The neglected practice: uncertainties encountered by occupants in a new energy efficient building

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Abstract

Technical and performance related uncertainties that come with an increased number of components and system complexity are often thoroughly examined and tested in demonstration buildings. On the contrary, and despite the energy research literature stressing the importance to understand the requirements and context of the users, the uncertainties that occupants encounter while adapting to new energy efficient buildings are seldom examined and identified in depth.

This paper will highlight the usefulness of seeing the technologies for buildings from the users' point of view. From a social practice perspective and the concept of domestication the paper examines various types of uncertainties encountered by occupants when managing technologies for buildings, such as bedrock heat pump, photovoltaic panels and LED-lighting, in a new energy efficient house.

The result demonstrates that it is demanding and tiresome to tackle uncertainties and learn how to handle technologies for building, as well as to contact professionals for support. It might in fact be more convenient to "leave it as it is", with the consequences that no one is managing the technologies. Instead of assuming that carrying out this practice is straightforward, it would be better to work on an approach where this is not the case. In fact, the later approach creates much better conditions for extended learning and product development than the former.

Introduction

According to a directive by EU, all new buildings ought to use "near-zero" energy in 2020 (Directive 2010/31/EU). The directive requires that stakeholders in the building sector are adapting to the new energy requirements, which includes those that will live in the new buildings. Previous studies on the development and implementations of new energy efficient solutions in the building sector stress the importance to involve the target users and understand their requirements, competencies and everyday practices (e.g. Rohracher 2003; Heiskanen & Lovio 2010; Brunsgaard et al 2012; Wågø & Berker 2014).

From an energy perspective the users' difficulties and /or disinterest in dealing with the energy system of the building simply means that they are not able to handle the technology in an energy efficient way. This has been highlighted in relation to peoples' use of various types of heating systems (Lindén et al 2006; Gram Hanssen 2010; Caird et al 2012; Isaksson 2014; Isaksson & Ellegård 2015) as well as in several evaluations and surveys of users of low-energy buildings (Leaman & Bordass, 2007; Isaksson 2009; Mlecnik et al 2012; Thomsen et al 2013; Wågø & Berker 2014; Tuohy & Murphy 2015). Common conclusions are that knowledge about technical solutions needs to be complemented by an understanding of user needs, context of the usage, and the users' own ability to handle the technology, as well as there is "a need for adequate levels of information/knowledge" to the user (Thomsen et al 2013, p 56).

However, taking the perspective of the users has different meanings in different research contexts (e.g.Wilson et al 2015); Commonly, it is an approach in which the developers and/or other professionals figure out the best solutions and/or information for the user, involving implicit understandings and assumptions about user needs. It might also involve gathering information from the occupants (e.g. distributing questionnaire) in order to examine if the occupants are satisfied with the assumed functional benefits e.g. the indoor climate and the building technology. Still, these dominating approaches departures, not from the everyday life of the users, but from ideas about how the technology ought to be used and about functional benefits of the technology, concerning energy efficiency, conveniences and comfort. These approaches need to be complemented with a sociotechnical approach and departing from what is relevant and meaningful for the user. In line with Bartiaux (2008), Darby (2006), Winther and Ericson, (2013) I argue that it is crucial that information and support as well as design to a greater extent correspond to people's own realities and concerns. It is the consistency with people's own experiences and various preferences that on the one hand make the technology or the support given understandable and on the other hand meaningful and relevant (Isaksson & Ellegård 2015).

The paper highlights the usefulness of seeing things from the users' point of view. For this purpose I will present an empirical examination of the occupants' experiences of managing technologies in an energy efficient building. The building has been the home of two adults and three children since the summer of 2015 and during their first year interviews were conducted twice with the adult members. The examination and discussion are restricted to one theme or in other words one concern in relation to the management of technologies for buildings. The concern examined is the matter of not knowing how to proceed, namely the uncertainty encountered by the occupants: It is well known that developing and implementing new energy efficient technologies for buildings contain various uncertainties. Therefore, technical and performance related uncertainties that come with an increased number of components and complexity of the system are often thoroughly examined and tested in demonstration buildings. On the contrary, the uncertainties that occupants encounter while interacting with new energy efficient buildings are seldom examined and identified.

The aim of this paper is to examine various types of uncertainties encountered by occupants when managing the technologies for buildings. It is technologies, such as heating system, mechanical ventilation, photovoltaic (PV), and lighting in a new energy efficient house that are of interest. The paper does not consider explaining what the developers or other professionals think is the best solutions for the users of the technologies and it has no intention to describe why or if the technology did not work, as it should, or exactly what went wrong in a certain situation. Rather the ambition is to "see" it as the users "see" it, discuss the lessoned learned and the usefulness of such approach. In order to examine and understand the maintenance and handling of the technologies from a user perspective I departure from a social practice perspective and the concept of domestication, which is briefly described next.

Domesticating technologies into the practices of everyday life

The concept of domestication captures the process through which technologies become integrated into the everyday life of the users. The concept originally developed in the 90s (Silverstone et al 1992; Silverstone & Haddon 1996; Lie & Sørensen 1996) has been used in various studies in order to understand how technologies and their services are experienced in everyday life. Understanding the energy consumption in private houses (Aune 2007), including passive houses (Isaksson 2009) interaction with smart energy monitors (Hargreaves et al 2013); or smart house solutions and assistive technologies (Brodersen & Lindegaard 2014; Frennert 2016) are some examples of empirical studies.

The core of domestication is that the process by which technology is integrated into the everyday life of the users is dynamic and changeable. It is dynamic, since the users shape the way technology is used and, in the long term, its future development (Silverstone et al 1992). As the literature emphasize, technologies are not just adopted and accepted by the users. The users are not passive receivers of knowledge, or rationalistic individuals acting as the producers of the technologies intend them to (Guy & Shove 2000; Parnell & Popovic Larsen 2005; Darby, 2006). Rather domestication is a process, in which the users both adapts to and shapes the novel technology in his/her social and material environment. The users undertake both practical (such as handling the technology) and symbolic work (values obtained by using the technology) as well as learn how to handle the technology in an appropriate way (Lie & Sørensen 1996; Sørensen 2006).

The relationship between the users and the technology is not static and changes over time (Silverstone et.al. 1992): Early expectations and imaginations, and the initial, often experimental, use of the technology is successively altered when the technology is incorporated and fitted into the routines and social practices of daily life. The technologies are integrated within practices which at the same time change the performance of these practices (McMeekin & Southerton 2012; Shove et al 2012). Thus, the intention with energy efficient technologies might be understood as a way to change the everyday practices in a more energy efficient direction. Several studies have used approaches within practice theory as a ground for understanding energy consumption (e.g. Shove 2004; Gram Hanssen 2010; Strengers et al 2016; Foulds et al 2016). From a social practice perspective, "energy efficiency" is neither part of the technologies or the individuals, but depends on people's routinized participation in everyday practices (see Foulds 2013). Such view captures the complexity with striving for energy efficiency:

People consume energy in order to carry out ordinary practices such as cooking, cleaning, washing or driving but the basic goal is to perform these practices not to conserve energy (Gram Hanssen 2010). Briefly, one needs technologies, objects and knowledge (practical and theoretical) to carry out a practice, as well as there are socially shared meanings and norms of how a practice ought to be performed (Shove et al 2012). Simply changing the technologies might not be enough to reduce the amount of energy used in the practice. Especially if other parts such as knowledge or norms related to the practice are neglected or not taken seriously.

Domestication of new technologies within practices does not necessarily run smoothly. There might be various views on how to handle the technology, and its meaning and what it brings to a certain practice is often reviewed and reassessed over time (Sørensen 2006). The empirical examination in this paper is restricted to such examples. It illustrates when the technologies for buildings, such as heating system, photovoltaic (PV), and lighting, which are part of and/or affects various domestic practices, don't deliver the comfort and convenient expected.

However, in this paper managing and handling the technologies for buildings are also seen as a practice by itself, which might be new to occupants moving into a private house. I will highlight three approaches for carrying out this practice and discuss related uncertainties encountered by the occupants. First a brief background to the empirical examination.

Methodology

BACKGROUND

This paper draws on research which is part of an EU-funded project, named Need4B, with the overall aim to stimulate the construction of energy efficient buildings. The project includes a demonstration program situated in four different climate zones and countries. The common target of the project was to achieve a yearly energy consumption lower than 60 kWh/m^2. The Swedish demo site consists of two pre-fabricated low energy houses with bearing construction made in wood. The key technologies integrated in the buildings are ground source heat pump, photovoltaic (PV) panels, exhaust air heat recovery and LED lighting. One of the buildings is equipped as a full scale test lab for energy efficient technologies and construction details, with artificial user behaviour. However, it is the other building, completed 2015, which is the focus for this paper. It is occupied by a household consisting of two adults and three children.

INTERVIEWS

Two semi-structured interviews were conducted with the two adult occupants living in the energy efficient building, in late October 2015 and May 2016. The interviews lasted between one and one and a half hour and took place in their home. Additionally, a first meeting with the occupants was conducted shortly after they moved in, June 2015, in order to inform about the project and to get an insight into their initial perceptions about the house. During this meeting a questionnaire was answered by the occupants. The questionnaire, as well as the two interviews, treated the occupants' perceptions about the indoor climate, (including light, sound, thermal environment and health concerns), and their use of technologies in the building.

The empirical investigations covered the first year in the house and made it possible to examine the early expectations, initial use and perceptions of the users, as well as their experience after approximately a year. Since the study was conducted during a complete year, conditions during various seasons were also captured. The analysis presented in this paper is based on the two interviews which I have conducted. I have not been part of the project (the planning and implementation) other than examining the experiences of the users. The interviews were audio-recorded and later transcribed for analysis. The investigation was conducted by qualitative thematic analyses. The quoted informants are referred to by either man or woman accompanied by 2015 or 2016. The year refers to the actual interview session described above.

Results

The following sections demonstrate three general approaches for carrying out the practice of managing technologies for building: leaving it as it is, handling the technologies and contact professionals for support. Uncertainties encountered by the occupants when carrying out the practice are highlighted. The principal concerns of the informants revolved around not achieving a comfortable indoor temperature. First this is illustrated from a slightly wider comfort perspective and its connection to the domestic practices of daily life.

TOO HOT OR TOO COLD

During the last decades the social norms of western society have moved towards standardized views of comfort that entail escalating energy consumption (Shove 2003). The indoor environments in the buildings should stay the same with the aid of cooling and heating installations, even though climate and activities of the occupants alter annually as well as daily.

In the new energy efficient house, the yearly and diurnal indoor temperature varied, and the floors had a high temperature gradient. The occupants found it difficult to get an even temperature:

> Now it is warm, so we turn it [the temperature setting] down, and then suddenly it becomes cold. So we never have this good thing. (Woman, 2015)

The "good thing" is a temperature that do not fluctuate, and according to the woman, that is a uniform temperature around 21–22 °C. The temperature had been acceptable during the autumn and spring, even though it has not exactly been the uniform temperature they desired. During the summer and winter the indoor temperature deviated more from "the good thing" and it did not meet the expectations of the occupants: It was either too hot or too cold.

During the first summer the house had been too warm, warmer than other apartments and houses the woman stated. A temperature around 24 °C, and at times warmer, reaching untenable temperatures according to the occupants. In order to lower the temperature they opened the windows and every day they ventilated frequently, which they described as a successful activity for decreasing the temperature and making it more comfortable. Thus, from the point of view of the occupants the indoor temperature was not desirable, but they had a method (opening windows) to handle it.

However, in the winter it became much more difficult for them to adjust the temperature in a comfortable way. Especially the temperature upstairs during the winter stood out:

> Man: It has been really, really cold upstairs. And down here really warm so we have not been able to handle it correctly. The children had to sleep down here.
>
> Woman: It was 17 °C in her [the daughter's] room. (2016)

As the quotes demonstrate, the situation with cold temperature upstairs bothered the occupants, since the rooms of the children were located there. Furthermore, they experienced the indoor temperature between the floors as "very uneven". It was too cold upstairs, but downstairs the temperature fluctuated during the day. They experienced the ground floor as cold in the morning, comfortable at midday, and too hot in the evening. The temperature also fluctuated depending on how many persons that was inside the building. When guests or relatives were visiting, it often became too warm, or when the household used many household appliances the temperature increased as the quote below from the interview in 2015 demonstrates.

> But I also believe that it gives a lot of heat when one cook and have all these appliances on. So it fits, it gets even warmer. (Woman 2015)

Their description of the indoor temperature reassembles what in relation to passive houses have been named as an event-based heating system (Isaksson 2009). Heat is supplied when the occupants are engaged in daily activities such as cooking, cleaning and washing, or when they have guests for dinner. The heat generated from the everyday activities of the occupants is more evident in low energy buildings than in traditional buildings (see also Foulds et al 2016).

However, during the interview in May 2016 when the use of the appliances and their influence on indoor temperature once again were discussed they were more doubtful about the connection. For instance the occupants mentioned that it got warmer in the washing room while washing, but when it concerned cooking they did not recognize any rise in temperature since they always opened a window to ventilate the smell of cooking.

The brief overview above illustrates the informants' experience of the indoor temperature during the first year. Some activities that influence their perception of the indoor temperature are mentioned, such as regulating the temperature setting, the use of appliances, the amount of people visiting their home, or the openings of windows.

Thus, seen from a practice perspective their experiences of the indoor temperature are on the one hand influenced by the ordinary domestic practices (it gets warmer when washing, cooking, guest visiting etc).

On the other hand, their experience of the indoor temperature also influences how the domestic practices are carried out. The everyday life of the occupants is oriented, not necessarily around the indoor temperature, but towards the daily domestic practices such as indicated above, (sleeping, cooking and guest visiting). The goal of the occupants are to carry out these practices in a socially acceptable way and there is as Foulds et al (2016) highlight, a practical rationality meaning that the households make decisions in accordance with the practice they carry out. That might contain various procedures, such as exemplified above; changing location in the house when the indoor temperature did not fit the practice of sleeping, or open windows when it became too hot when the guests came to visit. Or continuing doing what they always have been doing, such as opening windows while cooking. Whether these procedures are in line with the developers' idea of an energy efficient building is according to the thoughts of social practice theory, of secondary importance.

LEAVING IT AS IT IS

The idea that the technology will manage by itself without any active user involvement are found in empirical user studies (e.g. Isaksson 2009; 2014) as well as within research about automatic building technologies (Wilson et al 2015). The technology should take care of its intended purpose and the users need only to adapt to the service given to them. Such thoughts can also be found in this case study. When the occupants moved into the house they received a brief review of the technical installations, and messages of its self-managements with comments from professionals such as, "you should not touch it, you should not touch it" and "it will manage by itself" (woman 2016).

To hand over the responsibility to the technology in this way can be regarded as something desirable; an appropriate service, convenient for the user since they do not have to bother about the system. In a way that makes sense, since the energy system of the building often is not the focal point of peoples' everyday life. Rather the users' relationship with the system is characterized as a background relationship, in other words, the technology are working somewhere in the background, without much call for attention (Ihde 1990). Thus, the practice of managing the building technologies is not necessarily regarded as an ordinary domestic practice.

The informants in this case study previously lived in an apartment and had no experiences of handling the building technologies that came with their new house. They had in other words minor experiences of carrying out this type of practice. However, the quotations above indicate that the informants might not need to; in fact since they "should not touch it", and since technologies "will manage by itself" it could be interpreted as the managing and handling of the building technologies exclusively is a practice for professionals or perhaps even not for them; the automated technology should manage by itself.

Still, the informants live with the technologies, they get *involved* even if the practice is not intended for them, even if they can't control or handle upcoming incidents, even if they do not want to get involved. The following two examples related to the photovoltaics and lighting illustrate such involvements:

During the interview in October 2015 the occupants told that the photovoltaics alerted frequently:

> No, it says alarm, then it says corrected. I have no idea. You get no information. (Man 2015)

The frequent alert is directed to the users. It is a call to inform that something is wrong. In normal circumstances in most practices, people respond to alarms but in this case the informants learned that they do not need to, since the technology mange itself. The technology involves the users but still leaves them outside, since they do not know what has happened or might be wrong.

During the interview it was clear that the frequent alarms were frustrating. It created uncertainty on how to proceed; were the self-corrected behavior of the technology to be trusted, or should they contact someone who might know what the problem was? In addition, the frequent alerting might encourage less involvement and less determined action in the future when there is an alarm that ought to be taken seriously.

When automated or semi-automated technologies involve the user or, as is more evident in the following example, control the environment without the user knowing what is happening and how they could change the situation, contributes to feelings of powerlessness: The lighting of the house could be programmed to be turned on and off during certain hours, which was unknown to the users. The informants had accidental pressed a so called vacation button, resulting in the lightning turning on and off in an unexpected way. The occupants turned for help and managed to change it back to normal mode. However, the lighting is still not regulated in a desired way:

> Woman: We have found out that now it turns of at 11 and 5 o'clock. We do not even touch it.
>
> Man: We have not had the energy to call them either.
>
> Woman: You get so tired. (2016)

Thus, even though they were not satisfied with the situation and did not know how to proceed by themselves, one solution always is to "leave it as it is". The other alternatives; to figure out how to handle the technology by themselves or to contact the professionals might both be inconvenient and tiresome in an everyday life when many other things demand attention. Never the less, the overall consequences of such decision is that no one is carrying out the practice of managing the technology. Or stated otherwise, the technology is doing it all.

HANDLING THE TECHNOLOGY

If the section above demonstrated when the involvement with the technologies was "out of control", this section gives a brief insight into attempts to reach control and trying to carry out some parts of the practice of managing the building technology. The first example illustrates attempts to reach control over the heating technology. This was a main concern for the occupants since they were not satisfied with the indoor temperature; it was either too hot or too cold.

From a learning perspective one way to deal with uncertainty on how to proceed, is to follow explicit advice, such as written and oral information about the new subject to be learnt (Berner 2009). The man in this case study told that they had followed such procedure for learning how to handle the heating system. He had looked at the technical manual, and they both had asked one of the neighbors for advice (who also has a ground source heat pump). In addition they had explored how to change the settings for the heating system. However, despite following the advice given, the heating technologies did not deliver a uniform and preferred indoor temperature. The following quotation concerns the setting of the bed rock heat pump which, according to them, ought to be changed between winter and summer to gain a comfortable indoor temperature:

> We should change, now we changed [the setting], now we should have it on minus, it's the only thing we can do, +2 or -2. But what is everything else? How should it be? (Woman 2016)

Adaptive comfort research highlights that individuals make use of various activities in order to feel comfortable in an environment. In addition, individuals in control over their indoor environment are to a greater extent satisfied with their indoor climate (e.g. Brager & De Dear 1998; Brager et al 2004; Karjalainen 2009).

As previously illustrated, opening windows, worked out quite well when it was too hot. In contrast, the informants had no or did not yet know an activity for coming to terms with the uneven temperatures, and as the quote indicates there is a wonder about what all the other procedures are.

The quote also indicates that they have done their part, they have followed the recommendation and properly adjusted the technology. They became certain that the recommended adjustment did not deliver the preferred indoor temperature, even though they were still uncertain of what to do next. Whether the technology is able to deliver what they prefer, if it is performing correctly, or if the uneven temperature during the winter depends on them not yet knowing what has to be known in order to properly adjust the technology.

Thus, to exclude activities by trial and error is a procedure to become more certain of what does not work or as in the following example of troubleshooting, what is not causing the problem. Below, the activity excluded is "too much showering". During the interview in May 2016 the informants told that the heating technology had not functioned properly the last weeks, which they were sure of since the tap water did not become warm. However, from the beginning they were not certain. Did it depend on them showering too much or because it was something wrong with the technology? After all there was no alarm warning them:

> Woman: We notice it when we shower.
>
> Man: When we wash hands.
>
> Woman: There was no one who had showered before me, after I had shampooed it started to get cold, so that was how we started to notice.

Since they do not use a lot of hot water at home it cannot be that they were running out of hot water. Thus, the occupants made the assumption that it might be the heating technology that did not function properly, e.g. the bedrock heat pump not working correctly. Thus, to get control does not necessarily mean to solve the problem, rather it means knowing how to proceed. The next section also illustrates the attempts to reach control, by asking professionals for support.

SUPPORT FROM PROFESSIONALS

As Akrich (1992) highlights the product developers inscribe certain characteristics in the technical objects. Hence, the developers provide the technology with certain designs, features and possible actions. These various features illustrate how the user could handle the technology. However, the technology does not inform whether these possible actions ought to be followed in the current context. One example illustrating this issue concerns the heating of the building and the radiators upstairs, which provide the occupants with the option to adjust the temperature setting in the various rooms. According to the professionals this possibility is not to be utilized:

> Woman: They told us that we should have it on maximum in all the rooms (so that it would go together).
>
> Man: Then, we had it on five. (2016)

The quotation indicates that the informants rather listen to the professional's opinion than the information provided to them by the technology. In addition, it illustrates that support from professionals is important in order to adjust the technology to the current context.

However, the advice from professionals, contractors and experts in the field, is not necessarily regarded as reliable. For instance, when the informants searched for advice on how to adjust the bedrock heat pump on the internet, they did not relay on the information provided since they thought that their situations was not comparable to the use of bedrock heat pump in traditional buildings.

In addition the users might receive opposing advices from professionals, as manifested in the following quotation which in this case concerns the floor heating on the ground floor:

> It is always when it [technology] alerts. Then you have to call them [the contractor answers] do this and do that. Then the research institute comes, or whoever comes and says why do you have it like this? Nah, but they told us over the phone. Then someone else arrives, no, you should have it this way. Then the electrician comes and says "no I raise it now to two". Everyone goes on with their thing so you do not know what to do yourself. (Woman 2016)

In this case it might be easy to blame the various professionals; why can they not give a uniform advice to the occupants? However, as the energy system is new to the occupants, so is it to the professionals and the advice given are based on their disparate professional practices. Hence, there might be various ideas on how to adjust the technology.

Thus, from a user perspective there are uncertainties about who knows best regarding what to do, who they should rely on, and how they ought to handle the heating system in order to get a comfortable indoor environment. In addition, there might be other adjustments, solutions, or technologies that will better handle the indoor comfort. Since they did not achieve the indoor environment they desired, they searched for, and were sometimes advised to use alternative solutions: Such as air conditioning during the summer which were suggested by one of the professionals, or the possibility to warm up the house with electricity instead of bed rock heat, which were suggested by the neighbor as a solution to a troublesome heating.

ENERGY CONSUMPTION

During the interview in 2016, when they had lived in the house almost a year, the informants were concerned about the energy bills. It was much higher than they had expected. The measurements confirm their statement. The expected energy usage in the building was 20.8 kWh/m^2, but the actual measured energy usage after the first year was 41.9 kWh/m^2. The informants were not sure about the cause, but they thought it had to do with the technology:

> Woman: There is something that uses electricity unnecessarily, I think. The floor heating has not been working, and still it [electricity] has been used.
>
> Man: No, it does not work properly, and still it consumes. (2016)

Their own use of appliances and building technologies and their view of indoor comfort was not an issue in these discussions. After all, it is an energy efficient house and the technology ought to handle it.

Conclusions

This paper has examined various types of uncertainties encountered by occupants when managing the building technologies during the first year in a new energy efficient house. The paper demonstrate three general approaches for carrying out this practice: leaving it as it is, handling the technology and contact professionals for support. Each approach contain various types of uncertainties related to trust and ability to handle the technology, such as: Will the technology manage by itself? Is the technology able to deliver the service desired? Are the possible actions inscribed into the technology to be followed? Is the technology malfunction or not? Am I able to handle the technology? What do I need to know? Are there any other solutions that one can try out? Who knows what to do? Who can I trust?

The empirical example used for illustration might not be the most typical in the field. One could argue that it is only applicable for occupants moving into specific demonstration buildings, especially those with increased number of components and system complexity. Hence, the situations described are not comparable to cases with well proven technology for low energy buildings or traditional buildings, i.e. users purchasing a traditional building with, for instance, a bedrock heat pump. Most occupants will probably not encounter the amount of uncertainties highlighted in this paper. However, still many of the uncertainties remain, basically because a recent purchased heating system or a low energy building is new to the users. And in many cases the users are also unfamiliar with the practice of managing these technologies.

Unlike the informants in this case study many other occupants, as the review of nearly zero-energy houses by Mlecnik et al (2012) demonstrate, are fairly satisfied with the indoor climate. Still there is a call for improved information and support to the users as highlighted in the introduction and as Mlecnik et al (2012) conclude "detailed information provision … is of critical importance and should not be neglected" (p 477). I argue that it is not necessarily more information of the same kind that is needed, e.g. recommendations and information produced by the professionals and developers. Rather it is a matter of adjusting the information and support to the concerns and realities of the occupants. Then the point of departure is to identify and grasp how various users experience the interaction and involvement with the technologies and the minor and not so minor uncertainties they encounter in relation to each technology. Such user oriented studies are unfortunately very rare in this field, despite its potential to create conditions for extended learning and product development (see e.g. Skjølsvold and Ryhaug 2015).

I have highlighted that each of the approaches presented involve uncertainties. Probably the overall concern is to choose which approach to follow: In other words, what the user could handle, what the professionals ought to take care of, and when it is reasonable to leave it as it is. Thus, a main concern, not only for occupants, but for the research field in general is: who is going to carry out the practice of managing the technologies for buildings? It is not necessarily regarded as an ordinary domestic practice carried out by the occupants. Nor something that professionals continuously carry out in private houses. Then, from an energy policy perspective it is of significance to establish a clearer division of responsibilities concerning what the users ought to handle and what the professionals should do. In addition, strengthening the professionals' obligation to support and educate the occupants and continuously follow up on the performances of the technology while simultaneously strengthening the occupants' responsibility to handle the technology ought to be a priority within this field.

This empirical study demonstrates that it is difficult and tiresome to tackle uncertainties and learn to handle new technologies for buildings as well as to contact professionals for support to carrying out the practice. In the end it might be considered more convenient to "leave it as it is", such as not bothering to control if the district heating could be optimized for lowering energy use (Klintman 2003), or contacting professionals to deal with the fluctuating indoor temperatures (Isaksson 2014) with the consequence that no one is carrying out the practice. Seen from an energy perspective the neglected practice of managing building technologies is most likely an important cause to overconsumption of energy in private houses.

References

Akrich, M. (1992). "The De-Scription of Technical Objects" in Wiebe E. Bijker and Law, J. (eds) Shaping technology/building society, studies in sociotechnical change. Cambridge: The MIT Press.

Aune, M. (2007). Energy comes home. Energy Policy, 35 (11), 5457–5465.

Bartiaux, F. (2008). Does environmental information overcome practice compartmentalisation and change consumers' behaviours? Journal of Cleaner Production, 16 (11), 1170–1180.

Berner, B. (2009). Learning Control: Sense-Making, CNC machines, and changes in vocational training for industrial work. Vocations and learning, 2 (3), 177–194.

Brager, G., Paliaga, G., & De Dear, R. (2004). Operable windows, personal control and occupant comfort. Center for the Built Environment. Berkeley.

Brager, G. S., & De Dear, R. J. (1998). Thermal adaptation in the built environment: a literature review. Energy and buildings, 27 (1), 83–96.

Brodersen, S., & Lindegaard, H. (2014). Ability or disability–design for whom? Scandinavian Journal of Disability Research, 16 (3), 267–279.

Brunsgaard, C., Knudstrup, M. A., & Heiselberg, P. (2012). Occupant experience of everyday life in some of the first passive houses in Denmark. Housing, Theory and Society, 29 (3), 223–254.

Caird, S., Roy, R., & Potter, S. (2012). Domestic heat pumps in the UK: user behaviour, satisfaction and performance. Energy Efficiency, 5 (3), 283–301.

Darby, S. (2006). Social learning and public policy: lessons from an energy-conscious village. Energy Policy, 34, 2929–2940.

Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings, Official Journal of the European Union, 53, 2010.

Foulds, C. (2013). Practices and technological change: The unintended consequences of low energy dwelling design. UK: University of East Anglia, School of Environmental Sciences [Doctoral dissertation].

Foulds, C., Powell, J., & Seyfang, G. (2016). How moving home influences appliance ownership: a Passivhaus case study. Energy Efficiency, 9 (2), 455–472.

Frennert, S. (2016). Older People Meet Robots: Three Case Studies on the Domestication of Robots in Everyday Life. Lund: Lund University, Department of Design Sciences, Faculty of Engineering [Doctoral Dissertation].

Gram Hanssen (2010). Residential heat comfort practices: understanding users. Building Research & Information, 38 (2), 175–186.

Guy, S. & Shove, E. (2000). A Sociology of Energy, Buildings and the Environment. Constructing Knowledge, Designing Practice. London: Routledge.

Hargreaves, T., Nye, M., & Burgess, J. (2013). Keeping energy visible? Exploring how householders interact with feedback from smart energy monitors in the longer term. Energy Policy, 52, 126–134.

Heiskanen, E., & Lovio, R. (2010). User–Producer interaction in housing energy innovations. Journal of Industrial Ecology, 14 (1), 91–102.

Ihde, D. (1990). Technology and the lifeworld. From Garden to Earth. Bloomington and Indianapolis: Indiana University Press.

Isaksson, C., & Ellegård, K. (2015). Anchoring energy efficiency information in households' everyday projects: peoples' understanding of renewable heating systems. Energy Efficiency, 8 (2), 353–364.

Isaksson, C. (2014). Learning for lower energy consumption. International Journal of Consumer Studies, 38 (1), 12–17.

Isaksson, C. (2009). Uthålligt lärande om värmen? Domesticering av energiteknik i passivhus. [Sustainable learning about indoor heating?] Linköping, Sweden: Linköping University. Department of Thematic Studies, Technology and social change [dissertation in Swedish].

Karjalainen, S. (2009). Thermal comfort and use of thermostats in Finnish homes and offices. Building and Environment, 44 (6), 1237–1245.

Klintman, M., Mårtensson, K. & Johansson, M. (2003). Bioenergi för uppvärmning- hushållens perspektiv. [Bio energy for heating – household perspective]. Lund: Sociologiska institutionen, Lund University.

Leaman, A., & Bordass, B. (2007). Are users more tolerant of 'green'buildings? Building Research & Information, 35 (6), 662-673.

Lindén, A.-L., Carlsson-Kanyama, A. & Eriksson, B. (2006). Efficient and inefficient aspects of residential energy behaviour: what are the policy instruments for change? Energy Policy, 34, 1918–1927.

Lie, M. & Sørensen, K. H. (1996). Making technology our own. Scandinavian University Press.

McMeekin, A., & Southerton, D. (2012). Sustainability transitions and final consumption: practices and socio-technical systems. Technology Analysis & Strategic Management, 24 (4), 345–361.

Mlecnik, E., Schuetze, T., Jansen, S. J. T., De Vries, G., Visscher, H. J., & Van Hal, A. (2012). End-user experiences in nearly zero-energy houses. Energy and Buildings, 49, 471–478.

Parnell, R. & Popovic Larsen, O. (2005). Informing the development of domestic energy efficiency initiatives: an everyday householder centered framework. Environment and Behavior, 37, 787–807.

Rohracher, H. (2003). The role of users in the social shaping of environmental technologies. Innovation: The European Journal of Social Science Research, 16 (2), 177–192.

Shove, E. (2003). Comfort, cleanliness and convenience: the social organization of normality. Oxford: Berg.

Shove, E. (2004). Efficiency and consumption: technology and practice. Energy & Environment, 15 (6), 1053–1065.

Shove, E. Pantzar M., Watson M (2012). The Dynamics of Social Practice Everyday life and how it changes. London: Sage.

Silverstone, R., Hirsch, E. & Morley, D. (1992). Information and communication technologies and the moral economy of the household, in R. Silverstone & E. Hirsch (eds) Consuming technology: Media and Information in Domestic Spaces. Routledge, pp 15–31.

Silverstone, R. & Haddon, L. (1996). "Design and the Domestication of Information and Communication Technologies: Technical Change and Everyday Life" in Mansell, R. & Silverstone, R. (eds) Communication by Design. The Politics of Information and Communication Technologies. Oxford University Press.

Sørensen, K. (2006). Domestication: the enactment of technology, in T. Berker et al. (eds) Domestication of Media and Technology, Open University Press, pp 40–57.

Skjølsvold, T. M., & Ryghaug, M. (2015). Embedding smart energy technology in built environments: A comparative study of four smart grid demonstration projects. Indoor and Built Environment, 24 (7), 878–890.

Strengers, Y., Nicholls, L., & Maller, C. (2016). Curious energy consumers: Humans and nonhumans in assemblages of household practice. Journal of Consumer Culture, 16 (3), 761–780.

Thomsen, J., Berker, T., Lappegard Hauge, Å., Denizou, K., Wågø, S., & Jerkø, S. (2013). The interaction between building and users in passive and zero-energy housing and offices: the role of interfaces, knowledge and user commitment. Smart and Sustainable Built Environment, 2 (1), 43–59.

Tuohy, P. G., & Murphy, G. B. (2015). Are current design processes and policies delivering comfortable low carbon buildings? Architectural Science Review, 58 (1), 39–46.

Wilson, C., Hargreaves, T., & Hauxwell-Baldwin, R. (2015). Smart homes and their users: a systematic analysis and key challenges. Personal and Ubiquitous Computing, 19 (2), 463–476.

Winther, T., & Ericson, T. (2013). Matching policy and people? Household responses to the promotion of renewable electricity. Energy Efficiency, 6 (2), 369–385.

Wågø, S., & Berker, T. (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, 3 (3), 192–206.