust the temperature (e.g. at night, or when nobody is at home).
- c) Program the thermostat to automatically adjust the temperature during the day and night at certain times.
- d) Our household cannot control the heating equipment.

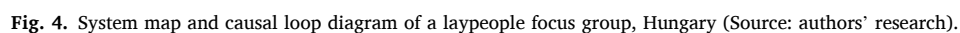
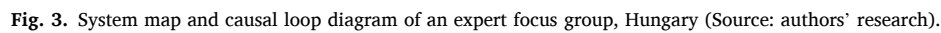
Beyond providing input for the pattern analysis and the formulation of appropriate survey questions, the qualitative study also helped with the comprehensive analysis of the participating countries. The latter focused on common challenges and strategies in the five countries using the results of all focus groups. Common challenges raised in all or most participating countries included both the widely studied and understudied features of heating- and cooling-related household energy consumption. The *Yellow area* indicates the challenge that *energy-conscious heating behavior does not necessarily lead to lower energy costs*. Several focus groups in France, Germany, and Hungary pointed out that distributing the energy bill in multi-apartment houses among residents (i.e. requiring everyone to pay a fee proportional to the floor area of their apartment) often results in a lack of motivation to save energy by heating more rationally, as heating bills do not directly depend on the heating behavior of individual households but rather on the behavior of the whole dwelling. Accordingly, the energy costs of some residents can be high even if they are very energy-conscious. Additionally, conflicts between tenants and landlords arise from landlords not being interested in investing into more efficient heating systems or insulation, even if such investments could increase the value of their properties. Tenants are more concerned by this issue, but they often have no voice in decisions about investments within dwellings. The decision-making processes of tenants in multiple occupancy dwellings (such as majority voting) and other financial commitments may also hinder the necessary investment into renovating houses or heating systems. The comprehensive qualitative study provided important input to the phase of comparative assessment of quantitative and qualitative results. Based on the focus group results, the following questions were formulated:

What are the major challenges you would face if you wanted to reduce the heating/cooling costs of your household? Please indicate on a scale from 1 to 5 how much the following statements describe your situation!

1. In the dwelling in which I live, the owner and the tenant are not the same person, and at least one of them does not want to invest in energy-saving measures.
2. Besides my own energy consumption habits, my energy bill also depends on the energy consumption of other households in the dwelling.

5.2. Contrasting qualitative assumptions with quantitative results

The results of the comprehensive qualitative analysis were contrasted with the survey results in a comparative assessment to improve



Compared to the all-country average (20–21 degrees Celsius), overheating is more common in Hungary and Germany. In Hungary, two-

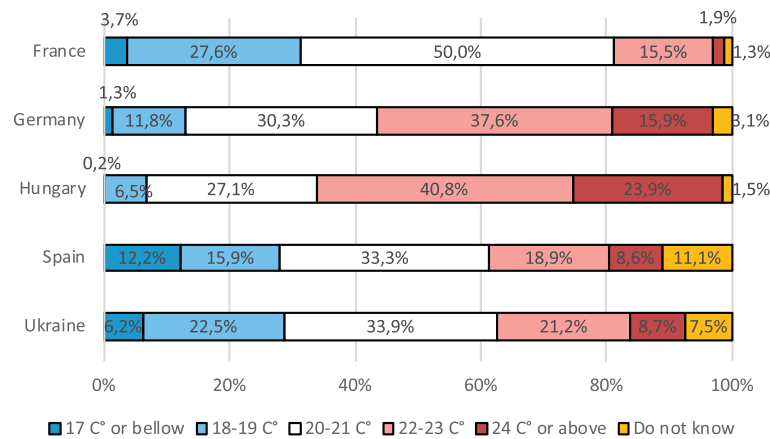


Fig. 5. Indoor winter temperature in the case study countries ($N = 5006$) (Source: authors' research).

thirds of respondents heat their homes to at least 23 degrees, and almost every fourth person maintains a temperature of at least 24 degrees Celsius in winter. In contrast, a French expert found a temperature of 20–21 degrees Celsius to be too high, as French regulations suggest an ideal temperature of 19 degrees Celsius. This phenomenon can be explained by overcompensation for a cold winter climate, cultural factors, and, in Hungary, the limited availability of temperature-management options and the impact of a legacy of low energy prices.

The factor of overcompensating for weather arose in the qualitative research, but its extent was only shown in the survey (Table 2).

The survey indicated that 25.6% of respondents keep their homes warmer in winter than in summer. Winter overheating and summer overcooling waste resources, lead to higher carbon emissions, and have negative health effects. When entering/exiting an air-conditioned building from/to outdoors people may suffer not only thermal discomfort but potential health problems (Jing et al., 2015). Indoor temperature has significant impact on energy consumption and may explain the significant variation in energy consumption under otherwise similar conditions.

Based on the focus group discussion, it was assumed that the elderly would set a higher indoor temperature in the winter as they would feel chilly and spend more time at home. This was not, however, confirmed by survey results. On the contrary, the homes of older residents had lower winter temperatures, a situation which cannot be explained by their generally lower income. To explain this phenomenon we again draw on the lessons from the focus group study, which reported changing habits over generations. In the past, people used to warm up by

dressing in layers, while younger people now tend to heat their homes and dress in lighter clothes. Early socialization for austerity and frugality may have led to this emphasis on thrift of the elderly, which overrides the demand for comfort.

Related to the loop associated with *getting meaningful information*, qualitative research was inconclusive about whether significant behavioral change can be achieved by providing more/easily understandable information to citizens. Survey results revealed cultural differences that were striking in this respect (Fig. 6). Hungarians were extremely negative about this option compared to other countries. This suggests a low level of trust between service providers and consumers, and less trust in top-down information.

Hungarians are also significantly less open to *receiving practical advice* than citizens of the four other countries that were surveyed (Fig. 7).

This has significant implications for policymaking. Experts should re-evaluate policy options, as their suggestion of providing more meaningful information does not trigger public support.

Regarding the *ability to control indoor temperature*, survey findings contrasted with the expectations expressed by focus groups.

The highest winter indoor temperature was identified for dwellings in which people can control indoor temperature, but only manually. Dwellings with thermostats were the least overheated, followed by dwellings where the supplier has exclusive control over the temperature (Fig. 8).

Testing the *influence of behavioral factors on energy costs* quantitatively using regression analysis for the whole sample indicated that the role of behavioral factors in shaping energy costs is small compared to

Table 2

The phenomenon of weather overcompensation in the sample ($N = 5006$) (Source: authors' research).

		Summer temperature						Total
		24 C° or above	22-23 C°	20-21 C°	18-19 C°	17 C° or below	Do not know	
Winter temperature	24 C° or above	2,9%	1,4%	2,5%	1,8%	1,8%	0,4%	10,8%
	22-23 C°	7,9%	5,1%	6,4%	3,3%	1,3%	1,4%	25,5%
	20-21 C°	10,7%	8,4%	9,1%	4,2%	1,8%	2,6%	36,7%
	18-19 C°	5,0%	4,7%	3,6%	2,5%	1,1%	1,3%	18,2%
	17 C° or below	2,5%	0,6%	0,8%	0,2%	0,2%	0,2%	4,5%
	Do not know	0,4%	0,2%	0,2%	0,0%		3,6%	4,4%
Total		29,3%	20,4%	22,6%	12,1%	6,2%	9,4%	100,0%

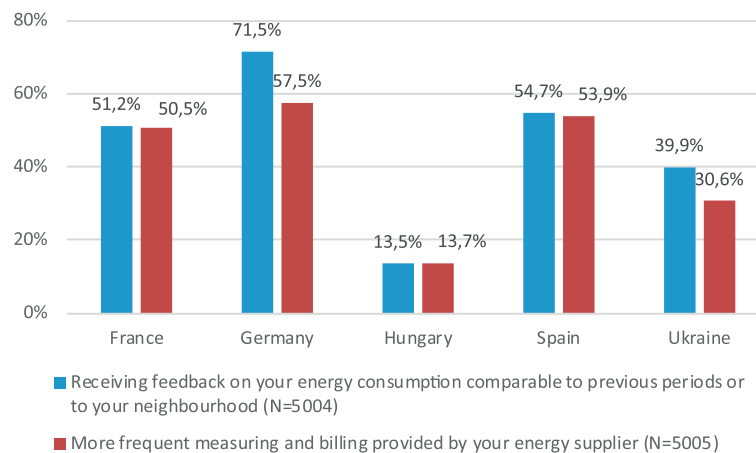


Fig. 6. Openness of consumers towards feedback about energy consumption behavior (Source: authors' research).

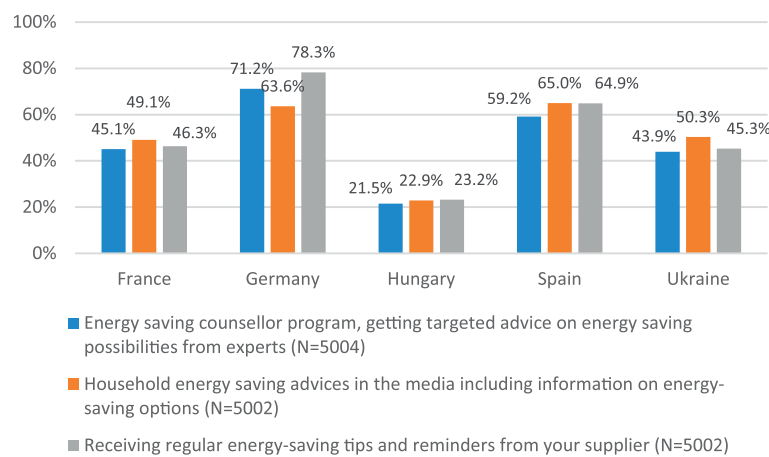


Fig. 7. Openness of consumers towards receiving practical advice on energy-saving options. (Source: authors' research).

that of technical factors. However, in focus group discussions, people generally attributed a significant role to behavioral factors. The contrast between the results of the quantitative analysis that included the whole sample and the results of the qualitative analysis encouraged us to further investigate the causes. The solution was again provided by a return to pattern analysis. In the case of multi-apartment houses, the issue of conflicts of interest between owners and tenants, as well as the problem of the unfair distribution of costs between tenants, emerged. As the distribution of energy-related costs associated with a multiple occupancy dwelling often does not reflect the characteristics of apartments and the behavior of residents, even energy conscious residents may be faced with high energy bills. This acts as a counter-incentive to changing behavior in order to reduce energy costs. There was no such disinterest in the single house groups. The finding suggested that, in relation to evaluating the weight of behavioral factors, the sample should be divided into two according to the type of dwelling (condominium / single family house). After this division, the discrepancy between the results of qualitative and quantitative research disappeared. The role of behavioral factors was found to be significant in the single family house sample, and not significant in the multi-apartment house sample.

6. Discussion

We argue that an integrative approach delivers synergy-based benefits compared to either a solely qualitative or quantitative one. Table 3 summarizes the major outcomes from the two illustrative loops, highlighting the added value of the integrated study approach.

These outcomes also incorporated different patterns of household energy prices, the share of energy cost in total household expenditure, and energy affordability indicators in the sample countries (except for Ukraine), as summarized in Table 4.

Data suggest that while nominal prices vary among countries, on a PPP basis there are no significant differences among sample countries (albeit those in Hungary seem to be somewhat below average). Considering the share of the energy cost in total household expenditure, that of Hungary exceeds the sample and EU mean, but the average share of the latter (4.6%) is well below the rule-of-thumb value that defines energy poverty (10%). This finding suggests that, for most consumers in most countries, energy costs alone are not high enough to generate radical changes in energy consumption. However, as the energy affordability indicators (the last three columns of Table 4) show, energy poverty is still an issue for many countries in the sample, even though household energy is affordable for most consumers. Furthermore, these relatively low average energy costs may exceed 10–20% of the total household expenditure of individuals in low income groups. This situation suggests that for a significant proportion of households the subjective affordability of energy is a real challenge. Indeed, household energy use practices may be changed more effectively if climate change is taken more seriously. The current COVID pandemic has shown that behavioral and social practices can change rapidly if the public – and their policy makers – perceive change to be necessary. The risk of catastrophic climate change could lead to a shift in attitudes – particularly if extreme weather events increase in intensity or frequency.

When compared to the benefits, challenges and drawbacks of the

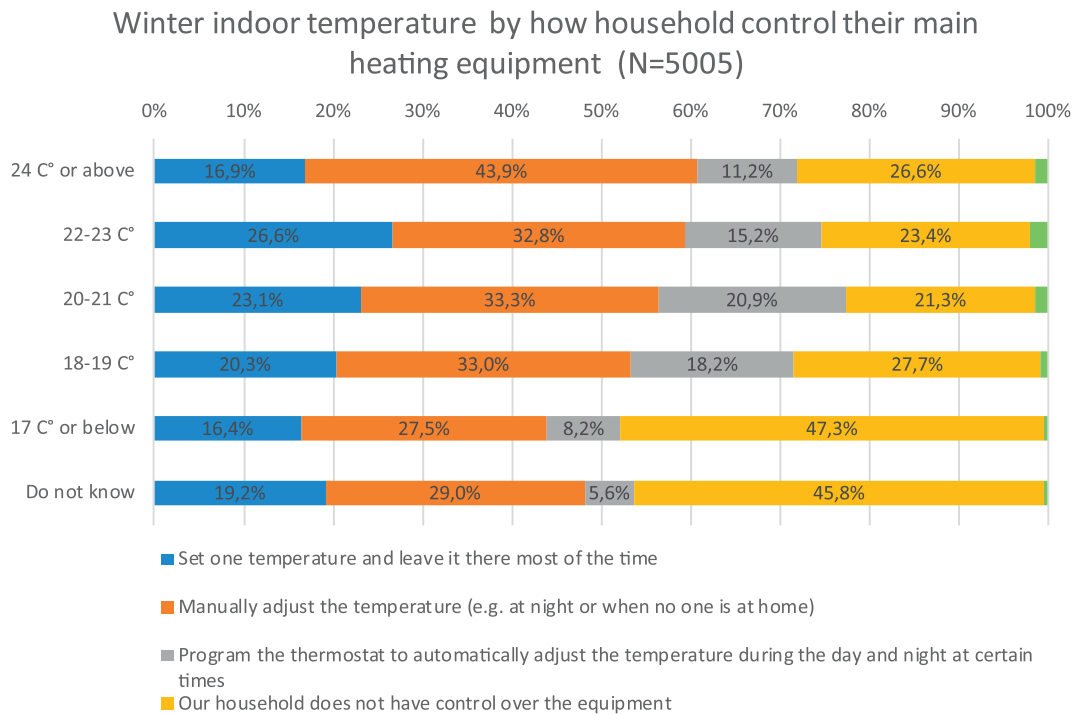


Fig. 8. Relationship between controllability of heating equipment and winter indoor temperature (Source: authors' research).

quantitative and qualitative approaches covered in earlier subsections (summarized in Table 1), the added value of an integrated approach seems to be more detailed and relevant inputs for policy making. The ideas and points that emerge from the integrative study are both obtained from stakeholder discussion and tested by statistical methods.

Integrative, participative approaches are also rising in importance at the EU level of policy making. Qualitative research is traditionally more acceptable as a basis for local rather than regional or national decisions. However, when the results of focus group discussions are integrated into quantitative research and tested through representative surveys, the validity of results can be increased on a regional or national level.

The integrative approach also helps to address validity and reliability issues. In the present case, validity was improved by organizing several focus groups (including expert and laypeople ones) in all participating countries. The evaluation of overlapping patterns can help provide a more valid basis for surveys. Reliability was improved by identifying representative samples for the surveys, using three researchers to decode the patterns, and the cross-interpretation of the results of the two methodological approaches.

The limitations of the integrative approach are the following:

- With the focus groups, the research question(s) has(ve) to be quite general at the beginning, as most questions will be the product of the qualitative phase. This approach may be unfamiliar and unpalatable for some researchers who have a quantitative focus.
- Higher research budget. Including a qualitative and survey-based element into the research process increases the research budget. By how much depends on how deeply researchers become involved in the qualitative phase, but extra resources are required for obtaining sufficient input on which to base a survey.
- Uncertainties and a longer time for survey design. Adding qualitative research to the research process complicates the overall design. Furthermore, it lengthens the period of analysis, as surveys cannot be designed before the results of the focus groups are available. In the current case, the qualitative phase (designing, organizing, and implementing the focus groups, including training other project partners) extended the research effort by about six months.

- More complex human resource coordination is required. Participants included in the qualitative phase had very diverse backgrounds (energy experts, social scientists with different specializations, practitioners, etc. in the expert focus groups, and further diversity within the laypeople group), thus coordination and collaboration on a transdisciplinary level is more complex.

7. Conclusions

This paper has proposed a methodological approach for increasing understanding of the behavioral factors that drive household energy consumption patterns. A novel approach involving pattern analysis in the field of household energy consumption was implemented to overcome the barriers associated with both quantitative and qualitative studies.

The relationship between the qualitative and the quantitative phase was established through pattern analysis by highlighting repetitive patterns in the focus group studies. The two techniques fertilized each other in the following ways:

- the qualitative phase (focus groups) helped us to ask better questions in the survey instrument about heating habits and the factors that challenge people, and about acceptable policy options;
- the questionnaire/survey helped us to validate questions raised in the focus group studies using a nationally representative sample. It was used to identify the issues and problems that are relevant at national level or the level of specific social groups. Additionally, we could use the responses in multivariate statistical analyses of the relationships among variables;
- finally, in reinterpreting the results of the statistical analysis, the outcomes of the qualitative focus groups were applied.

This integrative approach enables deeper understanding of the behavioral factors behind energy consumption. For example, at the individual level there is theoretically a technical relationship between higher winter indoor temperature and heating energy consumption (about 6% more energy per extra degree of heating), suggesting a

Table 3

Major outcomes of different approaches illustrated through the example of four issues (Authors' compilation).

Qualitative study	Quantitative study	Integrative grounded study
<i>Role of indoor temperature</i>		
Individual comfort temperature may vary, explaining some difference in heating costs	Besides individual-level variation there are surprisingly large differences in heating temperatures between countries.	The qualitative study was better able to reveal some differences at the level of individual behavior and motivation, while the quantitative part was able to reveal cultural differences. Large inter-country differences can be explained by overcompensation for weather, state regulation of historically low energy prices, and a lack of control over heating in certain types of dwellings.
The elderly require a higher comfort temperature and tend to heat more when they can afford it.	The elderly maintain a lower temperature at home than younger people, even if they could afford higher heating-related costs.	The quantitative survey refuted some common beliefs that were reflected in the focus group survey. Energy awareness is greatly influenced by early socialization, thus the elderly tend to heat less. Socializing for frugal behavior overrides the need for a higher temperature.
People tend to overcompensate for the effects of weather.	One in four people keep their homes warmer in winter than in summer.	Consumption patterns are changing and people tend to keep homes warm rather than their bodies directly. This sometimes leads to weather overcompensation, increasing energy use, high carbon dioxide emissions, and negative health consequences.
Only some expert groups mentioned the link between indoor temperature and income.	Heating temperature is essentially income-independent. Only the poorest have too low heating temperatures. Even people with relatively low incomes may overheat.	Culture and established habits play a very important role in defining heating temperatures. Even people with a relatively low income may overheat.
<i>Role of background information about energy use</i>		
People need more detailed information about their energy consumption (expert focus groups). People are fed up with too much information (some laypeople focus groups).	In some countries, people are quite resistant to receiving further information.	The quantitative survey clarified the discrepancy that existed between the opinions of experts and lay people. Lack or excess of information may also result in a failure to save energy. There is less need for "dry" data.
People need practical advice rather than data about their consumption (laypeople focus groups). Local information and word-of-mouth information are preferred to central sources.	People prefer practical advice to energy-consumption-related data.	In terms of energy conservation, people prefer to rely on the advice of their acquaintances and local sources.
<i>Ability to control indoor temperature</i>		
Many people overheat because they cannot control indoor temperature.	Manual heating control results in a higher room temperature than if no adjustment is possible	The survey showed that the focus groups are partly wrong in assuming that if they can control the

Table 3 (continued)

Qualitative study	Quantitative study	Integrative grounded study
	at all. Dwellings with a thermostat are the least overheated.	temperature this will lead to lower heating costs. Bad behavioral habits are worse than a lack of controllability. Ability to control indoor temperature does not necessarily lead to less energy consumption. Using a thermostat proved to be the most effective way of saving energy, while manual temperature adjustment resulted in more excessive overheating than when there is no possibility to regulate heating.
<i>Significance of behavioral factors in heating costs</i>		
Behavioral factors play an important role in determining heating costs. Cost sharing among tenants in multi-apartment houses is often unfair and therefore discourages consumption reduction	Behavioral factors play only a minor role in determining heating costs according to regression analysis for the whole sample.	The sample must be divided into two subsamples: respondents living in multi-apartment houses and those living in single family house. Unfair cost sharing between residents in multi-apartment houses may result in higher costs for less fortunate inhabitants, even if their energy consumption is lower. In the case of single family houses, there is a strong relationship between behavioral variables and heating costs.

significant statistical relationship between behavioral factors and household energy use. However, previous studies have found only a weak relationship in this respect, and were unable to explain this paradoxical (i.e. strong theoretical but weak statistical) relationship.

Our pattern analysis, by combining qualitative and quantitative techniques, was able to shed light on the deeper relationships between the variables, thus resolving the paradox. Our research also served as the basis of policy proposals that can strengthen the relationship between heating behavior and heating cost. The four loops (indoor temperature, information availability, temperature control, and energy-conscious behavior) served as illustrations that several behavioral, technical, and social factors play an important role in household energy decisions that can be better revealed using a PSM-based integrative approach.

In general, the grounded survey method is suitable for use in the study of wicked or paradoxical problems that involve very complex relationships between behavioral and technical factors, with limited options for intervention (related to few, mainly behavioral variables). Channeling the views of laypeople into the process reduces the degree of bias that experts may unintentionally introduce into surveys. It also allows for the channeling in of ideas about challenges the former may face, and policy options they could back. The results are not only useful for academics, but may serve as the basis of more sound policy tools.

Regarding further research directions, our model can be applied in areas where development can only be achieved through behavioral change (e.g. decreasing individual mobility-based carbon footprints, or food waste). As the current Covid 19-related pandemic situation has shown, individuals are able to quickly change their behavior when the need for action is unquestionable, and when individual interests are aligned with shared interests. Well-grounded policy tools and their appropriate justification are required to stimulate rapid and effective adaptation in human behavior towards more sustainable lifestyles, including energy consumption behavior.

Table 4

Different energy-related indicators in the sample countries (except for Ukraine). (Source of data: Eurostat and the EU-SILC survey.)

Country	Electricity (€/KWh PPP, 2019)	Natural gas (€/GJ PPP, 2019)	Household energy (% of total expenditure, 2018)	Arrears on utility bills (% of households, 2018)	Inability to keep home adequately warm (% of households, 2018)	Households with significant financial burden due to housing costs (% 2018)	Households with financial burden and significant financial burden due to housing costs (% 2018)
EU 28	0,2164	17,45	3,9	6,6	7,3	29,3	75,2
France	0,1749	18,74	4,3	6,4	5	24,7	46
Germany	0,2678	16,36	3,9	3	2,7	13,1	70,5
Hungary	0,1826	15,98	4,6	11,1	6,1	22,9	80,5
Spain	0,2617	22,34	3,3	7,2	9,1	49,8	96,7

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.

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References

- Alberini, et al., 2016. Free riding, upsizing, and energy efficiency incentives in Maryland homes. *Energy J.* 37 (1), 259–290.
- Stemers, Koen, Yun, Geun, 2009. Household energy consumption: A study of the role of occupants. *Build. Res. Inf.* 37, 625–637. <https://doi.org/10.1080/09613210903186661>.
- Abrahamse, W., Steg, L., Vlek, C., Rothengatter, T., 2005. A review of intervention studies aimed at household energy conservation. *J. Environ. Psychol.* 25 (273–29).
- Ameli, N., Brandt, N., 2015. Determinants of households' investment in energy efficiency and renewables: evidence from the OECD survey on household environmental behavior and attitudes. *Environ. Res. Lett.* 10 (4), 044015 <https://doi.org/10.1088/1748-9326/10/4/044015>.
- Bauwens, T., Eyre, N., 2017. Exploring the links between community-based governance and sustainable energy use: quantitative evidence from Flanders. *Ecol. Econ.* 137, 163–172. <https://doi.org/10.1016/j.ecolecon.2017.03.006>.
- Bernardo, G., D'Alessandro, S., 2019. Societal implications of sustainable energy action plans: from energy modelling to stakeholder learning. *J. Environ. Plan. Manag.* <https://doi.org/10.1080/09640568.2018.1483905>.
- Boardman, B., 2004. New directions for household energy efficiency: evidence from the UK. *Energy Policy* 32 (17), 1921–1933.
- Carragher, V., Lockwood, H., McCormack, S., 2017. Identification and review of factors which drive sustainable consumption. <https://www.tcd.ie/civileng/assets/documents/Carragher%20et%20al%202017%20Review%20Final.pdf>.
- Chen, J., Wang, X., Stemers, K., 2013. A statistical analysis of a residential energy consumption survey study in Hangzhou, China. *Energy Buildings* 66, 193–202. <https://doi.org/10.1016/j.enbuild.2013.07.045>.
- Druckman, A., Jackson, T., 2008. Household energy consumption in the UK: a highly geographically and socio-economically disaggregated model. *Energy Policy* 36 (8), 3177–3192. <https://doi.org/10.1016/j.enpol.2008.03.021>.
- Ekholm, T., Krey, V., Pachauri, S., Riahi, K., 2010. Determinants of household energy consumption in India. *Energy Policy* 38 (10), 5696–5707. <https://doi.org/10.1016/j.enpol.2010.05.017>.
- Fong, W.-K., Matsumoto, H., Lun, Y.-F., Kimura, R., 2007. Influences of indirect lifestyle aspects and climate on household energy consumption. *J. Asian Architecture Building Eng.* 6 (2), 395–402. <https://doi.org/10.3130/jaabe.6.395>.
- Fraser, E.D., Dougill, A.J., Mabee, W.E., Reed, M., McAlpine, P., 2006. Bottom up and top down: analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *J. Environ. Manag.* 78 (2), 114–127.
- Gibson, R.B., 2006. Sustainability assessment: basic components of practical approach. *Impact Assess. Project Appraisal*. 24 (3), 170–182.
- Hendrickson, D., 2010. Community indicators and sustainable consumption: a blended approach toward implementation. *Can. J. Urban Res.* 19 (1), 111–133.
- Hu, S., Yan, D., Guo, S., Cui, Y., Dong, B., 2017. A survey on energy consumption and energy usage behavior of households and residential building in urban China. *Energy Buildings* 148, 366–378. <https://doi.org/10.1016/j.enbuild.2017.03.064>.
- Inam, A., Adamowski, J., Halbe, J., Prasher, S., 2015. Using causal loop diagrams for the initialization of stakeholder engagement in soil salinity management in agricultural watersheds in developing countries: a case study in the Rechna doab watershed, Pakistan. *J. Environ. Manag.* 152, 251–267. <https://doi.org/10.1016/j.jenvman.2015.01.052>.
- Jensen, C.L., Goggins, G., Fahy, F., Grealis, E., Vadovics, E., Genus, A., Rau, H., 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.
- Joon, V., Chandra, A., Bhattacharya, M., 2009. Household energy consumption pattern and socio-cultural dimensions associated with it: a case study of rural Haryana, India. *Biomass Bioenergy* 33 (11), 1509–1512. <https://doi.org/10.1016/j.biombioe.2009.07.016>.
- Karlin, B., Ford, R., McPherson, 2015. Exploring Deep Savings: A Toolkit for Assessing Behavior-Based Energy Interventions. International Energy Program Evaluation Conference, Long Beach.
- Király, G., Köves, A., Gy, Pataki, Kiss, G., 2014. Rendszermodellezés és részvétel: egy magyar kísérlet tanulságai (System modelling and participation: lessons from a Hungarian experiment). *Szociológiai Szemle* 24 (2), 90–115.
- Kiss, G., Pataki, G., Köves, A., Király, G., 2018. Framing sustainable consumption in different ways: policy lessons from two participatory systems mapping exercises in Hungary. *J. Consum. Policy* 41 (1), 1–19.
- Lich, K.H., Ginexi, E.M., Osgood, N.D., et al., 2013. A call to address complexity in prevention science research. *Prev. Sci.* 14, 279. <https://doi.org/10.1007/s11121-012-0285-2>.
- Martinuzzi, A., Scholl, G., 2016. Advancing evidence-informed sustainable development policies. *Evidence Policy; Bristol vol.* 12 (3), 311–319. <https://doi.org/10.1332/174426416X14712603178988>.
- Mendoza, G.A., Prabhu, R., 2006. Participatory modeling and analysis for sustainable forest management: overview of soft system dynamics models and applications. *Forest Policy Econ.* 9 (2), 179–196.
- Milfont, T.L., Markowitz, E., 2016. Sustainable consumer behavior: a multilevel perspective. *Curr. Opin. Psychol.* 10, 112–117.
- Morgan, D.L., 2013. Integrating Qualitative and Quantitative Methods: A Pragmatic Approach. Sage.
- Oberst, C.A., Schmitz, H., Madlener, R., 2019. Are Prosumer households that much different? Evidence from stated residential energy consumption in Germany. *Ecol. Econ.* 158, 101–115.
- Pachauri, S., Jiang, L., 2008. The household energy transition in India and China. *Energy Policy* 36 (11), 4022–4035. <https://doi.org/10.1016/j.enpol.2008.06.016>.
- Pohl, C., Hadorn, G.H., 2007. Principles for Designing Transdisciplinary Research. Oekom, Munich.
- Poortinga, W., Steg, L., Vlek, C., 2004. Values, environmental concern, and environmental behavior. *Environ. Behav.* 36 (1), 70–93. <https://doi.org/10.1177/0013916503251466>.
- Reed, M.S., Kenter, J., Bonn, A., Broad, K., Burt, T.P., Fazey, I.R., Stringer, L.C., 2013. Participatory scenario development for environmental management: A methodological framework illustrated with experience from the UK uplands. *J. Environ. Manag.* 128, 345–362.
- Salvia, G., Morello, E., Sangalli, A., Pagliano, L., 2015. Sustainability Designed with(out) People? Understanding for What Energy Is (over-)Consumed by Tenants in an Energy Efficient Public Housing in Milan.
- Sedlacro, A., Martinuzzi, A., Røpke, I., Videira, N., Antunes, P., 2014. Participatory systems mapping for sustainable consumption: discussion of a method promoting systemic insights. *Ecol. Econ.* 106 (10), 33–45.
- Seligman, C., Kriss, M., Darley, J.M., Fazio, R.H., Becker, L.J., Pryor, J.B., 1979. Predicting summer energy consumption from Homeowners' Attitudes I. *J. Appl. Soc. Psychol.* 9 (1), 70–90. <https://doi.org/10.1111/j.1559-1816.1979.tb00795.x>.
- Sells, S.P., Smith, T.E., Sprenkle, D.H., 1995. Integrating qualitative and quantitative research methods: a research model. *Fam. Process* 34, 199–218. <https://doi.org/10.1111/j.1545-5300.1995.00199.x>.
- Solér, C., Bergström, K., Shanahan, H., 2010. Green supply chains and the missing link between environmental information and practice. *Bus. Strateg. Environ.* 19 (1), 14–25.
- Tonooka, Y., Liu, J., Kondou, Y., Ning, Y., Fukasawa, O., 2006. A survey on energy consumption in rural households in the fringes of Xian city. *Energy Buildings* 38 (11), 1335–1342. <https://doi.org/10.1016/j.enbuild.2006.04.011>.
- UNEP, 2010. In: Hertwich, E., van der Voet, E., Suh, S., Tukker, A., Huijbregts, M., Kazmierczyk, P., Moriguchi, Y (Eds.), *Assessing the Environmental Impacts of Consumption and Production: Priority Products and Materials, A Report of the Working Group on the Environmental Impacts of Products and Materials to the International Panel for Sustainable Resource Management*.
- Vaidya, A., 2016. The Utility of the Participatory Approach for Sustainable Development Assessments. Open Access Dissertation. Michigan Technological University. <http://digitalcommons.mtu.edu/etdr/215>.
- Vergragt, P., Schröder, P., Brown, H.S., Dendler, L., Dallesio, T., Gorenflo, N., Matus, K., Quist, J., Rupperecht, C., Tang, X., Tukker, A., Waheed, A., Wennersten, R., Xiong, Y.,

- Zhang, L., 2018. Sustainable Consumption and Production in Cities. http://www.futureearth.org/sites/default/files/files/CitiesWGScopingPaperFinal1_17_18.pdf.
- Videira, N., Antunes, P., Santos, R., 2009. Scoping river basin management issues with participatory modelling: the Baixo Guadiana experience. *Ecol. Econ.* 68 (4), 965–978.
- Warren, K., 1995. Exploring competitive futures using cognitive mapping. *Long Range Plan.* 28 (5), 10–21. [https://doi.org/10.1016/0024-6301\(95\)00034-g](https://doi.org/10.1016/0024-6301(95)00034-g).
- Webber, W., Stoddard, P., Rodriguez, M., Gudiño, P., Chagoya, T., Jauregui, D., García, A.P., 2016. Improving Rigor in a Door-to-Door Health Survey: A Participatory Approach in a Low-Income Latino Neighborhood. *Progress in Community Health Partnerships: Research, Education, and Action* 10 (1), 103–111. <https://doi.org/10.1353/cpr.2016.0015>.
- Whitmarsh, L., O'Neill, S., Lorenzoni, I., 2013. Public engagement with climate change: what do we know and where do we go from here? *Int. J. Media Cultural Politics* 9 (1), 7–25.
- Xiaohua, W., Zhenming, F., 1996. Survey of rural household energy consumption in China. *Energy* 21 (7–8), 703–705. [https://doi.org/10.1016/0360-5442\(96\)00019-9](https://doi.org/10.1016/0360-5442(96)00019-9).
- Yu, B., Zhang, J., Fujiwara, A., 2013. Evaluating the direct and indirect rebound effects in household energy consumption behavior: a case study of Beijing. *Energy Policy* 57, 441–453. <https://doi.org/10.1016/j.enpol.2013.02.024>.
- Yun, G.Y., Steemers, K., 2011. Behavioral, physical and socio-economic factors in household cooling energy consumption. *Appl. Energy* 88 (6), 2191–2200. <https://doi.org/10.1016/j.apenergy.2011.01.010>.
- Zheng, X., Wei, C., Qin, P., Guo, J., Yu, Y., Song, F., Chen, Z., 2014. Characteristics of residential energy consumption in China: findings from a household survey. *Energy Policy* 75, 126–135. <https://doi.org/10.1016/j.enpol.2014.07.016>.