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ECSCW CONTRIBUTION

Green IT Meaning in Energy Monitoring Practices: The Case of Danish Households

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Abstract. Eco-conferences like COP26 in Glasgow (UK) in 2021 have brought the debate on energy consumption and climate change to the fore. Given that a third of the energy produced worldwide is consumed in the home, it is pertinent to investigate how households use emerging technologies that allow households to monitor their energy consumption. This paper investigates how Danish households use green IT to monitor and manage their energy use and studies the related meaning householders attach to the green IT. We present qualitative data collected through interviews with 14 households, electric car owners mostly, who have adopted an application to monitor green energy availability – and its derived consumption. The paper highlights these householders' green energy monitoring practices with an emphasis on the meaning they make of the green IT application they used. Our study found that households can use more green energy without interacting continuously with the green IT application. This contrasts with a common assumption in the field of green IT design that consumers must continuously engage with the green IT to consume more green energy. We also posit that including householders in future green IT design is paramount for designing successful green IT applications. Finally, this paper calls for household energy consumption studies to view energy consumption as a service where specific practices are matched to energy sources – rather than viewing energy availability as a solitary incident.

Keywords: Energy consumption, Energy monitoring, Green IT, Green energy, Sustainability

1 Introduction

Since the formulation of the Sustainable Development Goals (SDGs) by the United Nations (UN), environmental sustainability has become of great interest to world leaders. The UN Climate Change Conferences (referred to as COP – Conference of the Parties) have been gathering country leaders with the aim of negotiating plans to reverse climate change. These negotiations have been motivated by the rise in global energy consumption (Pablo-Romero et al., 2017). Such worldwide initiatives have also become the catalyst for business leaders

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to include environmental sustainability in their corporate visions (Wunderlich, 2013), leading to a proliferation of IT solutions to better support the green energy transition.

The above developments have led to a rise in studies on energy and sustainability (Pierce and Paulos, 2012), as well as studies on technologies designed to support more sustainable living (e.g., technologies including smart homes, smart cities, censors, energy feedback systems, electricity consumption feedback). Some of these studies are related to energy use and consumption in workplaces (Bedwell et al., 2016), while others examine the domestic setting (Fischer, 2008; Pothitou et al., 2017). Within Sustainable Human Computer Interaction (S-HCI) (Disalvo et al., 2010a, b; Hansson et al., 2021), investigating ways to nudge consumers towards a behavioural shift in energy consumption is becoming increasingly popular (Lehner et al., 2016; Ranchordás, 2019). However, nudging approaches have been criticised for failing to have significant and long-term effects (Hansson et al., 2021). This has led some researchers to shift focus from changing consumer behaviour to understanding the everyday practices related to consumer consumption behaviours. Some of these studies use the practice theory approach, and focus on the interplay between people and technologies, and the way in which this manifests itself in everyday practices (Neustaedter et al., 2013; Rinkinen et al., 2019). Other scholars argue that the study of everyday practices is not enough to inform S-HCI, and posit that we also need to understand how practices are part of wider experiential environments and flows of practical activity (Pink et al., 2013).

While there has been a sharp increase in the number of studies of energy monitoring technologies in S-HCI and Ubiquitous Computing (UbiCom) (Hansson et al., 2021), this has not been the case in Computer Supported Cooperative-Work (CSCW), despite the field's increasing attention on sustainability (e.g., Meurer et al., 2018) and sustainable design (Simone et al., 2022). In sustainable CSCW (S-CSCW) (Prost et al., 2015), research focuses predominately on the social aspects related to the use of technologies, and on finding ways to motivate users (Dillahunt et al., 2014). We believe that the CSCW community has much to contribute to energy monitoring studies by providing a deeper understanding of the diverse energy consumption practices within the household setting, and thus to the design of technologies that actually support these local and situated practices (Suchman, 1987). Furthermore, the CSCW approach is able to identify gaps between on the one hand designers' intentions for and assumptions about users, and on the other hand actual use (Jensen et al., 2018; Orlikowski and Gash, 1994).

The topic of sustainability has become increasingly popular in the past decade, giving rise to a wide range of studies that focus on different technological solutions to support sustainable behaviour. However, research into technologies that support everyday energy consumption practices in households is still at an early stage. Furthermore, not much attention has been paid to understanding how householders use and experience these technologies in real-life settings over a longer period of time (Costanza et al., 2016; Jensen et al., 2018). This paper attempts to fill the gap in the literature by examining the meaning householders place on green energy monitoring technologies. Meaning is one of three elements that (re)configure practice over time and refers to a socially shared understanding about how a practice ought to be performed based on purposes and common beliefs of what is considered as socially acceptable by a specific community of practice (Shove et al., 2012). Focusing on meaning (e.g., purposes and beliefs) is essential, as it is one of the elements that holds practice together (Gram-Hanssen, 2011) and can help explain actual use of green energy monitoring technologies. The term green IT is used in a broad context in the CSCW literature, but is always linked to energy demands and global warming. Some studies have used this term as an expression to denote the need to raise awareness of data centres' energy consumption, see for example (Lincke, 2012), while other studies use it to refer to paper reduction, see for example (Bandi et al., 2015). In this study, we will use the term green IT for technologies that enable householders to monitor and shift their energy consumption to periods when energy is green (i.e., produced from renewable resources).

We address three key research questions: (1) how do householders make sense of, and engage with, green IT? (2) What impact do these different types of meaning-making and engagement practices have on the actual use of the green IT? (3) How can green-IT be designed to better support various types of energy consumption practices? The paper draws on interviews with 14 households in Denmark who have used an application for monitoring their household energy consumption over a period of 18 months. This study is therefore based on a unique and rich sample of long-term use of green-IT in real-life settings. While the study is not a longitudinal study, the data collected reflect a long-term use of green-IT. This paper is motivated by a recognition that one of the challenges facing energy monitoring technologies is the question of how to translate everyday energy consumption practices into viable design requirements.

The study's findings show a shift away from viewing continuous engagement—with the green IT—essential for successful green energy monitoring. In line with other studies within the literature, we found a group of respondents that had stopped engaging with the technology after a while -see e.g.(Strengers et al., 2019a, b)-, while another group deemed certain energy consumption routines non-negotiable (see Pink et al., 2013). We also identified another group of respondents: early adopters as defined by Rogers (2003). These are users who have been with their green IT provider ever since the product was launched and see themselves as part of a community of practice (see Prost et al. (2015)). We find this new form of engagement raises the question of how we might design green IT that also allows for engagement not solely driven by energy cost saving. Many energy monitoring technologies are designed with a strong focus on monetary benefit alone, at the risk of neglecting other aspects that may be meaningful to householders. This had led some designers to focus on finding ways to ensure users maintain a constant engagement with the technology. This focus is due to the assumption that constant engagement is necessary for changing individuals' energy consumption behaviour. Our study problematises these assumptions and argues for the need to rethink the design of energy monitoring technologies such that they accommodate various types and levels of dis/engagements driven by different motivations. Our empirical case contributes to the fields of S-CSCW and energy monitoring technology by discussing ways in which we can design technologies to support a wide range of green energy consumption practices.

In the next section, we introduce our conceptual grounding and present the literature related to energy consumption practices and technologies designed to support these practices. We then present our research and the methods used to collect and analyse the empirical data. This is followed by our results and a discussion of the actual types of engagement we identified and design suggestions. We conclude with a few remarks on future implications for design of green IT. We believe this case study to be a strong candidate for empirical generalisation as defined by Yin (2013). By this, we mean transferable to a larger population of cases (Byrne, 2013) in a secondary or even tertiary empirical enquiry. This paper's main contribution is to identify different types of user engagements at play when designing green IT to support the monitoring of green energy. This paper contributes to CSCW literature by highlighting ways in which householders engage with the technology that allows them to monitor green energy—for better future green IT design.

2 Related work

This work can be placed within the 3rd paradigm of human–computer interaction (HCI) (Pink et al., 2013), which views interaction as a form of meaning making that is inseparable from its situated context and is open to multiple interpretations.

Practice theory gives us a lens through which we see the world. We use Shove et al's (2012; p12) three-part model 'Meanings, Materiality and Competences' to express the meaning that householders make of the technology that enables them to monitor green energy.

To establish the conceptual grounding required to analyse energy consumption in households, we provide a brief overview of studies focusing on everyday practice and energy consumption in the household, and an overview of studies of technologies that support the monitoring of green energy consumption.

2.1 Energy consumption practices in households

There is a wide range of studies investigating everyday consumption practices in domestic settings, using quantitative, qualitative, and mixed methods. Some studies are based on quantitative data and focus on developing databases of both household expenditures and energy usage and time, in order to map patterns related to the total household energy consumption of the various household activities (Mashhoodi, 2021; Smetschka et al., 2019). For instance, de Lauretis et al. (2017) found that income, household composition and the dwelling type are all drivers of energy and expenditure intensities, influencing the time of use of energy and the type of use. While these quantitative studies help map various energy usage patterns of behaviour (the 'what'), they fall short of providing an understanding of the meanings and reasons (the 'why') behind the identified patterns. Furthermore, they tend to focus on the individual consumer, neglecting the cultural and social dimensions that influence the consumer's behaviour (Dourish, 2010; Pierce and Paulos, 2012).

These shortcomings have led some scholars to draw on a practice theoretical research tradition, arguing that energy consumption behaviour cannot be studied meaningfully without considering its relationship to the larger cultural system surrounding it (Gram-Hanssen, 2010; Reckwitz, 2002; Shove and Walker, 2014). Essentially, we need to move away from focusing on the consumer as someone driven by self-interest and economic rational choice (Froehlich et al., 2010), to holistically examining the social practice within which behaviour is embedded. This implies a move away from identifying individual personal attributes, to examining shared conventions and routines for how sustainable practices might be developed and cultivated (Shove and Spurling, 2013.p.104). Thus, scholars drawing upon social practice theory argue for several shifts in the units of analysis. First, a move away from behaviour and rational choice (Froehlich et al., 2010) to socio-cultural practices (Reckwitz, 2002); and second, a move away from individual consumers to groups and communities (Disalvo et al., 2010a, b; Prost et al., 2015).

Several scholars have applied the above-mentioned analytical shifts, carrying out qualitative studies of household practices, while considering both cultural and socio-technical aspects related to these various practices (Gram-Hanssen, 2010). These scholars demonstrate how our everyday life is defined by the rise, change and collapse of social practices (Shove et al., 2012). Some of the everyday practice studies include analysis of housework as well as washing and cooking practices (Bourgeois et al., 2014; Rinkinen et al., 2019). To this effect Wilhite (2005) points out that people do not consume energy per se, but rather the things energy makes possible, such as light, clean clothes, travel, refrigeration and so on. Put differently, "energy is…not something that the consumer has a direct interest in but is something that happens because they perform other activities, which are important to them" (Gram-Hanssen et al., 2020.p.2). Common to these studies is the focus on the way in which expectations, practices, routines, and habits change over time, and what their consequences are. In a recent collection of essays, Energy Fables, Rinkinen et al. (2019) analyse different everyday practices (e.g., showering and cooking) in the past 50 years and show a direct correlation between climate change and changes in everyday practices. Hargreaves (2011) reveal the profound difficulties encountered in attempting to challenge and change practices – difficulties that extend far beyond the removal of contextual 'barriers' to change and instead implicate the organisation of everyday life.

In keeping with the idea of the limitations offered by consumer choice and behaviour, Pink et al. (2013) argue that studying everyday practices is not enough to inform sustainable HCI. They posit that we also need to understand how practices are part of wider experiential environments and flows of practical activity. Their approach builds on theories of place, perception and movement and enables us to situate practices, and understand practical activities, as emplaced within complex and shifting ecologies of routines.

This paper wishes to contribute to these studies, by examining energy consumption practices as part of a wider ecology in the home, whilst moving a step further, to present the meaning that householders make of energy monitoring technologies. Studying households' energy consumption requires an understanding of the technology that makes energy monitoring consumption feasible whilst providing an opportunity for the user to act (Pink, 2011; Pothitou et al., 2017). Householders have always been able to monitor their energy consumption through utility bills. Studies report that people do not typically investigate their bills unless the bills are exceptionally high, since people are more concerned by the costs the bills impose on them than they are by energy conservation (Kempton and Layne, 1994). Therefore, technologies that enable real-time energy consumption monitoring could potentially play a significant role in shifting consumers' behaviour toward a more sustainable energy consumption (Hargreaves et al., 2010). In the next section, we will provide an overview of studies that focus on understanding how technology might support the monitoring of energy consumption in households.

2.2 Technologies for monitoring energy consumption

There is a wide range of technologies that are designed specifically to raise people's awareness about energy consumption and nudge them to change their behaviour towards more sustainable energy consumption. Some technologies focus on persuading people to reduce their energy consumption (Selvefors et al., 2015; Wågø and Berker, 2014), others persuade them to shift to off peak-time/low demand (Pierce and Paulos, 2012; Prost et al., 2015), and some persuade them to shift energy consumption to when it is green, i.e., produced from renewable resources such as wind and solar power (Wunderlich, 2013). These technological solutions are composed of technological artefacts (e.g., IoT, digital displays/dashboards, and web-based/mobile applications), and they come with different labels such as energy consumption feedback systems, eco-feedback systems, energy monitors, and green IT (Froehlich et al., 2010; Petkov et al., 2011; Pierce and Paulos, 2012; Vassileva et al., 2013). Despite their increased popularity, these technologies and systems have been criticised for providing fast and temporary solutions to energy consumption monitoring, with relatively low impact (Brynjarsdottir et al., 2012).

The configurations of the feedback provided in current energy consumption technologies have relied predominantly on cognitive or behavioural factors (Schwartz et al., 2013). Some studies focus, for example, on understanding the effects of different attributes and factors on energy consumption behaviour. These include, for instance, demographic attributes related to the individual user (e.g., age, education and income) and behavioural factors related to the household's energy consumptions (e.g., household composition and appliances) (Bakaloglou and Charlier, 2019; de Lauretis et al., 2017; Mashhoodi, 2021; Vassileva et al., 2013). Other studies focus on identifying features for effective feedback, for example in terms of frequency, duration, or presentation of information (Fischer, 2008). While these may be important aspects to take into account, such a limited and somewhat mechanistic focus on mapping individual behaviour and effective feedback (e.g., Leroy and Yannou, 2018) may risk missing other characteristics that support sustainable lifestyle and are important for technology design (Schwartz et al., 2013). To overcome these limitations, researchers have argued for the need to move away from focusing heavily on individual behaviour, and to analyse collective responsibilities and decision-making around energy consumption practices (Bedwell et al., 2016; Dourish, 2010; Pierce and Paulos, 2012).

Providing consumers with information and feedback has been found to have the potential of reducing energy consumption by up to 25 percent (Vassileva et al., 2013). This has given rise to the development of various types of energy monitoring systems designed to provide feedback on energy consumption. Indeed, these technologies have been found to be successful in terms of increasing awareness and getting consumers to pay attention to their energy consumption practices (Prost et al., 2015). Furthermore, some studies have found that these energy monitoring technologies do lead to reduction in energy consumption (Bull et al., 2018). While some scholars question the extent to which these limited behavioural changes have a global impact (Brynjarsdottir et al., 2012; Pierce and Paulos, 2012), others view the residential sector as a crucial hub for saving energy and achieving CO2 emission reductions (Pablo-Romero et al., 2017).

As mentioned above, not all energy monitoring technologies focus solely on reduction in energy consumption. Some technologies emphasise the shift of consumption to off-peak periods and/or periods where energy is green (i.e. renewable). To this effect, various types of incentives have been used to encourage householders to modify their energy consumption practices. This includes, for example, informing consumers about the amount of energy saved, the amount of CO2 emission reduced, and/or the amount of money saved. The last incentive has been highly popular, used in many technological solutions, as it has been shown that monetary saving can be achieved by shifting energy demands to green energy availability periods and/or to off-peak hours (Monigatti et al., 2010). Nevertheless, some argue that despite substantial reduction in energy consumption, the monetary saving is rather minimal when compared to the total household costs (Prost et al., 2015).

In recent years, much attention has been paid to the type of information and feedback provided to consumers. This is due to the fact that researchers have observed that while energy monitoring technologies increase consumer awareness, they tend to leave users in a state of 'helplessness', missing concrete actions as to how to change unsustainable practices (Prost et al., 2015). Researchers have, therefore, been experimenting with different types of technologies and devices that visualise households' energy consumption/usage in real time. This includes, for example, an IoT-enabled ambient display that glows in different colours depending on the energy consumption level in the home (Chowdhury and Moore, 2018); a smart light that indicates its energy sources and provides recommendations for appropriate times to undertake energy-intensive tasks (Martin, 2020); a prototype that uses traffic light symbols to convey to householders when it is recommended to use energy (Monigatti et al., 2010); or a system that displays a single polar bear or a family of polar bears on a block of ice to indicate a household's energy consumption level (Dillahunt et al., 2014). While these studies are highly valuable, they often tend to be tested over a relative short amount of time, and typically use a small sample of users, making it difficult to generate clear conclusions about the effects of these technological solutions on households' energy consumption. Furthermore, while studies that target the design and adoption of technologies are useful, they rarely consider how technologies transform social practices (Rinkinen et al., 2020). Tolmie et al. (2007) made an attempt at highlighting the wider ecology that technology and the social context households exist within, thus coining the term 'digital housekeeping'. The term digital housekeeping refers to all the work done in a household to make the home network of technologies work.

In order to address the above-mentioned shortcomings, some scholars argue that, for successful adoption in households, technology needs to be 'domesticated' and become rooted in daily lives (Brause and Blank, 2020). Aune et al. (2016) bring technology to the fore by first and foremost using the concept of domestication to challenge the linear understanding of technology within domestic energy consumption.

Understanding how householders use and experience energy monitoring technologies in real-life settings and over a longer period of time has been overlooked in research (Costanza et al., 2016; Jensen et al., 2018). This paper attempts to fill this gap in the literature by examining the meaning householders make of their green energy monitoring technologies. Such understandings of actual use can in turn be used to enhance the design of green IT.

Studies that do examine the acquisition of these energy monitoring technologies and their impact on energy consumption practices report that some energy consumption practices are changed, while others are not (e.g., Selvefors et al., 2015). These unchanged practices have been labelled ‘non-negotiable practices’ (Strengers, 2011), as they are practices (e.g., cooking habits) that cannot be so easily changed and/or influenced by external circumstances. There are many reasons for why some practices are non-negotiable; these include for instance, personal reasons, such as not wanting to be tied up to the technology and perceiving the monetary saving as too small; social reasons, such as practical negotiations with other household members; and cultural barriers, such as stable cultural arrangements which cannot be influenced (Prost et al., 2015).

While energy monitoring technologies offer great potential for increasing consumers’ awareness, several studies report a decline in users’ interaction with these technologies over time (Barreto et al., 2013; Erickson et al., 2012; Hargreaves et al., 2013); in some cases, this has led to non-use (Prost et al., 2015). This declining pattern has been described as a stage where the technology’s novelty wears off (Strengers et al., 2019a, b). Other scholars associate the decline in interaction not with the technology’s novelty, but rather to the users and their desire to ‘detox’ from the digital technology (Syvertsen and Enli, 2019). A related phenomenon is technology un-use, “a form of human-artefact disengagement that focuses on the activities involved in disengaging with interactive systems or functionality” (Krischkowsky et al., 2021.p.2). This refers to the transitional capabilities of users to actively reduce their engagement with the technology to different degrees over time (ibid.).

Research shows that user engagement with these energy monitoring systems depends on social practices, location and time (Prost et al., 2015). This has led some scholars to examine ways of addressing the decline in interaction and preserving long-term engagement. For example, Petkov et al. (2011) examine the use of elements from gamification and reward systems (by comparing data within a community of energy consumers) and the potentials for socialising energy-related feedback.

To better support the integration of energy consumption practices with other daily activities in the domestic sphere (Selvefors et al., 2015), a few scholars have explored the use of other artefacts beside stand-alone technology. This includes, for example, the use of a calendar as a tool to incorporate energy-related information into people’s calendars of everyday activities (Neustaedter et al., 2013), and households diaries (Ellegård and Palm, 2011). Many of these solutions are often designed for adults, excluding children, who—despite being part of the household—are not made aware of energy consumption choices by their parents

(Neustaedter et al., 2013). To address this, (Dillahunt et al., 2014) present an application that is designed, not only for adults, but also for the involvement of children. While this approach opens up the idea of the 'household unit' to include all members of the household, it does not provide an analysis of the long-term effects the application.

3 Methods

This paper is based on data collected from interviews with 15 participants from 14 Danish households. These interviews were conducted with the aim to understand households' existing practices in relation to energy monitoring with a special focus on the meaning householders make of their energy monitoring technology. We use Practice theory as a lens through which we see the world.

We use Shove et al's (2012, p12) three part model 'Meanings, Materiality and Competences' to express the meaning that householders make of the technology that enables them to monitor green energy.

3.1 Case setting

The Danish government has recently announced that it aims to ensure all domestic flights use renewable energy by 2030. Such initiatives have reawakened the debate on energy across Denmark, a country where a third of the total energy produced is consumed at the residential level (Gram-Hanssen et al., 2020). To meet the residential sustainable development goals, various green transition initiatives are being developed at both public and private organisational levels. For instance, Photo Voltaic systems – solar panels – are being introduced in homes across Denmark (Gram-Hanssen et al., 2020). Moreover, numerous technical solutions target residential consumers; technical solutions that aim to nudge householders towards either reducing their energy consumption or shifting their consumption demands to green energy availability timeslots. To this effect, there is currently a proliferation of energy monitoring solutions being developed to help householders through the monitoring of their energy consumption behaviour.

As a green IT solution, Barry for example, is both an energy start up and an app. Barry is a member of Fortum, a Finish company which generates and sells electricity and heat. Barry was founded in Denmark in 2018 and has employees in seven different countries. On their website, the company describes itself as "the electricity supplier of the future", and goes on to explain that:

'A promise of "100% green power" is 100% hot air. But you probably already know that. On the other hand, we believe that data can show us the truth and help us on our way to a better everyday life and a greener future.

We do this by showing you exactly how green your electricity is and how much CO2 it emits, hour by hour - kWh for kWh. (https://barry.energy/dk/about, accessed 24 Jan 2022, own translation).'

As can be seen from the above statement, Barry is strongly capitalising on their application's ability to enable users to monitor their green energy consumption – and the related CO2 emission. While there are many other options for households in Denmark to monitor their energy consumption, there are not so many electricity suppliers that offer a related application solution (green IT). Moreover, as can be seen from Fig. 1 below, Barry as a green IT provider targets specifically electric car owners, by stating that Barry is '100% digital electric supplier created for you who has an electric car' (https://barry.energy/dk/, accessed 3 Dec 2021, own translation).

Most of the electricity in Denmark is hydro-based and natural gas is used for home and water heating. Stoves are typically electric and, as mentioned above, Barry as an energy provider also provides an application that comes with various features displaying energy consumption charts over a period of time (see Fig. 1 below) as well as the energy price forecast for the next 24 hrs.

Barry allows its users to see historical energy consumption, as well as the monitoring of energy type and price through a 24- hour forecast. Having access to energy type forecast– and its subsequent price- thus makes it possible for the users to plan energy consuming activities accordingly and thus shift energy consumption to 'green energy windows', i.e., when the sun shines and when the wind blows. In effect, tools such as Barry empower households to consume green energy and participate in the global green transition.

Barry was chosen as the principal technological application in this study because it had been very popular amongst participants in an earlier study—also related to green energy consumption -see (Tchatchoua et al., 2020). It had therefore felt obvious to us as researchers to carry on with the same technological solution in this study for consistency and ease. It had been our intention during the research design to only interview Barry users in this study. However, we found ourselves having to add two users of a different green IT tool to the pool of respondents towards the end -due to the tight project deadlines. Since the questions we asked were not application specific per se, we believe the tool does not diverge from the research goals and findings.

The other application used by our participants (two households) was an application called SEAS-NVE, provided by an energy company of the same name. SEAS-NVE is a company also based in Denmark. SEAS-NVE offers users the same type of data as Barry does, with a similar interface and functionality. For the purpose of brevity, in our analysis we use the term green IT to refer to both Barry and SEAS-NVE.

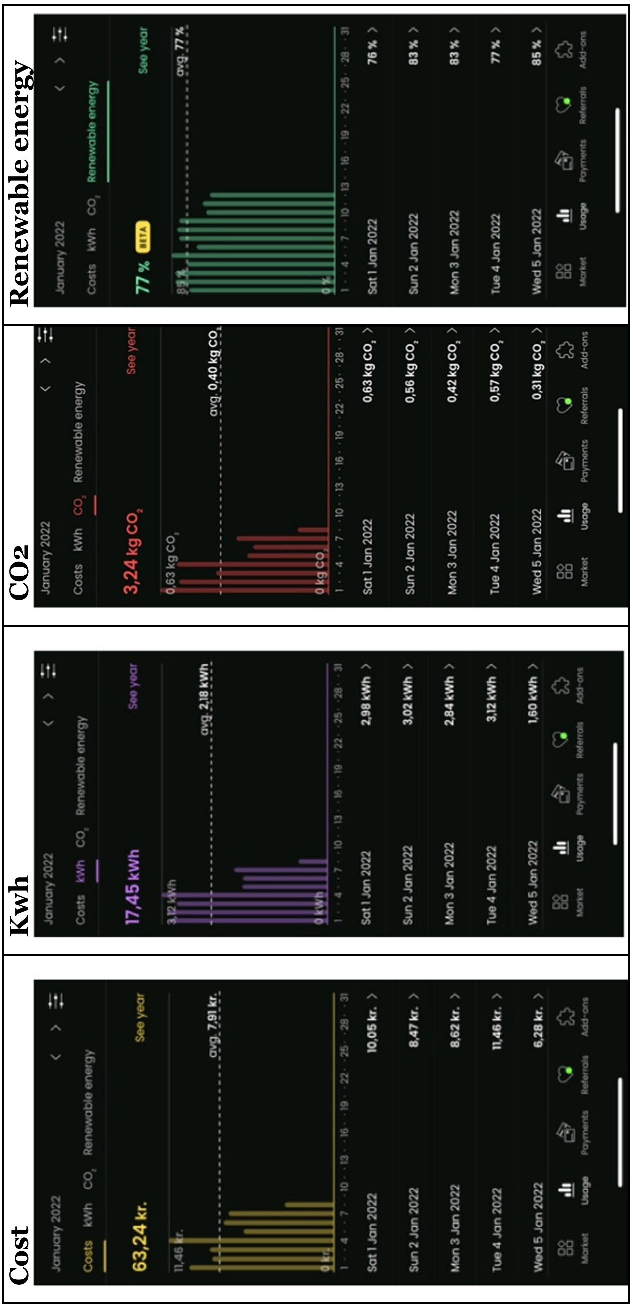

Figure 1. Barry's main features.

3.2 Data collection

> '[…] there are no such things as unmediated data or facts; these are always the results of interpretations. Yet, the interpretation does not take place in a neutral, a-political, ideology-free space. Nor is an autonomous, value-free researcher responsible for it' (Alvesson and Sköldberg, 2009.p.12)

Qualitative research was chosen in order to create in-depth understanding of the diverse experiences of individual households (Bansal and Corley, 2012). There was a need to focus on specific practice cases and their special features – or contextual setting – for each of our 14 households. In doing so, we also hoped to unearth implicit and -or—unconscious aspects of a social phenomenon linked to green IT and its related green energy consumption support in households in Denmark (Bansal and Corley, 2012). Additionally, we had planned for observations in our participants' homes; the planned observations ended up being hampered by the ongoing COVID-19 pandemic. However, the online interviews did allow for a wider geographical sample for our study.

We chose the interview approach for our data collection because we had aimed to capture a rich account of the householders' experiences, knowledge, ideas and impressions (Alvesson, 2003; Bryman, 2006; Fontana and Frey, 2003).

We recruited households' participants through snowball sampling and ads on Facebook, Twitter and LinkedIn. The majority of study participants were selected from a pool of households who have already made a leap towards green energy monitoring, and use an existing energy monitoring application in Denmark called 'Barry'. The first author contacted Barry's group of users on Facebook after suitable vetting by the group administrator – who acted as a gatekeeper and subsequently surrendered the right access and credibility in due course. This same author created a series of posts on the website giving details about the research and its purpose. It is also worth noting at this stage that because of the ongoing pandemic, and due to the fact that the home became multifunctional as a result, the interviews generally competed with householders' other home responsibilities. The posts needed refreshing in the -fast paced and highly technical content—group quite frequently. The researchers also used another type of gatekeeper: owners of an electric car for access to such closed Facebook groups – the Tesla car owners' group in this case—in order to recruit through these individuals' posts.

All participants lived in Denmark. Table 1 below provides an overview of the participants' sample used in this study, including, age bracket, the type of household composition, type of home and participants' role in energy monitoring activities. The length of time householders had been using the energy monitoring technology at the time of the interview is also provided. 'Given

Table 1. Participants details.

Informant First name	Age	Profession	Number of years with the green IT – at the time of the interview	Household size	Electric car owner ?	Dwelling type	Type of engagement with the green IT	Meaning made of the green IT
1.Nis	42	Software Programmer	Just over a year	1.5 (visiting son)	Yes	House	Active daily user	Cost saving and opportunity for green energy consumption
2.Anders	43	IT infrastructure architect	About 4 years	1	Yes	Villa	Active daily user	He likes to see his energy data but 'doesn't want to be told what to do by the app'- notifications disabled
3.Thomas	45	Partner manager	1 year	4	Yes	House	Active daily user	Low energy price – also likes the consumption awareness and the energy consumption educational opportunity Barry offers. Notifications disabled
4.Kristian	43	IT Professional	2 years	4	Yes	House	Active daily user	Barry helps his household confirm their green choices. He doesn't act on the notifications although he feels they – as a household- have learned a lot about energy consumption from Barry

Table 1. (continued)

Informant First name	Age	Profession	Number of years with the green IT – at the time of the interview	Household size	Electric car owner ?	Dwelling type	Type of engagement with the green IT	Meaning made of the green IT
5.Christian	41	Finance consultant	1.5 years	5	Yes	House	Active daily user	Barry has created CO_2 consumption awareness in his household as well as a correlation between green energy and low energy pricing. Barry enables them to use their household appliances efficiently
6.Sune	Over 45	Manager	1 year	4	Yes	Villa	Active daily user	'I am not that religious about energy price saving but Barry helps me be conscientious and use energy when there is a lot of wind for example.'
7.Thomas N	Over 40	Business consultant	9 months	5	Yes	House	Active daily user	'Barry helps me charge my car at a lower price.' Notifications turned off
8.Jesper	Over 55	Professor	2 years	3	Yes	House	Seasonal user	He feels insulating the house is more important than saving on electricity consumption

Table 1. (continued)

Informant First name	Age	Profession	Number of years with the green IT – at the time of the interview	Household size	Electric car owner ?	Dwelling type	Type of engagement with the green IT	Meaning made of the green IT
9.Britt & Chris	45	IT professionals	Over 2 years	3	Yes	House	Seasonal users	Barry helps them be green but they won't trade being green for convenience. They are unsure Barry has a place in their home as such these days compared to when they first started using it 2 yrs. ago
10.Oscar	Over 40	Project manager	Over 2 years	1	No	Flat	Active daily user	'Electricity was just a number before but Barry has made me very aware of my consumption.'
11.Henrik	Early 50 s	Software engineer	1.5 years	3	Yes	House	Active daily user	Barry helps him make the planet inheritable in years to come
12.Jesper F	Over 40	Lawyer	1 year	4	Yes	House	Active user	'We tried to use as little energy as possible before but now Barry makes us aware of green energy availability much more easily. With 2 electric cars, energy is very important to us.'

Table 1. (continued)

Informant First name	Age	Profession	Number of years with the green IT – at the time of the interview	Household size	Electric car owner ?	Dwelling type	Type of engagement with the green IT	Meaning made of the green IT
13.Rasmus	Over 50	Firefighter	1 year	6	Yes	House	Active daily user	'Barry helps me check energy prices in advance and then schedule energy practices accordingly.'
14.Martin	Over 50	Engineer	1 year	3	No	House	Active user	He doesn't feel that the green IT has much of a place in his house. He only uses it for washing clothes and cleaning the dishes

that the claims that we, as qualitative researchers, want to make are based on working closely with relatively small numbers of people, interactions, situations or spaces, it was essential that our participants are chosen for good analytical reason' (Chalhoub and Kraemer, 2021). We focused on interviewing people who had already made a leap towards using a green energy monitoring technology. Emergent analysis and the researchers' reflexivity prompted a decision to also interview households—two in total—with a different type of energy monitoring technology than Barry. Meaning that in total we interviewed 12 users of Barry and two users of SEAS-NVE. Due to the fact that Barry and SEAS-NVE offer users the same type of functionality and information, we judged that the SEAS-NVE users' experiences could be combined with those of the Barry users in addressing this study's research questions. In the research design, we had not intended to only interview educated men between 40 and 45 who drive an electric car, but this is the main constituency we have ended up interviewing. The research plan was to interview 20 participants, based on literature illustrating similar studies; 11 interviews into the project, we reached a saturation point – where no new information was coming through in the respondents' responses – and therefore decided to stop collecting data after three additional interviews, two of which happened to be SEAS users (Byrne, 2013). Homogenous recruitment in energy related studies is not uncommon or new. Literature illustrates a heavily gender-biased sample in similar studies – see for example (Wunderlich et al., 2013). In addition, our sample was largely homogenous in that 13 of 14 households owned electric cars. We return to the issue of homogeneity of our sample and its implications for this study and future research in the study's limitations section.

We conducted a semi-structured interview with each participant (representing a household). Interviews lasted between 30 and 60 min. All but 2 interviews were conducted online—due to the pandemic distancing measures. The interviews targeted 5 main areas. The first area investigated how and why the green IT was introduced into the household, as well as its main usage norms within the household (e.g., who uses it, when and how). The second area of focus was the technical affordances the green IT provides to the households, and the influence that it had on householders' day to day activities. The final part of the interviews was centred around the meaning householders made of the technology after it had entered their homes, and the way in which the technology had been domesticated within each of the households. We also asked participants to describe the typical energy routines in their household as well as a description of their homes, their energy related appliances—including electronics such as iPads.

3.3 Data analysis

All interviews were conducted in English and transcribed. We kept handwritten or typed notes and audio-recorded all interviews. The transcribed interviews were coded using NVivo. We applied open, axial and selective coding (Strauss and Glaser, 1967) to the empirical data, in order to identify similarities and differences in energy consumption practices and use of technology. Open coding was mainly performed as debriefings of the interviews and discussions of the general meanings of the choice of words and statements of the interviewees. Axial coding (Corbin and Strauss, 2008) allowed for categorisation of the codes found in open coding and comparing them through various weightings (e.g. finding the attribute of 'height' and extrapolating how interviewees deem that attribute as both 'tall', 'huge', 'short' or 'wide' in the data).

We worked both inductively and deductively when connecting and generating ideas from the data. We first applied induction to outline themes and key elements in the empirical data such as energy monitoring practices, the meaning of the energy monitoring technology, the length of use of the application, the main learning activities derived from using the application etc. A deductive approach then followed to apply practice theory to our empirical data. In using practice theory, we wanted to know how the technology was used in their household. To this effect, we targeted questions focused on the usage of the technology. Namely: 'are there any householders who do not use your energy monitoring application?', 'why did you choose to bring the green IT into your life?

Deduction was adopted owing to the research questions: How do householders make meaning of, and engage with, green-IT? What impact do these different types of meanings and engagement practices have on the actual use of the green-IT? How can green-IT be designed to better support various types of energy consumption practices? Some of the key patterns derived from literature using deduction included 'non/negotiable practices' and 'if/how the application had moved to the background after a certain period of usage'. The goal of our analysis was to understand each household's practices around the adoption, usage and meaning they made of the technology—together with their everyday energy consumption routines. We were less concerned about whether their recollection of specific energy related consumption routine was linear but focused more on the overall picture. During the interviews and data analysis, reflexivity was used by the researchers as a framework to stimulate the interplay between co-constructing interpretations and challenging them (Alvesson, 2003; Alvesson and Sköldberg, 2009.p.12). Reflexivity came to play during the data analysis when we regularly stopped and ask ourselves if our data was pointing to a particular direction. When the informant said 'they had not used the application in a while' for example, reflexivity was used to ask ourselves to quantify 'a while' in terms of months or weeks in order to better assess the new usage status and deduct actual engagement practice for example. In this particular example, we had to use additional data such as the question asking 'how often do you use the app' for instance in order to confirm our conclusion.

Worth reiterating at this stage that throughout the data analysis, our aim was not to develop or extend a theory but instead we hoped to extend our understanding of households' everyday energy consumption practices and discuss the implications such practices may have on future energy monitoring technology design. To this effect, our research falls within the subjective ontology paradigm, with specific focus on interpretations (Thorpe, 2019). We believe there to be multiple coexisting realities, experiences and meanings, and there is, therefore, not one single successful manner to design green technology.

Next, our results step through the various stages of our analysis and present the general themes we constructed from our participants' responses.

4 Results

4.1 Sporadic yet similar acquisition of green IT

We asked participants how their green IT system entered their households and what meaning it had for their households. The analysis of our data identified that there was a sporadic acquisition pattern across the households.

Most of the negotiations that led to the acquisition of the green technology were similar throughout the data analysis: the purchase of an electric vehicle. Typically, our respondents were keen to monitor green energy – through the energy monitoring technology- after they had bought a Tesla for example. New energy demands resulted in new considerations which in turn led to the procurement of the energy monitoring technology. For instance, Kristian explains that:

'It was… I think it was around the time when I was looking at electric cars I also looked into different ways of purchasing electricity. And especially for… I found that… Basically I just stumbled across Barry on the internet. It wasn't like recommended or anything it was just doing research and finding it'. (Kristian).

Similarly, Nis observes:

'I came across Barry because I bought an electric car. And when you have an electric car of course the price of electricity is quite a bit more important to you than before, because you are going to use a lot more electricity. So, there is a lot of talking in Facebook groups and other forums for owners of electric vehicles about, where do you get your electricity from'. (Nis).

Looking beyond the adoption stage, the data analysis highlighted a sense that householders dealt with the new green IT differently; sometimes rejecting the green IT as a tool after a while and at other times working out how exactly to fit it into their everyday routines. To exemplify the first scenario, a respondent conceded: 'I don't know if it (the green IT) has a place. It is you know… In the beginning it was kind of fun it is not something I use actively now; I don't think Britt (my wife) does either. So, you know in the start you look at it'.

We spoke to another respondent, Kristian, who defined the place that the green IT occupies in his household in these terms:

'It was more... It definitely was a bigger deal just when we started, because there was a lot of information that I, we, haven't had before. So basically, for us and for me what was really interesting was seeing obviously the changes in price during the day but also the changes in the carbon footprint or green energy as I think they call it. But obviously given a certain period of time you kind of learn when these periods are, so I would say that the green IT has definitely helped us to adapt or change our habits when it comes to using electricity but it is something that happened because of the data that was available in the beginning but now that this data has kind of been processed and is part of our daily life I don't really... I don't think Barry, honestly, I don't think it is that big of a difference than any other company with the same pricing would be to us. If that makes sense?'

By contrast, other respondents, newer users, found a way to include their green IT regularly into their routines. We spoke to Rasmus, a fireman, who explained:

'I think it has become a little habit to check out (the green IT)... For myself every afternoon almost every day, I go in the app and check out, what are the prices going to be tomorrow and then I'm scheduling do I need to charge my car and then we talk about it, okay, do we need to put over a wash or the dryer or anything tonight. And then we also got to... It is just a habit just checking it out, I do it every afternoon and I know my mother does it in the morning when she gets up. I do it in the afternoon because then I get the day ahead price because it is available around 2 o'clock or something like that'.

Here we could see that the energy monitoring technology has become a well-integrated part of Rasmus' life and checking green energy availability (and price) is almost a kind of 'sport' that he enjoys practicing.

Staying with the acquisition process, we looked to understand how householders mobilised the energy monitoring technology as part of their identities and how they presented themselves to the researchers. Again, it was clear from the data analysis that some of our respondents identified strongly with the green IT and felt that it helps them achieve their 'green energy transition' ambition. To exemplify this, a respondent observed: 'It helps me… It enables me to make more or better choices when it comes to choosing green energy, so yes. I guess the rest is up to me.' (Respondent). While another respondent added:

'Yeah, yeah, it doesn't have to be like big like TV2 – a local tv channel- …I think we all just have to do some thinking regarding that (being green). To me it's like a stamp of approval that Barry has implemented this feature (the CO2 feature)... I think that having a focus on it catches the spirit of the users as well, so I do feel like Barry-the green IT- is helping towards this. And I do feel like every time I am doing small things it just adds up, so I do personally feel that it (the green IT) is helping me contribute. In a tiny bit in a larger scale but I suppose it all adds up'.

In summary, the responses we received in regards to what the green IT meant were fairly similar, geared towards climate change reversal, with a lesser focus on monetary gain. Barry was therefore a useful tool in helping towards a common intrinsic value. To this cohort of participants, the green IT is a form of 'green energy consumption coach'. Having stated the above, although they welcomed the idea of Green IT helping them be 'greener', other participants did not share the same enthusiasm about the impact their green IT monitoring regime has at a larger scale. They feared that it was too big a problem for their little input. It was felt that, to these householders, the climate change issue appeared too big a task to tackle by an isolated household monitoring energy consumption in a small country as Denmark. To this effect, a respondent conceded: 'Denmark is a small country'. (respondent). While another respondent declared:

'What we do in order to be green is that we probably try to pick the greener solutions and in all honesty without compromising our own mental well-being too much… always making sure that the washing machine is running in the point in time where the electricity is the greenest is probably a little above our involvement. But I wouldn't mind paying a little bit more for my electricity in order to make sure that we receive green energy as a preferred energy source.'

The above expositions of the acquisition framework of green IT in this study illustrate that although technologies come with meanings through the guidance of design and advertising discourses, householders generally invest said technology with their own personal meanings and significance. To sum up, the overall acquisition of the energy monitoring technology is sporadic and diverse, where to some the green IT means a step towards their green transition goals and values, while two others that sentiment is somewhat too ambitious.

4.2 Green IT as a learning tool

Our data highlights that, despite the fact that the majority of participants had adopted the green IT because it had been recommended to them as a technical intervention for energy consumption monitoring, many of them no longer checked their apps frequently. Consequently, once they felt they had memorised the regular green energy availability – and the equivalent low pricing (at times) -windows, they stopped engaging actively with the app although still operating within the new routines – such as charging the electric car at night or hoovering the house on a windy day for instance.

Our participants described different energy consumption practices and activities, some driving the electric cars to drop the kids off to nursery a mile away from home, while others saved the drive for longer commute for instance. However, what was shared amongst them was the fact that regardless of the current frequency of use of their green IT, most respondents had 'memorised' typical green energy availability timeframes. They had thus taken the appropriate steps to shift an essential bulk of their energy consumption routines to meet those timeframes – despite some participants no longer engaging regularly with the technology.

To this effect, respondents with a focus on green energy consumption mentioned washing clothes at night because that is when energy is green. Others, although more interested in the monetary gain, reported to have made a correlation between low energy prices and green energy availability and were also washing their clothes during such timeframes. This latter group felt a sense of 'double achievement', as they were both consuming green energy and saving money. To exemplify this, Nis, an engineer living by himself, who has used Barry since the company first started, no longer checks the app but is still keen on saving on his energy bills, observed: '…my dishwasher exclusively runs at night when the electricity is cheap, and I also wash my clothes at night'. Meanwhile Sune, the male adult of a family of 5, is keen to leave a better world to his children and a fairly new and loyal user of Barry declared: 'But now I always program the dishwasher to run in the middle of the night…I have noticed a few times I even got money for spending electricity at night'; signalling here that the one sometimes gets paid to use green energy, when there is an abondance of it in the grid. Similar to Sune, Oscar learnt to relate the weather conditions to green energy availability: 'So, I always know now when it has been windy today, I know tomorrow is a good time to charge up things and wash laundry and so on'.

The above scenarios demonstrate the learning opportunity available within green IT design. Many of our participants have memorised slots during the day when electricity is green and cheap—from using the technical intervention and paying attention to weather conditions. Our results demonstrate how when opportunities for green energy consumption are learned, long term on-going engagement with the technology is no longer felt to be necessary.

4.3 Non/negotiable practices

All the study households reported a reluctance to sacrifice convenience in order to save money or to make best use of green energy. The data analysis confirmed that when it comes to using green (or cheaper) energy in the household, there exists negotiable and non-negotiable practices. Householders were generally willing to move certain routines they deem 'negotiable' to more suitable timeframes when energy is green – or cheaper. Some of these negotiable household practices include: doing the laundry or washing the dishes for example. Our data supported that; electric car owners typically waited for such time slots to charge their vehicles.

In contrast to the aforementioned negotiable practices, other household practices such as cooking dinner at a set time were deemed non-negotiable for our participants. All respondents in our study supported that they preferred to cook dinner around six o'clock in the evening regardless of the type of energy available at that time – or its related price. To this effect, householders with young children went on to elaborate on the short time window in the evenings before their children bedtime routines. Chris, our host, later confirmed: 'We have some hard things, so we have Pauline -our daughter- coming home from school and her bedtime and that window is actually quite small and we can't leave dinner too late because she needs to eat'.

For others in our study without the added pressure imposed by children's bedtime routines, dinner cooking at a set time, nevertheless, remained a non-negotiable practice. In most cases, practices that were routinely labelled negotiable or flexible in some households were non-negotiable in others. For example, in one household, a participant reported having stopped doing the laundry during the night because the washing machine noise kept her husband awake, while in another household, daytime laundry was not an option due to home working requirements.

4.4 A conflated picture of 'digital housekeeping'

We observed that the green IT usage in these households is part of a digital housekeeping routine. In these households, once it enters the home, the green IT is accountable to existing routines in the home, such that it will not unduly disrupt other courses of action central to domestic life. Our participants checked the green IT periodically because they didn't want the monitoring process to interfere with other activities- such as watching a movie together as a family for example—key to their domestic lives. To this effect, some householders checked green energy availability as part of their traditional housekeeping routines -such as hoovering for instance.

For a subset of our participants, once they had taken all suitable measures for green energy consumption (i.e., learning and acting upon the suitable green energy slots), they continued to engage with the green IT frequently. They also attended all the workshops organised by the green IT provider as a form of loyalty to the green transition cause, or to show support to the provider. Digital housekeeping for these specific householders was motivated by a different goal, a goal not intended in the original design of the green IT.

To this effect, Oscar, an informant living in a flat in Copenhagen, enjoyed being part of the green IT community. He highlighted his regular engagement with the green IT as a form of loyalty to the green IT provider. He mentioned 'having been there since the beginning' with a sense of achievement. Similarly, Anders had a grin on his face when he explained: '…I was actually a part of Barry, a customer with Barry in the beginning'. These cases exemplify the fact that loyalty to the start-up was a sentiment some of our participants tapped into in order to keep their motivation to use the green IT, thus giving the perceived digital housekeeping role a secondary – or maybe even tertiary- value.

Meanwhile, others kept the green IT as part of their digital housekeeping work – nothing else. In other words, this specific cohort of participants used the green IT when they needed to perform a task, they then turned off every notification and suppressed the interaction with the green IT after that. Similar to putting the vacuum cleaner back in the utility room after usage, in traditional housekeeping, for example. To highlight his sentiment about the green IT's notifications in particular, and his interaction level with the green IT in general, Henrik observed:

'…I just have another way of "working" with it, I choose when I want to go in and plan laundry or whatever. I don't want the app to come up with something on the screen when I'm in a meeting or doing something. I mean sometimes I need to focus, and I don't want to be disturbed… I don't have any noise or sound on it, also when I get I don't get alerts either. I choose myself when I want to go in and look at emails or Facebook or whatever. I don't think the phone should help me because that is not a help it is actually a disturbance'. In other words, he engaged with the app, as with traditional housekeeping, as and when necessary.

5 Discussion

We next examine the different types of household engagement with energy monitoring technologies, including the meaning attached to these. This will lead to a discussion about some of the assumptions embedded in the design of these energy monitoring technologies, and how we can design technologies that support a variety of energy monitoring practices – and types of engagement with the technology.

5.1 Acquisition of the green IT

Our results show that soon after householders had adopted the energy monitoring technology, the acquisition process led to an energy 'audit', where householders used the app to quickly identify any inefficient energy consumption practices. Indeed, one of the strengths of energy monitoring technologies is that they make visible inefficient energy consumptions which arise due to misconceptions, mistakes and/or errors. For instance, Peffer et al. (2011) have illustrated how misconceptions of heating systems can result in inefficient heating in the homes. Similarly, Yang et al. (2014) describe how participants in a study realised that they had left the air conditioning on by mistake while away from home -using a technological solution. Finally, Bedwell et al. (2016) demonstrate how technologies can be used for, among other things, fixing errors, and thereby lead to significant energy saving. Indeed, our empirical data confirms the usefulness of features built in in the monitoring applications in this study.

To this extent, once the technology is adopted and further appropriated through the energy audit, we witnessed householders shift some of their energy consumption routines to a time window when green energy is available. Indeed, they have developed new technology-in-use practices (Orlikowski and Gash, 1994), using the technology proactively to change their energy consumption and integrate these into their housekeeping activities. In addition, our data demonstrate that once the energy monitoring technology enters the home, it is made accountable to existing routines in the home, such that it will not unduly disrupt and interfere with other courses of action central to domestic life.

In line with other studies, we have observed that in every household, there exists practices that can be changed, while others are non-negotiable (Strengers, 2011; Pink, 2012; Strengers et al., 2019a, b). While it was clear that households with more than two adults as family members tend to have less flexibility when it comes to changing their energy consumption practices. Most of these households had some practices deemed non-negotiable; dinner cooking for instance. As was pointed out by (Prost et al., 2015), some practices are unchanged due to personal, social or cultural reasons. Indeed, several households in thus study were reluctant to shift certain energy consumption practices due to personal preferences. A number of householders in this study often perceived the cost saving to be too little, while others' reluctancy to change habit came from ingrained cultural habits. In these particular set ups, comfort seemed to be more important than lower energy price – or energy type available—at the time for that matter. This is in line with other studies that also found households to typically prioritise comfort over price (Shove et al., 2014).

In essence, energy monitoring—and its related consumption—behaviour cannot be studied disconnected from the larger cultural system surrounding it (Gram-Hanssen, 2010; Reckwitz, 2002; Shove and Walker, 2014). Our data demonstrates not only how energy consumption practices are embedded in other social practices, but also how they are interconnected and, at times, inseparable from other domestic practices. For instance, the practice of cooking dinner was interconnected to the practice of running the dishwasher in several households. Similarly, in a number of households with children, the practice of cooking (and eating) dinner could not be altered as it was interconnected to the children's bedtime routines. While this may be obvious, the interconnectedness of everyday households' practices is often overlooked in the design of energy monitoring technologies, as these typically target specific and independent practices rather than practice bundles. However, isolated energy consumption practices depend, among others, on household composition (e.g., social composition, electronic appliances, etc.), and are thus essentially part of an ecology of social practices within a household, where various elements will typically be shared amongst the practices. In so doing, changing one practice might affect another practice (Gram-Hanssen, 2011). To this effect, we echo other scholars who have argued for more holistic understanding of the 'where energy consumption happens' and 'why' (Bedwell et al., 2016).

5.2 Different levels of engagement with green IT

Our empirical data shows that the level of engagement with the technology decreases for many householders, once the technology has become domesticated and the negotiation process between the routinised energy consumption practices and the new recommendations provided by the technology is over. This perceived decline in interaction with the energy monitoring technology is not new in literature. In reality, it has previously been reported in several other studies (Barreto et al., 2013; Erickson et al., 2012; Hargreaves et al., 2013). A number of studies have even reported a trend from use to non-use (Prost et al., 2015). A range of scholars have described it as a stage where the technology's novelty wears off (Strengers et al., 2019a, b). On an ambivalent note, our empirical data highlights the fact that although the level of engagement recedes after a while, the energy monitoring technology initially allows for great learning about green energy availability, learning that the householders embrace – despite not interacting with the technology as much—when shifting their consumption practices to suitable time periods. To this effect, the energy monitoring technology acts as an educational platform for future energy consumption shifting (Cockbill et al., 2020). Indeed, as mentioned earlier, householders do learn, for instance, that electricity is cheaper at night and that it is greener when the wind blows. However, while these technologies do provide a learning opportunity for energy management, it has been argued that the design of these real-time feedback systems "might… distract from the 'real' problems" (Prost et al., 2015), as these focus on paying attention to short-term spikes (Prost et al., 2015) caused by appliances that are not necessarily major contributors to household's energy consumption, as these are used for a short period.

We also noted many householders to have disabled the notifications from the green IT in order to keep the level of disruption to a bare minimum -thus pushing back on the deemed 'overwhelming' energy type availability information. With these notions/phenomena in mind, we argue that disabling the notifications is not necessarily equivalent to complete disengagement with the energy monitoring technology, but rather a desire to control when they receive information related to energy consumption. In other words, lack of constant and continuous engagement should not be confused with lack of interest in the technology's ability to monitor green energy- or the initial effect through the learning as seen above. Rather, it should be seen as an indication of the extent to which the technology has become integrated in the traditional housekeeping routines, thus householders not perceiving constant engagement with the technology essential—or necessary. Afterall, energy monitoring is ubiquitous, and is not something at the forefront of householders' lives. Monitoring energy consumption can be seen as a new form of housekeeping, or digital housekeeping (Tolmie et al., 2007). The new technology-in-use practices (Orlikowski and Gash, 1994) developed across the household differs depending on the contextual circumstances surrounding energy consumption. This includes, for example, major changes in weather conditions (e.g., the transition towards the winter season), changes in everyday practices (e.g., going away), or changes in energy consuming devices (e.g., buying a new electric vehicle). In these circumstances, householders' engagement with the technology tend to follow the trend and adjust to the changes in settings.

5.3 Engagement is related to the meaning attached to green IT

While for several households the technology's novelty did fade over time (Strengers et al., 2019a, b), our data also demonstrates that other householders continue to maintain a high level of engagement with the technology. This is due to a different type of meaning they attach to the technology. To a number of these households, the energy monitoring technology is perceived as a medium that nudges towards green energy consumption, thus an environmental meaning attached. For others, the energy monitoring technology is essentially a cost saving device, making monetary gain a primary focus. This has been reported within literature, where many technologies for monitoring energy seem to focus on highlighting monetary gain, inscribing the assumption that this is the main motivator for all users. While it is undeniable that price does motivate households to improve their energy consumption (Morrison et al., 2013), some researchers have argued that we need to move away from focusing on the consumer – or households in this case- as someone driven by an economic rational choice (Froehlich et al., 2010). Indeed, our data demonstrates that price is not the only incentive for energy monitoring practices and that householders typically have a range of other meanings they attach to their green IT.

While a few studies have identified price, comfort and environmental concerns as major motivational factors for shifting energy practices (Morrison et al., 2013), our study presents a new cohort of householders driven by a particular meaning they attach to their green IT. That is, a sense of loyalty to the green IT provider and its community of first users. In other words, their continuous engagement with the energy monitoring technology is due to the intrinsic symbolic value the green IT provider and its community of users represents.

Indeed, the green IT applications in our study, do provide such communities of users. These are typically tech-savvy householders, with numerous online and offline platforms and forums within which they can gather and exchange experiences, and/or take part in the further development of the said technology. This includes, for instance, a private Facebook group dedicated solely to a particular green IT's users as well as various offline events where users are invited to provide input and feedback on new releases. Combining agile techniques with a human-centred approach in the development process, Barry for example constantly releases new features and actively involves users in the design decisions. Indeed, Cockbill et al. (2020) have proposed that householders be co-designers for energy monitoring technologies since they are experts in their own behaviour. Thus, one of the features that gives these green IT solutions a stronger standpoint in the family of energy monitoring technologies is the establishment of a strong user-community and their active inclusion in the design process. To this effect, several scholars have pointed out the importance of moving away from individual consumers to groups and communities (Disalvo et al., 2010a, b; Prost et al., 2015; Salovaara et al., 2021). This has led to a range of studies examining different forms of users' connectiveness by, for example, creating different types of comparisons, ranking and competitions (Dillahunt et al., 2014; Petkov et al., 2011). Other studies have explored various forms of gamifications and reward systems: by comparing a community of energy consumers to another for instance, the potential of socialising energy-related feedback (Petkov et al., 2011). Such studies aim to address the declining interaction with energy monitoring technologies (Petkov et al., 2011). We argue that they can also be used to highlight the urgent need to pay attention not only to the technologies' design and their affordances, but also to establishing and connecting communities of users and householders, thus actively involving them in the design of the said technologies.

Results from this study also identified a new group of engaged users who are driven by loyalty to the supplier and/or to the sense of belonging to a specific type of user community. This is compelling, as it raises the question of how we design energy monitoring technologies which can also accommodate engagements not driven by monetary gains or environmental preservation.

A range of energy monitoring technologies tend to be designed with a strong and, at times, sole focus on energy price. We argue that this narrow focus may lead to an oversight of other features that hold a stronger meaning to householders. To attract customers, Barry's provider for instance initially buys into the populist monetary gain narrative by highlighting energy cost savings in its promotional videos. However, the green IT applications in this study offer an interface which also displays CO2 consumption forecast as well as notifications of when the energy is green, thus also appealing to householders motivated by climate change reversal. In effect, these green IT solutions do provide various technical features with access to different types of data, appealing to different types of households – i.e., with different meanings attached to their energy monitoring technology. For instance, as aforementioned, they provide an overview of energy price forecast to those householders primarily motivated by cost saving, while also providing an overview of CO2 emission and green energy availability to householders interested in climate change reversal. When designing energy monitoring devices for households, it is therefore paramount to consider the fact that the said householders' engagement with the technology highly depends on the meaning they attach to it. Therefore, we posit that energy monitoring technology designers follow an explorative approach with room to accommodate various types of practices and meanings (Cockbill et al., 2020).

5.4 Designing green IT for different types of engagements and meanings

Many technological solutions have a tendency to support a frequent and constant mode of engagement, by for instance, incorporating gamification elements and reward systems (Petkov et al., 2011). This reflects an implicit assumption that the perceived decline in interaction and engagement with these technologies is to be expected. However, results from our study problematise the assumption that regular engagement with energy monitoring technologies is essential. It also raises the question of how much householders can keep shifting their energy consumption practices – as a result of energy monitoring. Our findings show that whilst householders can always shift more—due to the sporadic nature of green energy availability—, their engagement with the technology naturally tails off after they have memorised the peak times for green energy availability. Our data presents cases where householders have chosen to actively disengage with the technology and turn the notifications off in order to minimise disruptions from all the information they are constantly presented with. Indeed, there are various recommendations in the literature for ways to present data to users in a meaningful manner, thus avoid information overload (Cockbill et al., 2020). Fischer (2008), for example, recommends that feedback 'is given frequently and over a long period of time, that it provides an appliance-specific breakdown, is presented in a clear and appealing way, and uses computerised and interactive tools' (p. 79). Similarly, a range of studies have examined the use of visualisations (Murugesan et al., 2013) and additional artifacts—e.g. calendars and diaries—to support the relay of information to users (Neustaedter et al., 2013). While these studies are valuable, we encourage broadening the focus to include the establishment of communities of energy monitoring householders for instance.

Findings from our research reveal that while energy monitoring technologies can be designed as platforms for educating householders about energy types and consumption, they do not necessarily require to be continuously engaged with. As is evident in this study, householders use technology to monitor energy and adapt—when necessary- their energy consumption practices. However, the monitoring through technology does not require a specific frequency. The level of engagement with the technology, changes, depending on various other factors—as with any practice. This leads us to problematise implicit assumptions that may be found in the design of some energy monitoring technologies. We argue for the need to re-think the design of green IT in ways that cater for numerous types and levels of engagement—driven by the variety of meanings householders may attach to the said green IT.

Finally, we propose that when designing energy monitoring technologies, designers view energy as a service rather than a ubiquitous commodity and move towards technology design to match specific household energy practices to energy type – and perhaps price – for example. That is, for instance, having the green IT default to green energy for energy intensive practices such as electric car charging for instance and saving other energy sources for lighter energy consumption practices- such as cooking. We posit that by designing green IT in this way, a lower level of engagement will be required – and expected—of householders and green energy would thus be distributed in a more democratic and priority-based approach. Hence a huge step towards the global green energy transition.

Our empirical case contributes to S-CSCW and energy monitoring technologies, by discussing ways in which technologies can be designed to better support households' energy monitoring practices. That is, to include various forms of domestic work, and various levels of engagements householders may display towards the said green IT and its associated data.

6 Limitations and further study

This study presents some limitations in that the sample of informants was limited and quite homogenous. For example, 12 of the 14 households included in this study were electric vehicle owners (Teslas), which influenced their decision to adopt green IT, the meaning they made of it and how they used it. However, as mentioned in the Methods section, homogenous sampling is not new in energy-related studies – see for example Wunderlich et al. (2013). The intention was to capture early adopters, i.e., people at the forefront of the green energy monitoring chain, so we could learn from them for future green energy monitoring technology design for a more diverse group of users.

Due to the ongoing COVID-19 pandemic at the time of the data collection, it was not possible to visit the households—as initially planned in the research. Consequently, both adults were not always present during the interviews. We rely on information relayed to the main researcher by the informants online – mainly by the male adult in the household. A future study could interview female respondents only and compare the perspectives with the present study. Moreover, due to the above-mentioned reasons, interviews are used in this study as the only source of data. Since everyday householders' practices and engagement with the technology were the focus of this paper, we concur with Schatzki that 'language is an important clue as to which activities and practices exist' (Schatzki, 2012.p.24). We therefore consider the interviews to be a valuable source of data. We do however recognise that data from home visits and observations would complement interviews.

Based on the above, we posit that this study offers a foundation for further investigations that could use a wider sample with a mixed cohort of informants and supplementary sources of data.

7 Conclusion

Energy monitoring technologies can exist as educational platforms for energy consumption awareness that householders access if and when appropriate. Co-design to include householders is necessary when designing energy demand shifting interventions because, as we have seen, although energy is a ubiquitous commodity, energy consumption practices vary depending on the meaning attributed to the green IT—not merely with price. This study has demonstrated that while the green IT and its built-in features are similar throughout, different householders have different energy consumption practices and needs, and make different meanings of the green IT. Householders are the experts in their behaviour, and energy consumption should be viewed by green IT designers as a continuous practice with interconnected elements in an ecology of everyday household practices and activities. We have, therefore argued for the need to move towards green IT design that matches specific household energy practices to energy type – and perhaps price.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

References

Alvesson, Mats (2003). Beyond Neopositivists, Romantics, and Localists: A Reflexive Approach to Interviews in Organizational Research. *The Academy of Management Review,* vol. 28, no. 1, 2003, pp. 13–33.

Alvesson, Mats; and Kaj Sköldberg (2009). *Reflexive Methodology : New Vistas for Qualitative Research (2. ed).* Los Angeles. California: SAGE.

Aune, Margrethe; Åsne Lund Godbolt; Knut H. Sørensen; Marianne Ryghaug; Henrik Karlstrøm; and Robert Næss (2016). Concerned Consumption. Global Warming Changing Household Domestication of Energy. *Energy Policy,* vol. 98, 2016, pp. 290–97.

Bakaloglou, Salomé; and Dorothée Charlier (2019). Energy Consumption in the French Residential Sector: How Much Do Individual Preferences Matter? *Energy Journal,* vol. 40, no. 3, 2019, pp. 77–99.

Bandi, Rajendra; Anik Bose; and Ashay Saxena (2015). Exploring Green IT Awareness and Adoption among Indian Students. *SIGMIS-CPR '15: Proceedings of the 2015 ACM SIGMIS Conference on Computers and People Research, Newport Beach, USA, 4 June - 6 June 2015.* New York: ACM Press, pp. 87–96.

Bansal, Pratima (Tima); and Kevin Corley (2012). Publishing in AMJ—Part 7: What's Different about Qualitative Research? *Academy of Management Journal*, vol. 55, no. 3, 2012, pp. 509–13.

Barreto, Mary; Evangelos Karapanos; and Nuno Nunes (2013). Why Don't Families Get along with Eco-Feedback Technologies?: A Longitudinal Inquiry. *CHItaly '13: Proceedings of the Biannual Conference of the Italian Chapter of SIGCHI, Trento, Italy, 16 September - 20 September 2013*. New York: ACM Press, pp.1–4.

Bedwell, Ben; Enrico Costanza; and Michael O. Jewell (2016). Understanding Energy Consumption at Work: Learning from Arrow Hill. *CSCW '16: Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing, San Francisco, CA, USA, 27 February - 2 March 2016.* New York: ACM Press, pp. 1337–48.

Bourgeois, Jacky; Janet van der Linden; Gerd Kortuem; Blaine Price; and Christopher Rimmer (2014). Conversations with My Washing Machine: An in-the-Wild Study of Demand Shifting with Self-Generated Energy. *UbiComp '14: Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing, Seatle, USA, 13 September - 17 September 2014*. New York: ACM Press, pp. 459–70.

Brause, Saba; Rebecca; and Grant Blank (2020). Externalized Domestication: Smart Speaker Assistants, Networks and Domestication Theory. *Information, Communication & Society,* vol.23, no.5, 2020, pp.751–63.

Bryman, Alan (2006). Integrating Quantitative and Qualitative Research: How Is It Done? *Qualitative Research,* vol.6, no.1, 2006, pp.97–113.

Brynjarsdottir, Hronn; Maria Håkansson; James Pierce; Eric Baumer; Carl DiSalvo; and Phoebe Sengers (2012). Sustainably Unpersuaded: How Persuasion Narrows Our Vision of Sustainability. *CHI '12: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Austin, USA, 5 May- 10 May 2012.* New York: ACM Press, pp. 947–56.

Bull, Richard; Joanna Romanowicz; Neil Jennings; Marina Laskari; Graeme Stuart; and Dave Everitt (2018). Competing Priorities: Lessons in Engaging Students to Achieve Energy Savings in Universities. *International Journal of Sustainability in Higher Education,* vol. 19, no. 7, 2018, pp. 1220–38.

Byrne, David (2013). Evaluating Complex Social Interventions in a Complex World. *Evaluation,* vol. 19, no. 3, 1995, pp. 217–28.

Chalhoub, George; and Martin J. Kraemer (2021). It Did Not Give Me an Option to Decline: A Longitudinal Analysis of the User Experience of Security and Privacy in Smart Home Products. *CHI '21: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, Yokohoma, Japan, 8 May -13 May 2021*. New York: ACM Press, pp. 1-16.

Chowdhury, Niaz; and John Moore (2018). Attention Management for Improved Renewable Energy Usage at Households Using IoT-Enabled Ambient Displays. *UbiComp '18: Proceedings of the 2018 ACM International Joint Conference and 2018 International Symposium on Pervasive and Ubiquitous Computing and Wearable Computers, Singapore, Singapore, 8 October -12 October 2018*. New York: ACM Press, pp. 1215–21.

Cockbill, Stuart A.; Val Mitchell; and Andrew J. May (2020). Householders as Designers? Generating Future Energy Services with United Kingdom Home Occupiers. *Energy Research & Social Science,* vol.69, 2020, pp.101615.

Corbin, Juliet; and Anselm Strauss (2008). *Basics of Qualitative Research : Techniques and Procedures for Developing Grounded Theory. 3. ed.* London: Sage.

Costanza, Enrico; Ben Bedwell; Michael O. Jewell; James Colley; and Tom Rodden (2016). A Bit like British Weather, i Suppose': Design and Evaluation of the Temperature Calendar. *CHI '16: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, San Jose, CA,USA, 7 May - 12 May 2016.* New York: ACM Press, pp. 4061-72.

de Lauretis, Simona; Frédéric Ghersi; and Jean-Michel Cayla (2017). Energy Consumption and Activity Patterns: An Analysis Extended to Total Time and Energy Use for French Households. *Applied Energy,* vol. 206, 2017, pp. 634–48.

Dillahunt, Tawanna; Jennifer Mankoff; and Manos Papagelis (2014). Understanding Factors of Successful Engagement around Energy Consumption between and among Households. *CSCW '14: Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing, Baltimore, MD, USA, 15 February - 19 February 2014.* New York: ACM Press, pp. 1246–57.

Disalvo, Carl; Phoebe Sengers; and Hrönn Brynjarsdóttir (2010a). Mapping the Landscape of Sustainable HCI. *CHI '10: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Atlanta, GA, USA, 10 April -15 April 2010.* New York: ACM Press, pp. 1975–84.

Disalvo, Carl; Phoebe Sengers; and Hrönn Brynjarsdóttir (2010b). Navigating the Terrain of Sustainable HCI. *Interactions,* vol. 17, no. 4, 2010, pp. 22–25.

Dourish, Paul (2010). HCI and Environmental Sustainability: The Politics of Design and the Design of Politics. *DIS '10: Proceedings of the 8th ACM Conference on Designing Interactive Systems, Aarhus, Denmark, 16 August - 20 August 2010.* New York: ACM Press, pp. 1–10.

Ellegård, Kajsa; and Jenny Palm (2011). Visualizing Energy Consumption Activities as a Tool for Making Everyday Life More Sustainable. *Applied Energy*, vol. 88, no. 5, 2011, pp. 1920–26.

Erickson, Thomas; Mark Podlaseck; Sambit Sahu; Jing Dai; Tian Chao; and Milind Naphade (2012). The Dubuque Water Portal: Evaluation of the Uptake, Use and Impact of Residential Water Consumption Feedback. *CHI '12: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Austin, Texas, USA, 5 May - 10 May 2012.* New York: ACM Press, pp. 675–84.

Fischer, Corinna (2008). Feedback on Household Electricity Consumption: A Tool for Saving Energy? *Energy Efficiency*, vol. 1, no. 1, 2008, pp. 79–104.

Fontana, Andrea; and James Frey (2003). The Interview: From Structured Questions to Negotiated Text. *in Collecting and interpreting qualitative materials,* N. K. Denzin and Y. S. Lincoln (eds). Thousand Oaks. CA: Sage Publications, pp. 61–106.

Froehlich, Jon; Leah Findlater; and James Landay (2010). The Design of Eco-Feedback Technology. *CHI '10: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Atlanta, GA, USA, 10 April - 15 April 2010.* New York: ACM Press, pp. 1999–2008.

Gram-Hanssen, Kirsten (2010). Standby Consumption in Households Analyzed With a Practice Theory Approach. *Journal of Industrial Ecology,* vol. 14, no. 1, 2010, pp. 150–65.

Gram-Hanssen, Kirsten (2011). Understanding Change and Continuity in Residential Energy Consumption. *Journal of Consumer Culture*, vol. 11, no. 1, 2011, pp. 61–78.

Gram-Hanssen, Kirsten; Anders Rhiger Hansen; and Mette Mechlenborg (2020). Danish PV Prosumers' Time-Shifting of Energy-Consuming Everyday Practices. *Sustainability,* vol. 12, no. 10, 2020, pp. 4121.

Hansson, Lon; Teresa Cerratto Pargman; and Daniel Pargman (2021). A Decade of Sustainable HCI Connecting SHCI to the Sustainable Development Goals. *CHI '21: Proceedings of the*

2021 CHI Conference on Human Factors in Computing Systems, Yokohoma, Japan, 8 May - 13 May 2021. New York: ACM Press, pp. 1-19.

Hargreaves, Tom; Michael Nye; and Jacquelin Burgess (2010). Making Energy Visible: A Qualitative Field Study of How Householders Interact with Feedback from Smart Energy Monitors. *Energy Policy*, vol. 38, no. 10, 2010, pp. 6111–19.

Hargreaves, Tom (2011). Practice-Ing Behaviour Change: Applying Social Practice Theory to pro-Environmental Behaviour Change. *Journal of Consumer Culture,* vol. 11, no. 1, 2011, pp. 79–99.

Hargreaves, Tom; Michael Nye; and Jacquelin Burgess (2013). Keeping Energy Visible? Exploring How Householders Interact with Feedback from Smart Energy Monitors in the Longer Term. *Energy Policy*, vol. 52, 2013, pp. 126–34.

Jensen, Rikke Hagensby; Jesper Kjeldskov; and Mikael B. Skov (2018). Assisted Shifting of Electricity Use: A Long-Term Study of Managing Residential Heating. *ACM Transactions on Computer-Human Interaction*, vol. 25, no. 5, October 2018*,* pp. 1–33.

Kempton, Willett; and Linda L. Layne (1994). The Consumer's Energy Analysis Environment. *Energy Policy*, vol. 22, no. 10, 1994, pp. 857–66.

Krischkowsky, Alina; Verena Fuchsberger; and Manfred Tscheligi (2021). Making Un-Use: When Humans Disengage with Technology. *CHI '21: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, Yokohoma, Japan, 8 May - 13 May 2021.* New York: ACM Press, pp 1-10.

Lehner, Matthias; Oksana, Mont; and Eva Heiskanen (2016). Nudging – A Promising Tool for Sustainable Consumption Behaviour? *Journal of Cleaner Production,* vol. 134, pp. 166–77.

Leroy, Yann; and Bernard Yannou (2018). An Activity-Based Modelling Framework for Quantifying Occupants' Energy Consumption in Residential Buildings. *Computers in Industry,* vol. 103, 2018, pp. 1–13.

Lincke, Susan (2012) Green IT: Serving Multiple Purposes. *SIGITE '12: Proceedings of the 13th annual conference on Information technology education, Alberta, Canada, 11 October - 13 October 2012.* New York: ACM Press*,* pp. 81–82.

Martin, Rex Mulloch (2020). Illuminating Energy: Smart Lights, Householders and Intuitive Energy Data Visualization. *e-Energy '20: Proceedings of the Eleventh ACM International Conference on Future Energy Systems*, *Virtual event, Australia, 22 June - 26 June 2020.* New York: ACM Press, pp. 528–33.

Mashhoodi, Bardia (2021). Who Is More Dependent on Gas Consumption? Income, Gender, Age, and Urbanity Impacts. *Applied Geography,* vol. 137, January 2021, pp. 102602.

Meurer, Johanna; Claudia Müller; Carla Simone; Ina Wagner; and Volker Wulf (2018). Designing for Sustainability: Key Issues of ICT Projects for Ageing at Home. *Computer Supported Cooperative Work (CSCW),* vol. 27, no. 3-6, 2018, pp. 495-537.

Monigatti, Paul; Mark Apperley; and Bill Rogers (2010). Power and Energy Visualization for the Micro-Management of Household Electricity Consumption. *AVI '10: Proceedings of the International Conference on Advanced Visual Interfaces, Rome, Italy, 25 May - 29 May 2010*. New York: ACM Press, pp. 325–28.

Morrison, Mark; Jodie Kleinschafer; and John Hicks (2013). Improving Consumers'responsiveness to Electricity Demand Management Initiatives in Regional New South Wales: The Potential Use of Behavioural-Based Constructs for Identifying Market Segments. *Australasian Journal of Regional Studies,* vol. 19, no. 2, 2013, pp. 181–214.

Murugesan, Latha Karthigaa; Rashina Hoda; and Zoran Salcic (2013). Investigating Visualization of Energy Consumption. *CHINZ '13: Proceedings of the 14th Annual ACM SIGCHI_NZ conference on Computer-Human Interaction, Christchurch, New Zealand, 15 November - 16 Novemver 2013.* New York: ACM Press*,* pp. 2542255.

Neustaedter, Carman; Lyn Bartram; and Aaron Mah (2013). Everyday Activities and Energy Consumption: How Families Understand the Relationship. *CHI '13: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Paris, France, 27 April - 2 May 2013.*New York: ACM Press, pp. 1183–92.

Orlikowski, J. Wanda; and Debra C. Gash (1994). Technological Frames: Making Sense of Information Technology in Organizations. *ACM Transactions on Office Information Systems*, vol. 12, no. 2, April 1994, pp. 174–207

Pablo-Romero María, del P.; Rafael Pozo-Barajas; and Rocío Yñiguez (2017). Global Changes in Residential Energy Consumption. *Energy Policy,* vol. 101, 2017, pp. 342–52.

Peffer, Therese; Marco Pritoni; Alan Meier; Cecilia Aragon; and Daniel Perry (2011). How People Use Thermostats in Homes: A Review. *Building and Environment,* vol. 46, no. 12, 2011, pp. 2529–41.

Petkov, Petromil; Marcus Foth; Felix Köbler; and Helmut Krcmar (2011). Motivating Domestic Energy Conservation through Comparative, Community-Based Feedback in Mobile and Social Media Queensland University of Technology Chair for Information Systems. *C&T '11: Communities and Technologies, Brisbane, Australia, 29 June - 02 July 2011.* New York: ACM Press, pp. 21–30.

Pierce, James; and Eric Paulos (2012). Beyond Energy Monitors: Interaction, Energy, and Emerging Energy System*s. CHI '12: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Austin, Texas, USA, 5 May - 10 May 2012.* New York: ACM Press, pp. 665–74.

Pink, Sarah (2011). From Embodiment to Emplacement: Re-Thinking Competing Bodies, Senses and Spatialities. *Sport, Education and Society,* vol. 16, no. 3, 2011, pp. 343–55.

Pink, Sarah (2012). *Situating Everyday Life : Practices and Places*. London: SAGE.

Pink, Sarah; Kerstin Mackley; Val Mitchell; Marcus Hanratty; Carolina Escobar-Tello; Tracy Bhamra; and Roxana Morosanu (2013). Applying the Lens of Sensory Ethnography to Sustainable HCI. *ACM Transactions on Computer-Human Interaction,* vol. 20, no. 4, September 2013, pp. 1–18.

Pothitou, Mary; Richard F. Hanna; and Konstantinos J. Chalvatzis (2017). ICT Entertainment Appliances' Impact on Domestic Electricity Consumption. *Renewable & Sustainable Energy Reviews,* vol. 69, 2017, pp. 843–53.

Prost, Sebastian; Elke Mattheiss; and Manfred Tscheligi (2015). From Awareness to Empowerment: Using Design Fiction to Explore Paths towards a Sustainable Energy Future. *CSCW '15: Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing, Vancouver, BC, Canada, 14 March - 18 March 2015.* New York: ACM Press, pp.1649–58.

Ranchordás, Sofia (2019). Nudging Citizens through Technology in Smart Cities. *International Review of Law, Computers and Technology*, vol. 0. no. 0, 2019, pp.1–23.

Reckwitz, Andreas (2002). Toward a Theory of Social Practices: A Development in Culturalist Theorizing. *European Journal of Social Theory,* vol. 5, no. 2, 2002, pp. 243–63.

Rinkinen, Jenny; Elizabeth Shove; and Jacopo Torriti (2019). *Energy Fables : Challenging Ideas in the Energy Sector*. Abingdon, Oxon : Routledge.

Rinkinen, Jenny; Elizabeth Shove; and Greg Marsden (2020). Conceptualising Demand: A Distinctive Approach to Consumption and Practice. Milton: Taylor and Francis.

Rogers, Everett M. (2003). *Diffusion of Innovations*. 5th ed. New York: Free Press.

Salovaara, Antti; Andrea Bellucci; Andrea Vianello; and Giulio Jacucci (2021). Programmable Smart Home Toolkits Should Beter Address Households' Social Needs. *CHI '21: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, *Yokohoma, Japan, 8 May - 13 May 2021.* New York: ACM Press, pp. 1-14.

Schatzki, Theodore R (2012). A Primer on Practices: Theory and Research. In Practice, Education, Work and Society, Rotterdam: SensePublishers, pp. 13–26.

Schwartz, Tobias; Gunnar Stevens; Leonardo Ramirez; and Volker Wulf (2013). Uncovering Practices of Making Energy Consumption Accountable: A Phenomenological Inquiry. *ACM Transactions on Computer-Human Interaction*, vol. 20, no. 2, May 2013, pp. 1–30.

Selvefors, Anneli; I. C MariAnne Karlsson; and Ulrike Rahe (2015). Conflicts in Everyday Life: The Influence of Competing Goals on Domestic Energy Conservation. *Sustainability,* vol. 7, no. 5, 2015, pp. 5963–80.

Shove, Elizabeth; Mika Pantzar; and Matt Watson (2012). *The Dynamics of Social Practice: Everyday Life and How It Changes*. London, England: SAGE Publications.

Shove, Elizabeth; and Nicola Spurling (2013). *Sustainable Practices : Social Theory and Climate Change*. Abingdon, Oxon : Routledge.

Shove, Elizabeth; and Gordon Walker (2014). What Is Energy For? Social Practice and Energy Demand. *Theory, Culture & Society,* vol.31, no.5, 2014, pp.41–58.

Shove, Elizabeth; Gordon Walker; and Sam Brown (2014). Material Culture, Room Temperature and the Social Organisation of Thermal Energy. *Journal of Material Culture*, vol. 19, no. 2, 2014, pp. 113–24.

Simone, Carla; Ina Wagner; Claudia Müller; Anne Wlebert; and Volker Wulf (2022). *Future-Proofing: Making Practice-Based IT Design Sustainable*. United Kingdom: Oxford University Press.

Smetschka, Barbara; Dominik, Wiedenhofer; Claudine, Egger; Edeltraud, Haselsteiner; Daniel, Moran; and Veronika, Gaube. (2019). Time Matters: The Carbon Footprint of Everyday Activities in Austria. *Ecological Economics,* vol. 164, 2019, pp. 106357.

Strauss, Anselm L.; and Barney G. Glaser (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Chicago: Aldine.

Strengers, Yolande (2011). Negotiating Everyday Life: The Role of Energy and Water Consumption Feedback. *Journal of Consumer Culture*, vol. 11, no. 3, 2011, pp. 319–38.

Strengers, Yolande; Jenny Kennedy; Paula Arcari; Larissa Nicholls; and Melissa Gregg (2019a). Protection, Productivity and Pleasure in the Smart Home Emerging Expectations and Gendered Insights from Australian Early Adopters. *CHI '19: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, Glasgow, Scotland, UK, 4 May - 9 May 2019.* New York: ACM Press, pp. 1–13.

Strengers, Yolande; Sarah Pink; and Larissa Nicholls (2019b). Smart Energy Futures and Social Practice Imaginaries: Forecasting Scenarios for Pet Care in Australian Homes. *Energy Research and Social Science*, vol. 48, 2019, pp. 108–15.

Suchman, Lucy (1987). *Plans and Situated Actions: The Problem of Human-Machine Communication.* Cambridge: Cambridge University Press.

Syvertsen, Trine; and Gunn Enli (2019). Digital Detox: Media Resistance and the Promise of Authenticity. *Convergence: The International Journal of Research into New Media Technologies*, vol. 26, nos 5–6, 2019, pp. 1269–83.

Tchatchoua, Nadine; Jan Pries-Heje; and Magnus Rotvit Perlt Hansen (2020). Changing Households Behaviour To Use Electricity From Sustainable Sources. Information systems Research Seminar in Scandinavia (IRIS), Online, Sweden.

Thorpe, Jared (2019). Social Research: Paradigms in Action, by Norman Blaikie and Jan Priest. *Rural Sociology,* vol. 84, no. 4, 2019, pp. 866–67.

Tolmie, Peter; Andy Crabtree; Tom Rodden; Chris Greenhalgh; and Steve Benford (2007). Making the Home Network at Home: Digital Housekeeping. *CSCW 2007 : proceedings of the 10th European conference on computer-supported cooperative work, Limerick, Ireland, 24 September -28 September 2007*. London: Springer London, pp. 331–50.

Vassileva, Iana; Erik Dahlquist; Fredrik Wallin; and Javier Campillo (2013). Energy Consumption Feedback Devices' Impact Evaluation on Domestic Energy Use. *Applied Energy,* vol.106, 2013, pp. 314–20.

Wågø, Solvår; and Thomas Berker (2014). Architecture as a Strategy for Reduced Energy Consumption? An in-Depth Analysis of Residential Practices' Influence on the Energy Performance of Passive Houses. *Smart and Sustainable Built Environment*, vol. 3, no. 3, 2014, pp. 192–206.

Wilhite, Harold (2005). Why Energy Needs Anthropology. *Anthropology Today,* vol. 21, no. 3, 2005, pp. 1–2.

Wunderlich, Philipp (2013). *Green Information Systems in the Residential Sector An Examination of the Determinants of Smart Meter Adoption. 1st ed. 20*. Berlin, Heidelberg: Springer Berlin Heidelberg.

Wunderlich, Philipp; Johann Kranz; Dirk Totzek; Daniel Veit; and Arnold Picot (2013). The Impact of Endogenous Motivations on Adoption of IT-Enabled Services: The Case of Transformative Services in the Energy Sector. *Journal of Service Research,* vol. 16, no. 3, August 2013, pp. 356–71.

Yang, Rayoung; Mark Newman; and Jodi Forlizzi (2014). Making Sustainability Sustainable: Challenges in the Design of Eco-Interaction Technologies. *CHI '14: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Toronto, ON, Canada, 26 April - 1 May 2014.* New York: ACM Press, pp. 823–32.

Yin, Robert K (2013). Validity and Generalization in Future Case Study Evaluations. *Evaluation* vol. 19, no. 3, 2013, pp. 321–32.