# Active consumers? Everyday innovation and adaptation for efficiency in thermal comfort services

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## Abstract

In everyday life, people perform, reproduce and recreate many different practices which have implications for patterns of energy demand. This paper focuses on thermal management at home, and explores everyday innovations and adaptations: techniques that are used by consumers who wish to limit their energy use while maintaining a warm home. This includes, for example, do-it-yourself home improvement; improvised forms of insulation and heating; novel ways of using appliances and technologies; and craft and the creation of new "products". These everyday innovations are ignored by most energy efficiency policy, but may make a real difference to consumer experiences of thermal comfort, and to energy use.

The paper presents new empirical findings from a study of everyday innovation in domestic energy consumption, using an online methodology. To access a range of accounts, relevant sources (forums, articles and blogs with comments) were identified in four categories: money-saving; environment and ethics; home improvement and craft; and family and well-being. Three English-language sources were selected in each category, the main criterion being that they included a range of responses. The aim was to generate rich data, not represent a population. Thematic coding of the data focussed on the questions: 1) How do consumers innovate and adapt in trying to achieve thermal comfort services efficiently? 2) What factors support or limit these adaptations and innovations? The paper presents findings and considers how different theoretical perspectives interpret them. Psychology and behavioural studies offer some relevant concepts such as knowledge, values, perceived behavioural control and social norms. However, further insights are suggested by Social Practice Theory and Science and Technology Studies. These approaches highlight processes of scripting, appropriation, tinkering and bricolage, and show how everyday adaptation and innovation are bound up with materials, know-how, shared understandings and rules.

## Introduction

Daily life involves performing, reproducing and recreating practices, many of which have implications for energy demand. For example, thermal management, or controlling temperatures, is a fundamental part of many people's routines, and makes a significant contribution to energy consumption. In this paper, I explore this important area of practice, drawing inspiration from Strengers' (Strengers, 2013) observation that everyday practices that use energy are full of messiness, disruption, adaptation and innovation. This paper investigates one group of everyday innovations and adaptations; techniques that are used by consumers who wish to limit their energy use while keeping their home warm. I use "everyday" to mean that these changes happen in people's homes, and are carried out by the householder (rather than by professionals). Innovation refers to practices and products that are new to that household, and adaptation refers to alterations to existing practices and products, but I generally write about the two together. These everyday innovations and adaptations are ignored by most energy efficiency policy, but may make a real difference to consumer experiences of thermal comfort, and to energy use.

Everyday innovation in thermal management is a topic which has received relatively little attention to date, though there are several areas of literature that are relevant. From a psychological or behaviourist standpoint, there has been work on energy saving (for example, Lindén et al., 2006; Martinsson et al., 2011; Oikonomou et al., 2009; Poortinga et al., 2004), though little specifically on home-warming. Some work on thermal comfort discusses strategies people use in heating and cooling their homes, including adaptive tactics (though there has been more focus on cooling than heating; e.g. Strengers and Maller, 2011. On keeping homes warm, notable studies include Vannini and Taggart (Vannini and Taggart, 2014) (regarding "off-grid" heating), and Gabriel and Watson (Gabriel and Watson, 2013) (regarding solar water heating, but also thermal management more generally). This past work suggests that this is a topic of considerable importance, as consumers' everyday tactics and techniques for home-warming can have a significant impact on their energy consumption. Further discussion of this literature can be found in a previous paper published as part of this study (Royston, 2014).

As Vannini and Taggart explain, managing temperature means people have a constant and active engagement in practices including "observing, controlling, recalling, regulating, and leaving traces (like carbon footprints), of their warming and cooling activities" (Vannini and Taggart, 2014 p. 68). These kinds of efforts have been called "heating work" (Jalas and Rinkinen, 2013). Shove et al. (Shove et al., 2014) suggest that keeping a home warm means controlling how heat flows within it, to ensure that heat is where it is needed, when it is needed. Doing this efficiently also means minimising unwanted heat flows: heat-out-of-place and heat-out-of-time (Royston, 2014). I draw on these ideas here, and this means that I consider a wide range of heat flows; while much past research has focussed on heat-generation, I am also concerned with how heat is moved or stored, and how it is lost from the home. This recognises that people do not wish to "heat" per se, but rather to feel warm (and/or achieve other outcomes, such as efficiency), which can be achieved through managing flows in many different ways.

I focus on keeping warm and not on keeping cool, in order to ensure a manageable scope. However, there is some evidence that similar themes emerge when cooling is in question; for example, Strengers and Maller's (Strengers and Maller, 2011) work on cooling practices in Australia. Many ideas suggested here are likely to have relevance across diverse contexts, albeit shaped by specific social, cultural, material and climatic landscapes. I also focus on space heating and not person heating (Kuijer and Jong, 2012). This distinction is not clear-cut, as thermal management involves diverse relations between clothing, housing, the environment and the body (Jalas and Rinkinen, 2013); however, it is helpful in focusing this discussion within a manageable scope. Use of person and space heating varies between cultures and in some contexts there may be an ongoing shift away from managing bodies' comfort and towards managing indoor environments (Kuijer and Jong, 2012). Given this, it seems particularly relevant to explore the forms of everyday innovation and adaptation that are involved in keeping homes warm, and efforts to do this in an energy-efficient way.

This paper first outlines the methodology used, then discusses the findings, focussing on the two research questions: 1) How do consumers innovate and adapt in trying to achieve thermal comfort services efficiently? 2) What factors support or limit these adaptations and innovations? The discussion considers how different theoretical perspectives help understand these findings. Psychology and behavioural studies offer relevant concepts such as knowledge, values, perceived behavioural control and norms. However, further insights are suggested by Social Practice Theory and Science and Technology Studies, which consider processes such as tinkering, bricolage and scripting, and show how practices of adaptation and innovation involve particular configurations of materials, skills, shared social understandings and rules. The conclusion summarises key ideas and implications.

## Methodology

### OVERVIEW OF METHODS USED

This paper draws on a two-part study of active consumers and thermal management. The first stage involved a literature review, which was used to guide a wide-ranging exploration of online sources. Findings from this stage have previously been published (Royston, 2014). The second stage involved a more structured approach to data collection from online sources. This aimed to develop and refine the findings of the first stage, and address the two research questions. The second stage (not previously reported on) is the main focus of this paper. The methodology for the second stage was as follows:

1. I used the initial wide-ranging review to identify four main categories of online source of relevance to the research questions. It is well-known that consumers do not generally think about energy, but about the services, practices and priorities associated with energy (e.g. Strengers, 2013), and for this reason I have focused on sources about aspects of daily life that are relevant to the issue of keeping warm efficiently. The aim was to ensure a breadth and diversity in accounts. The four categories identified were: money-saving; environment and ethics; home improvement and craft; and family and well-being.

2. Within each category, I identified three sources that contain content relevant to the research questions. A source is defined as a single webpage, unless a specific discussion continues on more than one page (e.g. a thread on a forum). This gave twelve "virtual outputs" (Bryman, 2004) to be analysed. The sources used are presented in table 1. Where a source is a sole-authored article/blog with comments, I have looked only at the comments and not the article, as I am interested in a variety of inputs from commenters, rather than a single expert opinion. I used sources only in English, but in order to access rich data I included a mixture of UK-based and North America-based sources.

3. I conducted thematic analysis of the virtual outputs, focussing on each research question in turn. This analysis was informed by the literature review and exploration of sources that was conducted in the first phase of the research.

The aim of this methodology was not to compare the different source types, as the sample is too small and non-representative, but to include a diversity of sources in order to generate rich data.

**Table 1. Virtual outputs used in the research. All websites accessed on 13.1.15.**

| Source name | Type of source | Number of comments | Geographic base | Date of first comment | Web link |
|---|---|---|---|---|---|
| **Money saving** | | | | | |
| This is money | Article (based on readers' comments) with comments | 85 | UK | 23 October 2013 | http://www.thisismoney.co.uk/money/bills/article-2471633/Thrifty-slightly-mad-ways-cut-energy-bills.html |
| A girl called Jack | Blog with comments | 175 | UK | 14 November 2013 | http://agirlcalledjack.com/2013/11/14/my-tips-for-keeping-warm-in-winter-from-a-veteran-of-freezing-houses-wooden-floors-and-big-windows/ |
| The simple dollar | Article with comments | 30 | US | 1 November 2009 | http://www.thesimpledollar.com/ten-tricks-for-staying-warm-this-winter-without-huge-energy-bills/ |
| **Environment/ethical** | | | | | |
| Treehugger | Article with comments | 12 | US and Canada | 4 November 2014 | http://www.treehugger.com/green-home/5-energy-saving-alternatives-portable-electric-space-heater.html |
| The green parent | Forum | 11 | UK | 21 October 2014 | http://thegreenparent.co.uk/forums/viewthread/27506/ |
| Care2 | Article with comments | 82 | US-based (global) | 17 November 2011 | http://www.care2.com/greenliving/10-cheap-winter-tips-to-stay-warm.html |
| **Home improvement and craft** | | | | | |
| Jack Kelly | Blog with comments | 51 | UK | 25 October 2010 | http://jack-kelly.com/insulating_our_victorian_living_room |
| Lifehacker | Article with comments | 9 | Global | 9 September 2011 | http://lifehacker.com/5841692/make-a-wool-curtain-out-of-a-surplus-blanket |
| The Guardian | Article with comments | 50 | UK | 5 January 2010 | http://www.theguardian.com/lifeandstyle/2010/jan/05/how-to-make-draught-excluder?commentpage=1 |
| **Family and wellbeing** | | | | | |
| Netmums | Forum | 58 | UK | 28 August 2011 | http://www.netmums.com/coffeehouse/house-garden-194/money-saving-budgeting-bargains-609/628438-what-can-i-do-keep-my-home-warm-winter.html |
| Mumsnet | Forum | 71 | UK | 15 September 2013 | http://www.mumsnet.com/Talk/credit_crunch/a1853722-Top-tips-for-keeping-warm-without-heating |
| Happy Simple Living | Blog with comments | 19 | US | 8 January 2015 | http://www.happysimpleliving.com/2015/01/08/a-challenge-to-radically-reduce-energy-use/ |

### ETHICS AND QUALITY IN ONLINE RESEARCH METHODS

In the interest of research ethics, I did not use any sources where I had to register or log in, as these could be seen as semi-private online communities. I only used sources that can be accessed directly from a search engine, as these can be considered published and publicly available. I do not publish any information about the writers of text, including screen names.

Quality is a critical issue for online research. Bryman (Bryman, 2004) states that research using virtual outputs should consider the same criteria as research using other documents: authenticity, credibility, representativeness, and meaning (clarity of the evidence) (Scott, 1990). I followed this advice in selecting and analysing sources, and considered authenticity and credibility issues around each one, e.g. why does this website exist? I also considered whether each writer might have any reason to give a distorted or inaccurate account, and excluded any text that appeared to be written in order to sell a product (for example, if it featured web-links to a specific product).

In any online research, especially with anonymous or pseudonymous writers, it is important to be aware that we cannot

**Table 2. Characteristics of two approaches to keeping homes warm efficiently.**

| Conventional or formal efforts to keep homes warm efficiently involve: | Unconventional or informal efforts to keep homes warm efficiently involve: |
|---|---|
| Using an appliance or material for the purpose for which it was designed. | Using an appliance or material for a purpose other than the one for which it was designed, or in an unusual way. |
| Taking advice from recognised, mainstream, expert sources such as the Energy Saving Trust. | Taking advice from friends and other lay people, or inventing new methods. |
| Following official instructions, drawing on factual and theoretical knowledge. | Using trial and error, and drawing on existing skills and experience-based knowledge. |
| Often (though not always) spending some money and using a new product or material. | Often spending little or no money, and re-using existing materials. Often creating new low-budget versions of conventional products. |
| Often (though not always) permanent or structural changes. | Often temporary or small scale changes. |

know for certain whether what is written is true (though any research with human participants encounters this problem to a degree). We also cannot make any assumptions about the person who wrote a comment (for example, a woman might post under a male name; or a person use multiple user names). This does not mean that the data cannot be used, simply that it must be used in an appropriate way. For example, I do not label quotes as coming from any particular source (e.g. their age or sex). Where I use quotes from sources, I give the name of the webpage in brackets. I also do not give counts of how many people made a particular point. I do not aim for representation or quantification as these are not appropriate for this online approach. In order to ensure I could interpret the evidence correctly, I used sites aimed at a general audience, not technical or expert websites.

I also followed the guidance provided by (Bryman, 2004) for rigorous online research, including:

- Use of diverse keywords.
- Use of several search engines.
- Research over a period of two years in order to include diverse virtual outputs.
- Presentation of all web links, with date accessed.

These methods ensure that the data is as rich and credible as possible, and that all evidence is used appropriately.

## Findings: Everyday innovation and adaptation for keeping homes warm

### HOW DO PEOPLE INNOVATE AND ADAPT IN TRYING TO KEEP THEIR HOMES WARM MORE EFFICIENTLY?

Keeping a home warm involves both monitoring and managing heat flows. Monitoring heat flows was a main theme in the first phase of the research (Royston, 2014). This found evidence of people using creative and improvisatory techniques to monitor temperature and heat flows in their homes, including:

- Using sensory indicators of temperature (e.g. hard toothpaste, frost on windows, seeing one's breath, pet behaviour).
- Using spider webs, stink bugs or moving curtains as evidence of draughts.
- Using incense sticks, candles and hairdryers to actively look for draughts.
- Using snow-melt as a sign of heat loss from the roof.
- Monitoring the look, sound, feel and smell of appliances.

The present paper aims to builds on this work, and focuses on managing, rather than monitoring, heat flows.

Analysis of the data revealed a very wide range of practices aimed at keeping homes warm in an efficient way. It was notable that some of these were techniques that are commonly suggested by energy saving experts and organisations, such as installing insulation and draught-proofing. Others were more creative and unusual methods, such as creating a heater from tea-lights, or a draught excluder from old clothes – these seem less formal and conventional than the accepted, mainstream methods of saving energy. It is possible to loosely characterise these different approaches, as Table 2 shows.

It is important to note that this is more of a spectrum than a polar categorisation; many efforts fall somewhere in the middle. The Table 3[1] gives some specific examples from the data of more and less conventional methods used by the commenters in this study. It shows that often, a conventional or formal method has an unconventional counterpart or alternative. The table is divided into two sections: creating and moving heat; and storing heat. This reflects the idea of thermal management as a system of flows, and the fact that keeping warm is not only about creating heat, but about ensuring heat flows in such a way that it is where it is wanted, when it is wanted.

A typical example of a conventional approach is provided by this commenter[2]:

> Those programmable thermostats are best used to reduce heat while you're off at work … Lagging the pipework for fluid-heating/cooling central units, insulating ductwork for forced-air central HVAC, improving exterior wall insulation … adding window seals and weather stripping doors … can make a serious difference in energy costs. (Care2)

1. Use hot water bottles and electric blankets (for beds): These bed-heaters are a good example of efforts that are hard to classify. They have some characteristics of informal efforts. However, since hot water bottles and electric blankets are specially designed for one purpose, I have listed them here as conventional.

2. Throughout this paper, spelling and grammar in quotes are corrected for clarity.

**Table 3. Examples of two approaches to keeping homes warm efficiently.**

| Conventional and formal efforts | Unconventional and informal efforts |
|---|---|
| **Creating and moving heat** | |
| • Create heat using central heating system or room heaters<br>• Choose an efficient system<br>• Use hot water bottles and electric blankets (for beds) | Use heat from:<br>• Oven during cooking, and after cooking<br>• Boiling pans<br>• Old-fashioned light bulbs<br>• Candles and tea-light "heaters"<br>• Vacuum cleaner<br>• Iron<br>• Hair dryer (for bedclothes)<br>• Home-made heaters using wheat, beans etc. (for beds)<br>• Home-made cardboard/tin can solar collector at window<br>• Laptops and computers<br>• Bathwater<br>• Pets and other people |
| • Improve efficiency of heating system by servicing, bleeding, replacing parts, lagging etc.<br>• Close wood-burner vents | • Shorten curtains to get more heat from radiators<br>• Stack firebricks on wood-burner |
| • Use heating timers and zonal controls<br>• Close air vents (or, some say, do not close air vents) for efficient running of hot air heating system | • Use rooms differently – heat only one room, sleep in a different room<br>• Open and close doors to control heat flow<br>• Use ceiling fan to move warm air downwards |
| **Storing heat** | |
| • Insulate loft or ceiling<br>• Insulate around ceiling joists | • Put duvets and blankets in loft |
| • Insulate walls | • Put blankets over walls<br>• Use bookcases and big furniture |
| • Draught proof windows and doors<br>• Buy door draught excluders | • Use plastic bags, sponge pieces and tape in cracks<br>• Make draught excluders or use towels |
| • Have double glazed windows | • Put cling-film, bubble wrap or tinfoil over windows |
| • Have an efficient door | • Hang curtain or blanket over door |
| • Put reflectors behind radiators | • Put tinfoil behind radiators |
| • Block off chimney, or put up chimney balloon | • Put newspaper up chimney |
| • Buy thermal curtains | • Make thick curtains, e.g. out of blankets, or line curtains with fleece |
| • Insulate and draught proof floor | • Fill floor gaps with papier mâché<br>• Put camping bed rolls under bed or sofa<br>• Make rugs, or put metallic reflective capes under rugs |
| • Buy an insulated bathtub | • Insulate bath panel with newspapers or loft insulation |
| • Buy foam inserts to cover air vents | • Cover fans or vents with plastic bags or a blanket with Velcro |

Typical examples of an unconventional approach are provided by these commenters:

> I skip weather-stripping my leaky old front windows and cover them completely with a huge old down comforter instead. (Treehugger)

> If your house has an attic fan or swamp cooler that isn't used in the winter you can make it a LOT warmer inside by covering and insulating the vent. They make kits to do this, but I cobbled together something from stuff I had on hand. Even taping a piece of plastic over the vent will help – but something that will both trap air and block radiant heat is best. I made mine from an old blanket and a piece of mylar [plastic sheet] – plus some stick-on velcro that I had lying around. (The Happy Simple Life)

While formal energy advice sometimes assumes a certain level of heat demand is taken for granted, some informal approaches

include changes to practice that actually result in less need for space heating, through adaptive thermal management (de Dear and Brager, 1998). For example,

> The easiest thing to do at times is just do more stuff in the living room (our office is in the bedroom) and we sometimes sleep in there if it gets too cold in the bedroom. (The Simple Dollar)

While comparing different categories is not an aim of this work, it did appear that the money-saving and family and wellbeing sources were especially focused on unconventional approaches. This could be explored further using a larger-scale and more representative data collection method. This research also does not explore how effective these different techniques are. As temporary and small scale solutions, it should be noted that many of the unconventional approaches may be less effective in the long term than their conventional equivalents. However, due to their lower cost, they may be accessible to more people.

## WHAT FACTORS SUPPORT OR LIMIT ADAPTATION AND INNOVATION?

The data suggested a range of factors affecting people's capacity to make these changes, and whether the changes are seen as successful.

### Knowledge, experience, skill and capacity

Knowledge was important to many of the practices mentioned, but the type of knowledge varied between the more and less conventional approaches. As noted in Table 2, conventional approaches draw on expert advice and following instructions, and often involve theoretical or explicit knowledge (e.g. about U-values or processes of heat loss). Meanwhile, unconventional approaches draw on trial and error and the advice of lay-people. Unconventional approaches often draw on experience-based practical know-how, including learning from bad experiences ("what not to do"). For example;

> These [home-made] solar heat collectors are great in theory, but not in practice. I've made them before and here are my thoughts based on experience & research: They are better than nothing, but don't expect much … (Lifehacker)

> I have actually done a certain amount of research in this field, since I have the draughtiest house in London, and have a number of observations (from experience) re: filling … The problem with peas and rice is a) they are non-mouse-proof and b) if they get wet in any form you are potentially buggered. After no little research in this area I discovered two things were great: the first is the gravel you put at the bottom of fish-tanks … it is, however, very heavy, and so I modified slightly and my all-time stuffing winner is crushed shells from the garden centre. Gravel is a bit dirty, ditto sand. Shells are perfect. (The Guardian)

Another Guardian commenter concurred, saying their "bean heat bag" had been eaten by mice or moths.

These approaches sometimes used pre-existing skills, such as sewing for making draught excluders and curtain linings (one Netmums user made winter curtains as part of a sewing course). However, conventional approaches could also involve practical know-how and pre-existing skills (such as home-improvement skills). In a smaller number of cases, physical capacity was also relevant; e.g. one commenter mentioned risks involved in putting a covering on a ceiling (This is Money). The findings about experience-based learning suggest that these innovations and adaptations should not be seen as one-off events, but part of an ongoing engagement with the home and thermal flows within it.

### Buildings, products, materials and costs

Building factors were important for both conventional and unconventional approaches. The nature of the structure often placed limits on what could be done or meant that certain things needed to be done. For example:

> Our upstairs rooms have ceilings that go into the eaves slightly, a part of the loft that it is not possible to insulate very well, we have put insulation on the inside of the room and re-plastered etc. (The Green Parent)

Materials were a key concern for the unconventional approaches, which often involve an intense engagement with the limits and opportunities provided by different materials. For example, on draught excluders:

> … soft stuffings e.g. old tights etc. are fine but the draught excluder won't be as flexible to flop into all the gaps around your door. (The Guardian)

> Bubble-wrap covering the windows. The one with the big bubbles. (Mumsnet)

These approaches often involve re-using and re-purposing existing materials, for example:

> I cut up and crochet my son's (old wrecked) clothes into rugs which help keep the floor warm. (A Girl Called Jack)

> My wife found an ornamental draught excluder that had been discarded in the rubbish station outside but it was too thin to be effective. She stuffed it into one leg of a pair of tights and then wrapped it in a pair of long socks to make it fatter. Works a treat. (The Guardian)

However, discussions about conventional insulation also considered the properties of different materials, such as Celotex, screws, floorboards and glue, including U-values, cost and ease of installation (Jack Kelly).

Similarly, products and appliances were discussed by many commenters, across the different approaches, but in different ways. Conventional approaches consider the performance (and quality, appearance and ease of installation) of existing products that are available, and how to optimise the performance of appliances. Meanwhile, as table 2 shows, unconventional approaches may use products and appliances in novel and creative ways. This was especially notable in the list of appliances that were mentioned as potential sources of heat, from candles to old light bulbs and even vacuum cleaners and irons.

Financial issues were also mentioned, with many unconventional approaches aiming to cost little or no money, and some commenters appearing to take pride or satisfaction in the cheapness of their ideas. One commenter described using cardboard and paint to create a "poor man's solar heat collector" (Lifehacker). For conventional approaches, there would sometimes be a large up-front cost (e.g. buying a Rayburn oven or wall insulation) but this would be justified in terms of long term savings.

#### Rules and codes

Building regulations were mentioned in the context of conventional approaches such as insulation. Tenancy rules were also important, with renters often prevented from using permanent, conventional approaches by their landlords. This often led to them resorting to temporary, low-cost approaches instead. More informal rules and codes around health and safety in the home were also mentioned. For example, several commenters warned others to ensure adequate ventilation if they were blocking gaps and using certain types of heating. Even more subtle rules were those around aesthetics and social expectations; for example, one sarcastic commenter criticised the idea of covering windows, saying,

> [Y]eah … For when you want to give the ladies that sexy, "no one can see in" serial killer vibe … There has GOT to be a better solution, people. (Lifehacker)

#### Social interactions

A related theme is social interactions. First, I noticed that some commenters referred to ideas, help and advice from their family and friends – this acted as a source of knowledge for many different kinds of practice. It may be especially important for unconventional approaches, where less "official" or published information is available. In addition, it is possible to look at the interactions that occur between commenters within these virtual outputs. It appears that many people are using these sites to get new ideas and advice (and posting their thanks when these are useful). In some cases, commenters ask questions about particular techniques, and others answer them. The virtual outputs also show a few examples of ideas being criticised. The most common criticisms of a method are that it is ineffective, expensive, ugly, unsafe or unsustainable. Another common interaction consists of a commenter giving a warning or caution about how to take a particular action suggested by someone else. Such negative comments might put people off certain actions, but might also be useful in refining them. This suggests social interactions (offline and online) might play a part in guiding innovations and adaptations.

#### Meanings and multiple benefits

Naturally there were a wide range of motives alongside "keeping warm efficiently", which varied across the sources. For example, one commenter on a parenting site said,

> When I first started doing this, I googled things like frugal living and make-do-and-mend. I do stuff now that my great-grandparents were doing. Apparently it's becoming "trendy" again to make do but I don't really care about that. I just want my family to be safe, fed and warm. (Netmums)

Another person focused on environmental motives, and said of draught excluders (in response to suggestions of using rice and wheat to make these):

> … rather than use food which I could put to better use, I used an old rolled-up bath towel. Much 'greener', if you've one to spare. (The Guardian)

Some people mentioned that they made a change because it met their particular goals, and commenters seemed especially satisfied if they were able to meet several goals at once. This was particularly noticeable among the unconventional approaches, where goals of avoiding waste, being creative and saving money were prominent. However, the nature of these sources is such that people did not give many details about meanings or motives. Interview or ethnographic methods would be valuable to explore this theme further.

## Discussion: theoretical approaches to everyday innovation and adaptation

Everyday innovation and adaptation for keeping homes warm have not received much attention from researchers. However, several disciplines offer ideas and interpretations that help understand these processes. Work drawing on psychology and behavioural studies has looked at energy-saving behaviours, and suggests some relevant concepts (see, for example, Lindén et al., 2006; Martinsson et al., 2011; Oikonomou et al., 2009; Poortinga et al., 2004).

- Knowledge: Psychological approaches often include knowledge and information as variables affecting behaviour, and the data presented here suggests knowledge is important to everyday innovation and adaptation for keeping homes warm efficiently.
- Values and attitudes: Values and attitudes are central to many psychological approaches, and the data presented here suggests that motives and meanings have a role in what actions people take, and whether actions are seen as successful.
- Perceived behavioural control or agency: The data suggests factors such as tenancy and people's level of skill or ability may affect their actions, and this echoes the concept of perceived behavioural control (Ajzen, 1985).
- Social norms: social interaction and rules were themes of the data, so the psychological concept of norms might be helpful in understanding people's actions around efficient warmth. However, the current dataset does not allow in-depth investigation of this.
- Financial considerations are also considered in many behavioural approaches, especially microeconomic approaches (e.g. Oikonomou et al., 2009).

So a psychological or behaviourist approach suggests that a consumer makes a decision to change their energy-using behaviour based on their knowledge; values and attitudes; perceived behavioural control; social norms and financial considerations (among other factors).

However, some important findings of this study do not seem to fit with these approaches, notably the material dimension (buildings, products and materials) and the role of experience, ongoing trial-and-error, skill, know-how and capacity. Social interaction, apart from social norms, does not seem to be fully encompassed, and nor do many forms of rules. This reflects criticisms that have previously been levelled at psychological and behavioural approaches (e.g. Burchell et al., forthcoming; Hargreaves, 2011).

To gain a deeper understanding of processes of everyday innovation and adaptation, it is useful to draw on Social Practice Theory (SPT). Practice theories have recently been influenced

by concepts from the complementary field of Science and Technology Studies (STS), and some of these are also discussed here. In an SPT approach, a person's actions are understood as creating and being created by social practices – socially-shared understandings of what it means to do a certain activity. SPT takes us beyond the concept of "active consumers": individuals are understood not just as more or less active consumers of resources but as practitioners, as they perform, reproduce and recreate particular ways of acting. Their actions are seen not as one-off, individual decisions, but as ongoing, shared performances. Social practice theories also suggest that a practice is a configuration of elements. Shove and Pantzar (Shove and Pantzar, 2005) identify these elements as materials; skills or competences; and images or meanings, while Gram-Hanssen (Gram-Hanssen, 2010) adds a fourth element representing rules and theoretical knowledge. All four of these elements help explain the data in this study.

First, this approach helps interpret the findings regarding materials used in everyday innovation and adaptation for keeping homes warm. Social practice approaches suggest that managing energy flows to keep a home warm involves interacting with a wide range of material elements. This is not just a case of people "using" objects, but rather a process of engagement in which people adopt and interact with materials as part of their daily practices. This is partly guided by the design or "script" embedded within them (Shove, 2003) and their affordances (Pfaffenberger, 1992); the uses they suggest, enable and allow. The data here suggest that both conventional and unconventional approaches are strongly influenced by the affordances of materials – whether these are bubble-wrap, old clothes, insulated panels or buildings themselves. Conventional approaches tend to follow the script of particular objects, such as radiators and insulation materials. However, SPT and STS suggest that people also creatively respond to these material scripts, and can "appropriate" technologies for alternative purposes (Hand and Shove, 2004). Similarly, the practice theorist Certeau (Certeau, 1984) has described a process called bricolage. This refers to people's tactical re-employment of the materials to hand, improvising, making-do and sometimes deviating from the intended use, and often drawing on experience and acquired skills. Unconventional approaches to heating and storing heat often involve appropriation; for example, using a hair-dryer to heat a bed. Heat flows themselves can be appropriated; for example, using waste heat from an oven or bath water as a way to heat rooms. Bricolage is also apparent when people experiment with creative homemade solutions, such as making a solar heater from paint and cardboard. As Certeau's concept suggests, these practices represent tactical alternatives to more permanent, structural and commercially provided (often expensive) options for home-warming.

The STS literature also discusses "tinkering" (Knorr-Cetina, 1981); a process of getting things to work that is opportunistic, contingent, local and idiosyncratic. Pickering (Pickering, 1995) similarly speaks of "tuning", or a "dialectic of resistance and accommodation" between human actors and material things; a reciprocal process in which habits, skills and ways of doing things are developed and applied. These ideas are useful here because they reflect the trial-and-error nature of some (especially unconventional) home-warming practices. The Guardian commenter who tried old tights, gravel, sand, and finally crushed shells, was tinkering, opportunistically and idiosyncratically, in order to find a way of making draught excluders that worked. But this is not only true of informal adaptations; conventional practices such as adjusting thermostats, draught-proofing and insulating may also have characteristics of tinkering or tuning, as people experiment, use feedback, and test the possibilities and limitations of specific materials. This echoes Jalas and Rinkinen's (Jalas and Rinkinen, 2013) understanding of heating work as involving on-going negotiations between bodies, fuels, heating technologies and other forms of equipment.

Secondly, STS sheds light on the different forms of knowledge that were highlighted by the data. Practical skills and abilities represent a form of knowledge that Baumard (Baumard, 1999) labels as techne, drawing on classical Greek philosophy. Examples of techne would be the ability to programme a central heating system, bleed radiators or install loft insulation – all forms of formal or conventional practice for keeping homes warm. But the data suggests that home-warming also draws on more subtle and creative skills. Baumard labels these as metis – a form of intelligence that is creative, intuitive and tactical, often drawing on "ruses" and "short cuts". We can see this kind of knowledge in use, for example, in the informal and unconventional methods for creating homemade draught-excluders, solar heaters and vent-blockers. Furthermore, some practice-based approaches suggest that knowledge is embedded in the body and mind through the performance of practice (Royston, 2014; Wilhite and Wallenborn, 2013) – this helps explain why experience and trial-and-error are important in creating the skills and know-how that people use when making innovations and adaptations in their homes. As Vanini and Taggart argue, "To heat … means to take part in practices through which heating skills are applied and developed, insightful observations are made, and understandings are refined" (Vannini and Taggart, 2014) (p68). So keeping a home warm efficiently involves a creative and ongoing learning process.

The third element of practice in SPT is meanings. This category includes the motives and perceived benefits that were found to be associated with adaptations and innovations. Importantly, SPT sees these meanings as socially constructed, rather than focussing on attitudes that are held in an individual's mind. The data here does not allow detailed exploration of this idea, but does give some indication of how meanings around home-warming are socially negotiated. For example, some commenters on the Care2 site argued over whether it is environmentally-friendly to use candles for heating or not, weighing up issues around air pollution and energy generation; while posters on the Lifehacker site discussed whether window coverings were attractive and "cool". These sites act as spaces in which the meanings of practices are negotiated, challenged and disseminated, just as other groups, networks and communities of practices do (Hards, 2011). In this way, they may even play a role in the evolution of social practices on a wider scale.

As discussed in the Findings section, another theme of the data was rules. This is a key idea in social practice theory, which emphasises the role of standards, codes and rules, both in individual performances and the evolution of practices on the social scale. The data showed diverse kinds of rules were important in efforts to warm homes efficiently. A key characteristic

of conventional approaches is that they involve standards and codified and theoretical knowledge, such as building regulations and instructions for use of products. However, the data shows that unconventional approaches are also guided by rules, including health and safety principles and social codes such as taste.

These four ideas from SPT help to interpret the data on everyday adaptations and innovations, and the factors that support and limit them. Furthermore, we can build on these ideas to get a better understanding of conventional and unconventional practices. SPT suggests that certain forms of practice may become normalised, codified and dominant; for example, when they are embedded in material design, or established in laws and standards. The conventional forms of efficient home-warming practice listed in table 3 can be understood in this way: they are inscribed in specially-made products, published expert guidelines and building codes. However, practices are dynamic and diverse: every time a person performs a practice they may do so in a slightly new or different way, and there will be many alternative ways of performing a practice. The informal, unconventional adaptations and innovations described here can be seen as alternative, minority versions of dominant practices. They might be relics of past practices; many commenters mentioned that they were simply doing what older generations had done to keep warm efficiently, as noted in a Netmums quote, above (such as making thick curtains). Equally, they can be seen as proto-practices that could potentially become established in future. A key question raised by SPT is; what is the relationship of these innovations and adaptations in people's homes and the evolution of wider social practices? Which unconventional adaptations have the potential to become established and accepted, and how does this process occur? The online spaces and interactions considered here will themselves play a part in this evolution, alongside many other social processes. However, these are questions for a future study.

## Conclusion

In conclusion, it appears that people use both formal and accepted methods, and also more diverse and improvised methods to try to warm their homes efficiently. Heat is constantly flowing between materials and spaces within the home, while at the same time, outdoor temperatures fluctuate, and routines and needs vary, both in the short and long term. The need to manage flows, and the constant challenge of keeping heat in the right place at the right time, result in flexible, responsive and creative efforts to keep homes warm efficiently. Social practice and STS approaches can help us understand these, by identifying processes such as scripting, appropriation and bricolage, and the roles of meanings, skills, materials and rules.

It is important to note some limitations to this research. The sample is small and non-representative, and as in most online studies, little can be known about the participants and the accuracy of their accounts. However, by using a range of sources and by treating the data with due caution, some useful insights can be drawn. This paper also suggests opportunities for further empirical work. A key set of questions concerns the energy impacts of these different kinds of innovation and adaptation. Which informal tactics actually "work", and which do not? Can formal energy-saving advice learn anything from these home-made, grassroots solutions? Are there informal tactics that are problematic and should be discouraged? These could be addressed through experimental and quantitative work. Also, because online data is limited, it would also be beneficial to explore these home-warming practices in more detail using "sensuous ethnography" (Vannini and Taggart, 2014), home visits, house tours, narratives, photos and videos. This could provide a richer understanding of conventional and unconventional efforts, and how and why these practices vary between people and change over time.

It is not appropriate to make policy recommendations based on such a small study. However, this paper contributes to an emerging body of work that emphasises the importance of everyday practices-that-use-energy, and their meanings, skills, materials and rules. This work has implications for several current policy debates. For example, one current debate is around "energy literacy", and the types of knowledge that facilitate energy-efficient practices. Burchell et al. (Burchell et al., forthcoming) argue that both practical know-how and theoretical knowledge should be promoted in order to help householders save energy, and the data presented here lends support to the idea, since both forms of knowledge are important in home-warming practices. Another debate concerns the importance of designing "adaptive capacity" into buildings; affordances for people to manage their own temperature. Strengers and Maller (Strengers and Maller, 2011) suggest this approach as an alternative to highly-controlled and mechanised indoor environments. The high level of adaptation and innovation that occurs in people's homes, as shown here, suggests that there could be great potential to develop and promote more adaptive approaches to warming within design. The findings presented here are also relevant to debates about how people might react to demand management policies, and reinforce Strengers' (Strengers, 2013) argument that householders can show considerable resilience and flexibility in how they use energy, under the right conditions. Further work in this area could explore the potential role of everyday adaptations (like those described here) within policy interventions such as critical peak pricing or capacity markets. With domestic heat consumption currently high on policy agendas, it is important that we build an evidence base on everyday innovations and adaptations in thermal management practices. While these are largely ignored by policy at present, this study suggests they may play an important role in efforts to keep homes warm while reducing energy use.

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