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Household Energy Practices in Low-Energy Buildings: A Qualitative Study of Klosterenga Ecological Housing Cooperative

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Introduction

Smart technology and home automation systems are gaining traction in people's home, policy and research.[1] The underlying assumption is that smart technologies will contribute significantly to energy efficiency, which is good for consumer wallets and the environment. Smart

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technologies are further projected to overcome the looming perils of climate, by being instrumental in transitioning to a low-carbon society. However, research has shown that the complexity of social interactions linked to the use of technology is overlooked and poorly understood (Christensen et al., 2020; Standal et al., 2019; Skjølsvold et al., 2018; Strengers, 2013). By applying social practice theory, this chapter contributes to the growing body of research that critically examines how smart technology visions for reducing energy use in buildings are implemented and practiced by the residents living in them. Drawing on longitudinal research conducted in 2012 and 2015 that examined household energy practices in the ecological building cooperative Klosterenga in Oslo, Norway, we address the following questions: What are peoples' motives for choosing an ecological profile home? How are these smart technologies integrated into the architecture, and how does it affect household practices? Does the technology work as intended? How effective is the information provided on how to use it? The implementation of smart technology visions in building design and how residents are influenced to put visions into their daily practice addressed in these questions are important given the increasing prominence of smart technology concepts and designs in energy savings research and energy policy. Klosterenga provides an interesting case to study because it has implemented an integrated energy system to optimise energy efficiency as well as a holistic ecological design (e.g. communal garden with grey-water cleaning and shared garden/horticulture). These characteristics have given Klosterenga an image of green scenery, modern design and comfort, which together with the walking distance to Oslo city centre has made Klosterenga a popular housing cooperative in old town Oslo.

The Smart Discourse and Its Critics

The transition to a low-carbon society has put an emphasis on smart technology on several scales. The latest Norwegian Energy White Paper (GoN, 2021, 2022) presents home automation systems as pivotal to ensure future energy savings and energy demand flexibility, and announce new regulations to promote such a system. In economic, engineering and policy-making, the ideal household electricity consumption is envisaged as consumers that engage smart technology to obtain a better future (Skjølsvold et al., 2018). The expected result is consumers who are energy efficient, have flexible electricity use (reduce peak loads) or even engage in household energy production. In the emerging smart paradigm, technologies such as home automation systems, programmable thermostats and direct load control are intended to do the work for residents in achieving optimal energy use; or to put it another way, agency in accomplishing energy efficiency practices is assigned to the smart technology. But this requires ‘smart consumers’ who are informed and engaged in their energy consumption and willing and able to embrace new smart technologies and strategies to achieve energy-management goals (Korsnes & Throndsen, 2021; Strengers, 2014). In this imagined smart world, the technology is designed, built and programmed to ‘function as a means of seamlessly bringing ideals of efficiency and luxury to the home, in which technology takes care of and enhances a range of domestic practices’ (Strengers, 2013: 26). Strengers sees this as a new form of utopic technology positivism that ‘constitutes a distinctive ontology in which smart technologies perform and establish a highly rational and rationalising form of social order’ (Strengers, 2013: 2) where people are conflated to autonomous and homogeneous agents.

Strengers refers to the ideal consumer as ‘Resource Man’; a well-educated, techno-savvy male who is interested in energy and makes decisions for the entire household (ibid).[2] Software, hardware and utility companies try to help energy consumers become ‘energy fit’ by providing them information to become smarter, informed and more in control of their energy consumption while simultaneously allocating this control to technology to manage it on their behalf. The emphasis on smart technologies in energy policy and research as driving forces towards smart grids and a green shift indicates that this is a conscious and deliberate choice made by consumers and thus closely related to the understandings of consumers as rational individuals who respond to information and economic incentives in a predetermined way (Shove, 2010).

There are several challenges to such a perception of consumer choices and practices. Some studies find that several people are sceptical to the idea of living in a smart house and ceding control of comfort to smart technologies (Sæle, 2021; Mennicken & Huang, 2012; Vyas & Gohn, 2012). Further, people living in smart houses often use them in ways not intended by the designers due to lack of understanding the systems (Wade, 2015; Revell & Stanton, 2014; Valocci & Juliano, 2012; Woods, 2006; Rathouse & Young, 2004) or that residents feel that the need to control the indoor environment is preferred over user instructions (Wågø & Berker, 2014; Aune, 1998, 2007). Having a solely rational economic view of the resident as consumer of energy will reduce the subtle understanding of private energy use as a part of everyday life activities and the domestication of the home. Furthermore, energy consumption is not neutral as purchasing power, preferences, needs and everyday practices and routines are differentiated across gender, age and class, life situation and geography (Standal et al., 2018; Fraune, 2015; Bell et al., 2015; Carlsson-Kanyama & Lindén, 2007), as well as social and cultural dimensions (Westskog et al., 2015). These studies indicate that the 'utopia' imagined by the promoters of smart technologies is flawed.

Theoretical Approaches to Household Energy Practices

As a critique of the dominant role of economic and psychological theories in explaining consumer behaviour as a linear and individual process defined by rational choice (e.g. Gupta et al., 2018; Shove, 2010), a large body of literature has over the last two decades explored how energy consumption and adoption of low-carbon energy technologies could be understood as dynamic social practices (Bell et al., 2015; Wilhite, 2016; Strengers, 2013; Shove et al., 2012; Warde, 2005; Shove, 2003). Social practice theory has among others been inspired by Bourdieu (1977) and his concept of habitus, defined as a domain of dispositions for action, created and perpetuated through the repeated performance of actions in a given social and cultural space. Drawing on the definition offered above, Shove et al. (2012) suggest three main elements to guide empirical investigations of practices: (1) *materials*, including the use of tools, technologies and equipment; (2) *meaning*, referring to the particular idea/image that is related to a particular activity; and (3) *competence and skills* (learning) that are involved with an activity. Similarly, Sahakian and Wilhite (2014, see also Wilhite, 2012) point to elements of *body, material world* and the *social world*. The body includes cognitive processes and physical dispositions, while the social world refers to a similar understanding as *meaning*; norms, values and institutions. Sahakian and Wilhite's use of body deserves particular attention. Cognitive processes and physical dispositions are acquired by the body through social experiences, inscribed in space and over time. Repeated exercises, such as athletic training, or social learning from other practices and their performances, can transform the habitus in a durable fashion (Sahakian & Wilhite, 2014; Wilhite, 2012). This is counter-intuitive to more rational choice approaches that presuppose that all decisions are made in reflexive cognitive process. The element of material includes the concept of distributed agency (Sahakian & Wilhite, 2014; Wilhite, 2012). Materiality is not only an 'ingredient' in peoples' everyday practices, but objects and technologies have a 'scripting effect' on people's actions.[3]

Practices are thus characterised by the linkages that practitioners make or break between various pre-existing elements within these three categories. A change in practice accordingly involves modifying a combination of symbolic and material ingredients and of competence and knowledge (Shove et al., 2012), as well as disruption of embodied dispositions (Wallenborn & Wilhite, 2014). Practices evolve in different social fields where people have certain resources and positions and abide by common norms (Bourdieu, 1977). The formation of practices will usually depend on the integration of pre-existing elements. This can be linked to how socio-material histories define 'predispositions for subsequent actions that are embedded in bodies, practices, and material settings' (Wilhite, 2012: 62). The meaning or social context that is attached to the use of new technologies then is not necessarily unique or new but drawn from earlier practices or cultural ideas and representations. The interconnectedness and embeddedness of practices in other social practices can make them difficult to break up or change.

By applying social practice theory to explore energy consumption as a product of the interaction between (1) the building and its technologies; (2) the experiential and cognitive knowledge of the participants; and (3) the social and cultural contexts in which the buildings and households are immersed, this study contributes to the development of a more robust understanding of human-technology interactions that now dominates smart energy policy (and provides insights on design and information strategies that will improve the efficacy of human-technology interactions in smart buildings. A social practice framing is useful in understanding how people choose their homes; how they learn to live with the materiality and technologies present in a new home; and how energy-relevant practices develop and stabilise.

Klosterenga: The Building and Its Energy System

Klosterenga is an Ecological Housing Cooperative that stands out in its surroundings due to its facade and modern appearance in an area of old apartment buildings from early twentieth century (see Fig. 3.1).

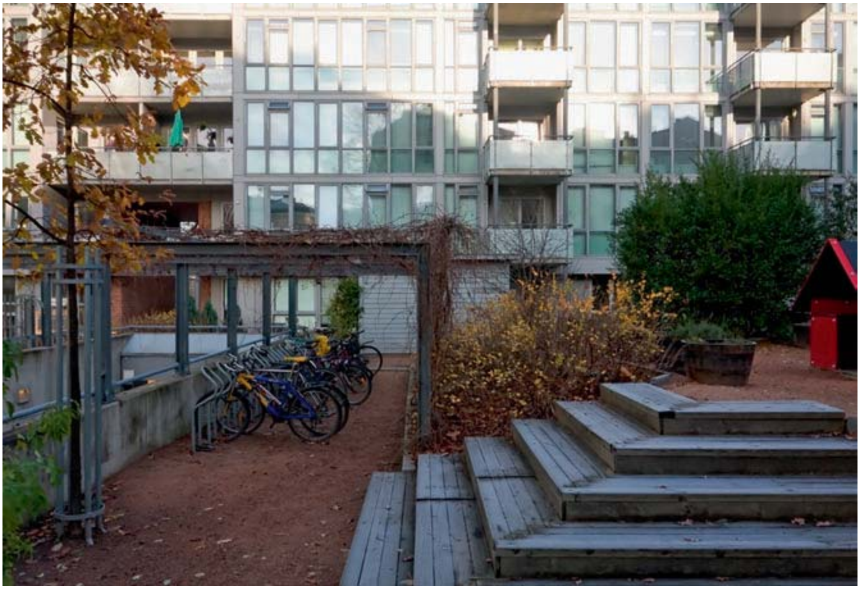

Fig. 3.1 Klosterenga facade seen from the garden. Note: Photo by GASA Architects

Klosterenga was established as a part of a governmental-supported city planning project called Environmental old Oslo. The building was designed by GASA Architects and built as a demo project of urban ecology, focusing on consumption and managing resources (water and sun) and waste. Life cycle cost analyses were an important tool in the design phase. When completed in 2000, the most advanced element was the integrated energy design, including solar collectors for water heating, water-borne floor heating, a double window-facade and balanced ventilation. Besides the energy-related aspects, Klosterenga includes aspects of urban ecology such as optimisation of materials, indoor climate, simplified building details, water saving, reuse of ecologically cleaned water,[4] garbage sorting and local composting and greening of outdoor areas. Architectural qualities like daylight and view were important to create a housing project that increased the architectural and aesthetical values in this neighbourhood of Oslo.

The low-energy apartment building provides 35 two-, three- or four-room apartments sized 53–100 m^2, all planned with a focus on ecological efforts. The floor plan can be seen in Fig. 3.2. The orientation of the floor plan was according to zoning principles. The living rooms face the south window façade, benefitting from sunlight and natural warmth, while bedrooms face the north with a natural airing brick-wall. Bathrooms constitute a heated core in the middle. Klosterenga is designed with a focus on involving residents. Heating (passive and active solar heat and electricity) and ventilation (window airing and balanced ventilation) are regulated by the residents. The double window-façade (see Fig. 3.3) works as

Fig. 3.2 Typical floor plan and section at Klosterenga. Note: Drawings by GASA Architects

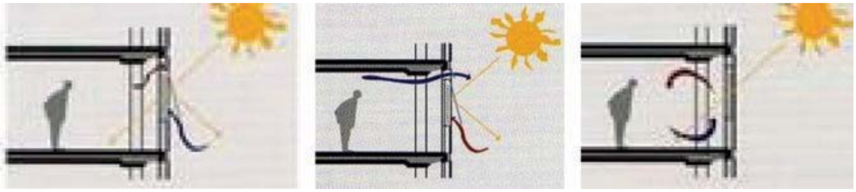

Fig. 3.3 Ventilation of double-window façade at Klosterenga. Note: Drawings by GASA Architects

natural energy-efficient ventilation that provides fresh air from the outside, which is preheated in the 35 cm layer between the sheets of glass in the double facade facing south. When needed, cold air can be admitted from the north-facing windows as described in Fig. 3.3.

Blinds between the panes of glass are meant to prevent overheating and provide a visual shelter from outside view. Windows are high and narrow to allow daylight to enter the building, a solution that also simplifies building details. Further, the residents have a display for controlling the temperature of the waterborne floor heating. The mechanical ventilation is operated through the kitchen fan and is designed as a simple, balanced ventilation system combined with local heat exchangers. Excess heat from the apartments is channelled to the underground residential parking space. In addition to engaging with the energy system of Klosterenga, residents have access to a common garden. Here, residents can socialise and get involved in composting, growing, and harvesting herbs, berries, fruit and vegetables. How residents get involved and pushed to visually and physically be in contact with the outdoors, aware of outdoor conditions and inspired to take responsibility to influence own indoor climate is an important part of the concept.

The starting point for the Klosterenga project was to build an ecological housing cooperative with a high energy efficiency standard. The aim of energy consumption for Klosterenga was set at approximately 100 kWh/m^2/year, which is 50 kWh/m^2/year less than the stipulated normal energy consumption for a similar building. The most important energy-saving resource is the heat exchanger in the balanced ventilation and the double window façade (Monsen, 2002). However, in 2000, the total energy use at Klosterenga was 138 kWh/m^2/year. The reasons for the underproduction in energy efficiency compared to the set targets can partly be related to malfunction in the solar collector system for water heating for a long period of time. But measurements also revealed that some apartments had extremely high electricity consumption (Monsen, 2002). The three apartments with the highest consumption add up to a third of the total consumption, with an average above 22.000 kWh/year. The average for the rest of the apartments is below 4.000 kWh.

Research Design and Methods

This chapter presents the results from two rounds of qualitative interviews and observations with residents at Klosterenga conducted in 2012 and 2015. The interview sample consisted of 18 interviews, where some families were reinterviewed (see Table 3.1). The informants were a diverse group of young couples, families with children, couples with adult

Table 3.1 Overview of informants

Informant	Description	Moved in	Interviewed
H1	Couple with small child	2009	2015, 2012
H2	Young couple	2014	2015
H3	Single woman	2006	2015, 2012
H4	Family with school children	2005	2015
H5	Family with small children	2007	2015
H6	Family with teenage children	2002	2015
H7	Family with school children	2007	2015
H8	Couple	2002	2015
H9	Couple	n/d	2015
H10	Couple	2011	2015
H11	Family with teenage children	2007	2015
H12	Family with school children	2014	2015
H13	Couple	2008	2015, 2012
H14	Young couple expecting a baby	2011	2015
H15	Single man	2010	2015, 2012
H16	Couple	2011	2015
H17	Family with two small children	2006	2012
H18	Family with two small children	2008	2012

children and singles. Though a significant part of the population in Old town Oslo are low-income and/or with immigrant background, all the informants were middle-class, many academics, and only a few were born outside Norway or had parents not originating from Norway. This reflects the resident composition of Klosterenga in general, since the modern apartments are higher priced than the average apartments in Old town Oslo.

The data material collected in March–June 2012 was part of a larger study of several efficient housing projects and was based on both in-depth interviews and observation with households (Wågø et al., 2016; Wågø & Støa, 2013). The data material collected in September 2015 complemented the 2012 study by re-interviewing 4 households, as well as interviewing new households. The 2015 study were conducted by an interdisciplinary research team (the authors) consisting of a specialist in architecture and building design, a human geographer and an anthropologist. The recruitment of the informants was done by providing information through the board and in the mailbox, and residents were contacted by the researchers by phone using the Norwegian tele-registry. The opportunity to obtain a gift card was announced to the household residents as part of the recruitment process in 2015. This was to reduce the chance that only households with a high interest in technology and energy participated. Each interview lasted about 1 hour, and the residents were invited to explain their motivation for choosing Klosterenga as their home; how living in Klosterenga influenced daily practices, leisure habits, as well as general questions concerning neighbourhood and environmental awareness. Open free conversation was encouraged. Some interviews were conducted with several family members of the household present, opening for discussion and diversity of practices. Informants were asked to demonstrate how they operated the energy system (e.g. control boxes, kitchen fan and airing practices). All interviews were recorded and transcribed. All informants in this study are anonymised and approval by Norwegian Social Science Data Services (NSD) was secured beforehand.

Choosing a Place to Call Home: Motivations for Living in Klosterenga

Choosing a place to live is a complex process dependent on many factors, including both symbolic and material dimensions, especially in Norway where it is more common than in other countries to own rather than to rent one's home. As reflected in the interview sample, Klosterenga is an attractive housing option for people of different ages and life situations. The rationale for building Klosterenga was anticipated to appeal to people's values concerning the environment. Surprisingly, however, only one resident said he and his family explicitly decided to buy their apartment for its ecological profile. He saw an advertising brochure of the project and 'thought it looked promising and were greatly tempted' (H8). He and his family were among the first residents when the complex was built in 2000. However, the majority of our informants actually did not put weight on Klosterenga's ecological profile, energy efficiency and technologies when bidding for an apartment in Klosterenga. Instead, they perceived these qualities as a bonus when manoeuvring in a challenging Oslo housing market. This view was also supported by one of the housing board members, who explained that many who moved in came with questions regarding the system, which revealed that they had not known about it when purchasing the home. The aspects of Klosterenga's ecological profile and energy system were, according to the residents interviewed, not advertised in the sale process of Klosterenga apartments, and the real estate agents had little knowledge concerning this. Traditionally, in Oslo, the main aspects of marketing homes are key factors such as price, location and standard. When profiling of the ecological benefits to customers is missing, it is also less likely that customers can weigh this in the balance when choosing a place to live. The prices of Klosterenga were higher than average in the area due to the modern standards and size. However, the apartments also have relatively high joint liabilities, which means that it is still an affordable option for those who are not able to take large housing loans with their bank.

According to most residents interviewed, the main aspects of choosing to settle in Klosterenga were the modern standard, practical size, and affordable price, at the same time as they were centrally located in the charming scenery of Oslo old town. Klosterenga provides a rather unique possibility in the Oslo old town housing market, because it has middle-sized apartments (100 m^2) and a relatively new housing standard. The old town Oslo area predominantly consists of old town houses from early twentieth century, and their history as factory worker apartments means they are usually small. Due to their age, the old town houses often need more extensive and expensive maintenance to keep the standard high. Klosterenga's distinctiveness also includes balconies, elevator and indoor car garage, which you will not find in Oslo's old town apartment buildings. The standard and layout plan of the apartments and apartment building was also often mentioned as the factor for choosing Klosterenga (though price and location were more decisive). The daylight and view in the apartments due to the large windows in the living room were highly appreciated. The location of bedrooms facing North and living-room area with large double-window façade to the South and facing the garden was mentioned as 'brilliant' (H12). Three of the interviewed residents were architects, and they would highlight the use of better and more costly architectural solutions such as extra floor to ceiling height, indoors stairwell, the double window facade and zoning principles. Several stated that they were attracted by the urban ecological mindset with a common garden where they could grow their own fruits and herbs while being so centrally located in Oslo. Some also underscored that the central location of Klosterenga made it possible for them to actively protect the environment by not using their cars in everyday life.

Three of the informants stated that moving to Klosterenga appeared in a hurry and rather arbitrary, because they were soon expecting a new arrival in the family. For them, Klosterenga provided an opportunity to live rather carefree in a very central location and with child-friendly qualities. Klosterenga is located a bit away from the road on the South side, and with a large park at the North side. The backyard is walled in and has nice greenery with berry bushes and fruit trees. Further, the size of the apartments meant that families could live there while the family was expanding with more children. It is quite common for families in the Oslo old town to move once children start school, but these informants had decided to stay even though they felt their children needed more space to roam and to bring friends home. Two families that considered moving felt this process was strenuous as they had a deep belonging to the area and had adjusted to the comfortable standard. Opting for detached or semi-detached houses meant either serious compromise of standard and suburb location, or a very high price. For several, this compromise was seen as needed, while others hesitated to make that move:

> It is funny you should ask, because we have been looking for a house [to buy]. But we keep coming back here with our tales between our legs and snuggle in the warmth, because everything is much worse than what we have here (H7).

As shown, emphasis on energy consumption and technology did not reflect the personal motivations the informants had when choosing a place to call home. Price of apartments, location, and aesthetics were not surprisingly held as most important.

Learning the System: Lack of Routines or Interest?

Klosterenga's low-energy system requires that residents interact with the energy system when adjusting temperature and ventilation of the double façade windows, the ventilation system and waterborne floor heating. These systems are designed to be simple in use but require some level of understanding and precise use to work 'optimally'. The residents (e.g. H8) who moved in when Klosterenga was newly built received a comprehensive direction manual with instructions. However, there were no standardised routines for instructing new residents. Direction manual and instructions was simply given to new owners at takeover (alongside any other relevant information).[5] The board did not have spare manuals, nor did they organise training of new residents. When interviewed, housing board members stated that they were available for questions concerning the system for new residents, and one of the board members always encouraged newcomers to address him with questions. Still, few of our informants had approached any of the housing board members concerning the energy systems. One of the interviewed residents had also not received the manual from the previous owner. The control box for the waterborne floor heating had been changed the previous year, and a new one-page manual was delivered along with contact information of the electrician firm responsible for the hardware and instalment. A short instruction was also given verbally by the electrician when it was installed. Some residents now kept the manual close to the control box, but as discussed later, few used the control box actively, and only one of our informants had contacted the firm with questions.

Though the design was meant to be easy to use, most of the people interviewed found the manual to be overly complicated and written in a technical language. Few consulted the manuals but sought advice from other residents when discussing problems related to the system, for instance when passing in the hallway. One of the board members had played with the idea of conducting meetings for the residents over topics related to the systems and, through that, provide more information and interest in the systems, but he was worried that the turn-out might be low and that being a board member already took up a lot of time. Further, the fluctuation of board members resulted in a lack of routines for providing such information. However, the board came regularly to deliver new filters for the balanced ventilation, and the residents were given instructions or help with this.

Generally, the informants approached the learning of the system in three ways; (1) most of the informants felt reluctant to 'tamper' with the systems and saw the automatisation as the main benefit as it did not require time and skills. The same group of informants also did not actively use the systems as intended, as explained in the next section, (2) some felt a need for more information and wanted the housing board to take a more active and systematic role to fill this need, (3) and last few had a genuine interest and prior knowledge of the technology. These informants took pride in living with such an innovative system, and they had a good overview of the manuals and different operation modes and even found it intriguing to open the ventilator with friends to 'check it out'.

Using the System: Everyday Life in Klosterenga

The informants at Klosterenga emphasised the benefits of Klosterenga's low-energy system in terms of comfort and automatisation. These aspects might explain why Klosterenga has not reached its anticipated potential in low-energy consumption. The design of the double-façade windows in the living room areas was first and foremost viewed as attractive as they provided abundance of sunlight and view. Their function as energy-efficient temperature regulators was viewed as less important. Using the double-façade windows optimally requires knowledge into how the system works (see Fig. 3.3). However, most residents interviewed were unsure of how to use it optimally and chose to air via the balcony door:

> we don't use that wall [double-façade windows] for airing at all. We open the [balcony] door (Interview H7).
>
> Actually, the way it is, is that in summer you should open many windows on the outside so the air is circulated, but I am a bit careless there. So when I air out, I have the balcony door open from morning till bedtime (H13).

Several complained over how the window facade resulted in extreme heat during sunny summer days, especially if they were not travelling in the summer holiday. For most informants, fresh air was synonymous with life quality (or even good health), making balanced ventilation inadequate. Furthermore, the practices of airing varied between individuals and households. Many wanted fresh air coming in continually (especially during the night) keeping certain windows or the balcony door open most of the time all year round. In one of the apartments heavy double set of curtains and decorations even made airing via the façade windows impossible.

The kitchen ventilator used to control the balanced ventilation of the apartments was the part of the system that our informants were most unsatisfied with. Several complained of the noise it was making and that it did not work properly. The ventilator was perceived as outdated in technology, design and function. Quite a few had also had the need for maintenance or changing of parts. Further, some apartments had problems with the ventilator capacity when cooking, making the fire alarm go off. The fire alarm is located on the ground floor, resulting in hectic running to turn it off before the fire department would be notified. As a result, residents of these apartments would always keep the kitchen window open during cooking. Another problem was for residents that had or wished to redecorate their kitchens as they would have to comply with the ventilation system. In practice, this meant that you had to keep the old ventilator as a new one would cost more than a new kitchen in itself. In addition, the location of the ventilator hood could not be moved, making rearrangements to the kitchen difficult. As a result, there was word of neighbours who had replaced the ventilator with new ones that by-passed the original system.

Indoor temperature was also associated with comfort and life quality. Most residents stated that they kept an indoor temperature of 19–21 degrees (Celsius), though several preferred up to 25 degrees, and most kept maximum temperature in the bathroom. Studies in European context have shown that a high indoor temperature of 23–24 degrees has become a general norm suited to most indoor habits (Exner & Mahlknecht, 2012), but there are notable gender differences where women prefer higher temperatures than men (Carlsson-Kanyama & Lindén, 2007). The heating system was operated through the control box for the waterborne floor heating, which had the possibility for regulating the temperature, holiday mode (turned off for a set time), and turning off. The view of the control box design and functionality ranged from 'fair enough' to outdated and difficult. Most residents did not regulate the temperatures because the system was not very flexible, and adjustments took up to 24 hours to take effect. Furthermore, several had been warned by the board against regulating it as this could disrupt the system:

> We have been told not to touch it. I mean it has come from the board that it is best not to so and they come on regular controls from the board to check… and we have been obedient. So now and then if it has become really hot I have fiddled with it and tried to adjust it, but I don't think it has much effect so I have opened the [balcony] door instead (Interview H5).

As a result, most residents never turned the heat down if it was warm, but simply aired through the balcony to adjust the temperature. Further, very few turned the heating off when going away for holidays or weekends.

The informants' practices concerning regulating ventilation and indoor temperature partly relate to their perception and meaning attributed to electricity consumption. Although many expressed environmental reasons as important for reducing energy use, few took measures to reduce electricity use. Most of the informants legitimised not reducing energy consumption in the fact that they were already living in a low-energy house stating that there would be no significant savings from changing energy use habits and that the energy was produced in an environmentally friendly way. Indeed, our informants perceived that the main benefit of the system was that one could live relatively carefree with a good conscience as opposed to owners of large and old villas that required high energy consumption to keep warm.

> I probably use more energy than I should. But I feel that I have well insulated windows and such, so it is not certain that it is too much heating in use anyway. I don't know … but it is very nice to walk around in shorts indoor in the winter. … Also, you do not get a guilty consciousness for heating up, because that is the challenge with waterborne floor heating, it takes 24 hrs. to change the temperature (Interview H15).

For several, this has led to a change of being less conscious about energy consumption after moving to Klosterenga.

> I: In your previous apartment did you adjust the temperature down when you were away?
>
> R: Maybe not during the day. … I travel a lot and can be away for a week…and then I turned off the heat…
>
> I: So you had a habit of thinking about it?
>
> R: Yes yes … but here you never pay so it is really a very stupid system (Interview H11).

These households had earlier had routines of turning off the heat when going away for weekends or holidays, and some had lived abroad and always kept the temperature to a comfort minimum to reduce heating costs. In these cases, the building's energy design had facilitated new domestic practices that increased indoor temperatures and less involvement in their energy consumption from the residents.

Further, several of our informants felt that both their own electricity costs at Klosterenga and the electricity prices in Norway, in general, were so low that there were no economic incentives for reducing consumption. Most of our informants did not keep track of their energy use and energy costs and paid electricity bills through automated bank systems. Compared to others, they express satisfaction with having quite low electricity bills:

> [electricity bill] is somewhere between 600-800NOK … and we appreciate that. … A friend of mine lived just across the street in an old town house and in winter they could have [electricity bills] 7000-8000NOK in a quarter of a year (Interview H16).

As an example, some of the residents did not think it worthwhile to go down to the fuse box in the basement to make the monthly reading of consumption and therefore the electricity company would send a bill based on calculations of general household consumption (often much higher than consumption in apartments such as Klosterenga).[6] One informant only read the metre as part of a yearly ritual (just before the television broadcasting of the New Year's concert in Vienna), while another had even lost the key for the cabinet years before. However, keeping track of energy costs was also complicated by the fact that energy costs for warm water and heating were included in the shared costs (as they often are in housing cooperatives), which were billed in the monthly rent: 'It is very convenient… we don't have to think about the electricity bill, it is 800 NOK 4 times a year so that is nothing' (Interview H16). Hence, any reduction in shorter showers or indoor temperature would not result in lowering the rent. Only electricity use for light, computers, entertainment, etc. was paid individually by the owners in their electricity bills, and there was a general impression that any reduction here would be miniscule in terms of saving money.

In contrast to Klosterenga's design to engage the residents in using the energy system, most of the informants expressed that it was very convenient that the system worked without them actively having to make decisions and changes. For them, the main benefit was not having to focus on their energy costs and habits.

Changed by Experience: 'This Home Has Taught Me to be Environmentally Friendly'

During the time of the study, the board had planned for starting individual calculation of heating and warm water consumption. The motive for the board was to ensure 'that people will have more consciousness around their own consumption, we think that it might contribute to that those who use warm water uncritically reflect on this for instance' (Interview H13). This initiative was started by one of the previous board members out of her environmental engagement. Most residents were either positive or neutral towards the decision and hoped this would result in residents trying harder to reduce energy consumption. Only one informant expressed concern that individual calculation would increase the cost of the residents at the first floor significantly and would feel unfair to them.

Though most of the interviewees did not feel motivated to reduce their energy consumption from electricity or heating, some of the residents felt that living there had made them more environmentally friendly. They had reduced their use of private cars since they lived centrally, but also out of concern for the environment:

> To be honest, we were not so environmentally conscious. But this apartment taught us to be environmentally conscious. By living in an ecological apartment, one manages to change culture or behaviour. Meaning that one is more aware about this and that—for instance we don't use the car (Interview H4).
>
> Yes, because we practically never drive the car when we are here. We use the car when we drive to the cabin in Sweden. And we try at least to think about how this is not good for the environment (H5).

Some also had changed their food consumption towards more vegetarian and ecological eating and a higher consciousness concerning reducing overall consumption to reduce climate emissions. In general, several emphasised how living in Klosterenga was inspiring in several ways, which made them reflect more on the environment:

> I will not claim being very environmentally engaged, but we are both children of the 1970s. We grew up with environmentally engaged parents, and I think moving to Klosterenga have made me even more conscious because our living environments with the garden, the compost and garbage sorting and the bike rack reminds us of environmental issues. The fact that these housing brings along some luxury; floor heating, spaciousness, lots of daylight through the double facade and the central location…. it implies qualities! (Interview H1, 2012)

Discussion: Reproducing and Reinforcing High Energy Habits Through Smart Technology

The thrust in smart energy solutions where economically rational consumers will seek out and deploy energy-efficient houses and technologies because they will save money or protect the environment is not found in the case of Klosterenga. Rather, people emphasised the architectural qualities of large windows providing daylight and view to the green scenery, and the modern characteristics that provide everyday comfort and convenience. The practice of choosing a home (for most of the interviewed) entailed a link to socio-material histories where predispositions for particular material settings and the meaning attached to these emerge. Klosterenga was seen as a 'good home' since it provided modern material standards, which fit into narratives of a good life (see also Shove, 2003). Such narratives relate not only to symbolic meanings and material aspects, but also embodied dispositions such as high indoor temperature, abundance of daylight and air.

It is fruitful to point to how social practice can identify aspects that strengthen or reduce the intentions of the smart and low-energy design in buildings. Ecological housing and energy systems such as Klosterenga have potential for changing practices. The experience of influence, control and fulfilled expectations (regarding reduced energy bills), together with experienced wellbeing, will support an overall feeling of being satisfied with the new housing. Domestication of new technology is by Aune (1992) and Sørensen (2006) described as a two-way process where residents and houses get mutually shaped (Berker, 2006). This is also supported in the concept of distributed agency, where materiality has a 'scripting effect' on people's practices (Sahakian & Wilhite, 2014; Wilhite, 2012; Shove et al., 2012) However, the materiality of the Klosterenga design has not considered how, in the course of their lives, people have developed routines for acquiring what they want from energy (energy services) in their homes: i.e., thermal comfort, light, cleanliness (bodies and things) and entertainment (Wilhite, 2016; Shove, 2010). All of these have roots in shared Norwegian cultural practices as well as embodied knowledge grounded in lived experience in 'non-smart' houses. These practices are linked to people's preferences for a warm atmosphere, as well as visual and sensory contact with the outdoors through fresh air directly from the outside (Wilhite, 2016; Wågø & Berker, 2014). Further, the materiality of the energy system at Klosterenga enables an opportunity to reproduce and strengthen the prevalence of these cultural values, while simultaneously provide technology to modify the practices in such a way that it requires minimum interaction and consciousness when using the energy services. In other words, residents could keep warm and use as much energy as they like without worrying about costs to their economy or the environment. Further, they valued the system because they could disengage from their own energy consumption. In an ideal setting, transferring responsibility for optimal energy use to smart technologies that require only minimal intervention on the part of the users themselves should ensure that energy is used efficiently resulting in an overall reduced energy consumption. But in the case of Klosterenga, most of our informants interacted with the system in a manner that degrade the energy performance. This tendency has also been found in other studies (Wågø & Berker, 2014; Wågø & Støa, 2013; Exner & Mahlknecht, 2012).

The materiality of the energy system reinforces the stability of cultural and embodied practices as they actively diffuse other values such as reducing energy consumption for the sake of the environment and costs of high consumption. Hence, the practices have gradually led to higher indoor temperature and airing practices that are not in line with the aims of energy efficiency of the system. Further, practices that take on social significance, such as within the family setting, can reinforce their strength. It is worth mentioning that the design of the system fails to take into account elements of care work within families, as exemplified in how the fans often could not cope with cooking fumes or airing routines to provide a good indoor environment in accordance with perceptions of fresh air as important for family health and wellbeing. This 'unproductive' work in the home (often done by women) is often overlooked in smart system design (Strengers, 2014) but constitutes an important part of a family's energy practices and the meaning given to such practices. For the present study, this approach has been useful in understanding wellbeing as a result of the experience of being in control of the indoor environment, thermal conditions, and energy use and for the feeling of home (Thomsen et al., 2011).

Another important aspect that was overlooked in the energy system of Klosterenga is the importance of competence in establishing energy practices. The assumption is that a smart design does not require any special skills or convictions on the part of the residents. But as shown, most of the residents felt that the system and manuals for it were too complicated for them (or would be too time-consuming to learn). According to Exner, teaching the residents the purpose and use of the system is the most cost-efficient way to avoid use that is detrimental to the energy performance of the system. Several studies have shown, however, that implementing and using new energy technologies require considerable know-how and interest, which can be excluded based on differences of gender, education, social networks, and financial resources (Inderberg et al., 2020; Standal et al., 2019; Bell et al., 2015).

Conclusions

Today's societies are characterised by an acceleration of consumption and high-energy habits such as individualised transport (private car), increasingly larger homes, high indoor temperatures, and rapid exchange of consumer articles (Wilhite, 2016). Energy consumption is a product of cultural, bodily and material dimensions and competence and know-how. As shown in the above analysis, the architectural design and ecological concept of Klosterenga were attractive to many types of residents, but the energy-efficient system was not considered when they bought an apartment. In fact, several did not even know about it until they moved in. Further, routines of passing on knowledge to new residents and keeping it fresh in the minds of the residents living there for long was almost non-existent. The ecological building design was also valued by the residents as the architectural and energy principles provide them with abundance of sunlight, modern standard, warmth, and good indoor and outdoor environments. This design also influenced the residents' practices in several ways; some reduced their use of private cars significantly; some were inspired to be more conscious in consumption of food and other goods. But also, quite notably, most of our informants had acquired new practices where they kept a higher indoor temperature, and were more passive towards their energy consumption (airing continuously, not reducing or turning off their heating when possible, etc.). Furthermore, most of the informants were reluctant to actively use the energy system because they felt that it was complicated, non-flexible, and they saw no point in trying to reduce their energy consumption (for cost reduction or the environment). Rather, our informants appreciated the system because it provided them the opportunity for comfort and good life in an environmentally friendly way. A successful low-carbon transformation thus cannot rely on technological innovation alone but needs to go 'deeper' to understand how a change in consumption require a change in several dimensions; symbolic, material and competence. All of which are associated with different social fields and relations. As exemplified in the Klosterenga case, innovative energy systems can promote disinterest, disengagement, and overconsumption of energy, as well as positive spillover effects on changing other consumption patterns.

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Notes

1. Hal Wilhite participated in several interviews leading up to this chapter and he led the writing on the section addressing the smart discourse and its critics. Further, he contributed to the paper as a whole in its early stages. He did not have the opportunity to review the final version of the manuscript.
2. According to Strengers, Resource Man is also closely related to Rational Man (Homo economicus), Tool Man (Homo faber), Choice Man (Homo optionis) and Social Man (Homo sociologicus), which makes him particularly apt to understanding and using new technologies to influence his energy consumption the way he please and share this with others in ways that enhance his use of the technologies further.
3. Theorisation of the material world as agentive has been incorporated in social science, such as Social Science of Technology (SST). See also the works of Madeleine Akrich and Annemarie Mol.
4. Klosterenga has collection and utilization of rainwater for outdoor use. Grey water is locally cleaned as part of the outdoor areas. Klosterenga is the first project in urban Oslo that has its own water-cleaning plant for grey water.
5. Generally, in Norway old owners are obliged to provide information about the home during the formal takeover. This takes place in the home when the full payment is received, and keys are handed over.
6. Power companies usually required monthly reporting of consumption, before the national roll-out of smart meters in 2019.

References

Aune, M. (1992). *Datamaskina i hverdagslivet: en studie av brukeres domestisering av en ny teknologi*. Norges teknisk-naturvitenskapelige universitet, [Fakultet for samfunnsvitenskap og teknologiledelse, Senter for teknologi og samfunn].

Aune M. (1998) *"Nøktern" eller "nytende"?: energiforbruk og hverdagsliv i norske husholdninger*. Norges teknisk-naturvitenskapelige universitet, [Fakultet for samfunnsvitenskap og teknologiledelse, Senter for teknologi og samfunn].

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

Bell, S., Judson, E., Bulkeley, H., Powells, G., Capova, K., & Lynch, D. (2015). Sociality and electricity in the United Kingdom: The influence of household dynamics on everyday consumption. *Energy Research & Social Science, 9*, 98–106.

Berker, T. (Ed.). (2006). *Domestication of media and technology*. Open University Press.

Bourdieu, P. (1977). *Outline of a theory of practice*. Cambridge University Press.

Carlsson-Kanyama, A., & Lindén, A. (2007). Energy efficiency in residences: Challenges for women and men in the north. *Energy Policy, 35*(4), 2163–2172.

Christensen, T. H., Friis, F. B., Throndsen, S., Ornetzeder, W., Skjølsvold, M., & Ryghaug, T. M. (2020). The role of competences, engagement, and devices in configuring the impact of prices in energy demand response: Findings from three smart energy pilots with households. *Energy Policy, 137*, 1–11.

Exner, D. & Mahlknecht, H. (2012). *User habits, impact on energy consumption in passive houses results of a comprehensive long-term measurement, result 5.4*, EURAC research Enerbuild, Bozen, pp. 1–79. Accessed November 15, 2020, from www.enerbuild.eu/publications/2012-06_ENERBUILD-result_5-4.pdf

Fraune, C. (2015). Gender matters: Women, renewable energy, and citizen participation in Germany. *Energy Research & Social Science, 7*, 55–65.

GoN. (2021.) Meld. St. 36. (2020–2021) Energy for employment. Long-term value creation from Norwegian energy resources (in Norwegian). White paper from Norwegian Ministry of Petroleum and Energy.

GoN. (2022). Meld. St. 11 (2021–2022) Additional notification to Meld. St. 36 (2020–2021) Energy for employment. Long-term value creation from Norwegian energy resources (in Norwegian). White paper from Norwegian Ministry of Petroleum and Energy.

Gupta, R., Barnfield, L., & Gregg, M. (2018). Exploring innovative community and household energy feedback approaches. *Building Research & Information, 46*(3), 284–299.

Inderberg, T. H., Sæle, H., Westskog, H., & Winther, T. (2020). The dynamics of solar prosuming: Exploring interconnections between actor groups in Norway. *Energy Research & Social Science, 70*(101816), 2–11.

Korsnes, M., & Throndsen, W. (2021). Smart energy prosumers in Norway: Critical reflections on implications for participation and everyday life. *Journal of Cleaner Production, 306*, 1–11.

Mennicken, S., & Huang, E. M. (2012). Hacking the natural habitat: An in-the-wild Study of smart homes, their development, and the people who live in them. In J. Kay, P. Luckowitz, H. Tokuda, P. Olivier, & A. Krüger (Eds.), *Pervasive Computing - 10th International Conference, Pervasive 2012 Newcastle, UK, June 18–22, 2012 Proceedings*. Springer.

Monsen, P. K. (2002). *USBL-Klosterenga, Oslo. Final Technical Report. Oslo, GASA Architects AS*.
Rathouse, K. & Young, B. (2004). *Domestic heating: Use of controls. DEFRA Market Transformation Program*.
Revell, K. M. A., & Stanton, N. A. (2014). Case studies of mental models in home heat control: Searching for feedback, valve, timer and switch theories. *Applied Ergonomics, 45*(2014), 363–378.
Sæle, H. (2021). *Description of survey among household electricity consumers (in Norwegian). Project report, Flexeffect*.
Sahakian, M., & Wilhite, H. (2014). Making practice theory practicable: Towards more sustainable forms of consumption. *Journal of Consumer Culture, 14*(1), 25–44.
Shove, E. (2003). *Comfort, cleanliness and convenience: The social organization of normality*. Berg.
Shove, E. (2010). Beyond the ABC: Climate change policy and theories of social change. *Environment and Planning A: Economy and Space, 45*(6), 1273–1285.
Shove, E., Pantzar, M., & Watson, M. (2012). *The dynamics of social practice*. Sage.
Skjølsvold, T. M., Throndsen, W., Ryghaug, M., Fjellså, I. F., & Koksvik, G. H. (2018). Orchestrating households as collectives of participation in the distributed energy transition: New empirical and conceptual insights. *Energy Research & Social Science, 46*, 252–261.
Sørensen, K. H. (2006) *Informasjonsteknologi, kultur og samfunn: kompendium*. Tapir, Kompendieforlaget.
Standal, K., Winther, T., & Danielsen, K. (2018). Energy politics and gender. In K. Hancock & A. Juliann (Eds.), *Oxford handbook of energy politics*. Oxford Univeristy Press.
Standal, K., Talevi, M., & Westskog, H. (2019). Engaging men and women in energy production in Norway and the United Kingdom: The significance of social practice and gender relations. *Energy Research & Social Science, 60*(101338).
Strengers, Y. (2013). *Smart energy technologies in everyday life. Smart utopia?* Palgrave Macmillan.
Strengers, Y. (2014, July–August). Smart energy in everyday life. Are you designing for resource man? *Interactions*.
Thomsen, J., Hauge, Å. L., Denizou, K., Jerkø, S., Wågø, S., & Berker, T. (2011). *User evaluations of energy efficient buildings: The interplay of buildings and users in seven European case studies*. SINTEF Academic Press.

Valocci, M., & Juliano, J. (2012). *Knowledge is power: Driving smarter energy usage through consumer education. IBM Business Report*. Accessed June 30, 2015, from http://smartgridaustralia.com.au/SGA/Documents/Consumer_Behaviour_Report

Vyas, C., & Gohn, B. (2012). *Smart grid consumer survey*. Pike Research.

Wade, F. (2015). *An ethnography of installation: Exploring the role of heating engineers in shaping the energy consumed through domestic central heating systems*. PhD thesis, UCL Energy Institute, Bartlett School of Environment, Energy and Resources, University College London.

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.

Wågø, S., & Støa, E. (2013). Daylight, view and fresh air in energy-efficient housing. *Nordic Journal of Architectural Research, 25*(1), 129–158.

Wågø, S., Hauge, B., & Støa, E. (2016). Between indoor and outdoor. Norwegian perceptions of well-being in energy efficient housing. *Journal of Architectural and Planning Research, 33*(4), 326–346.

Wallenborn, G., & Wilhite, H. (2014). Rethinking embodied knowledge and household consumption. *Energy Research & Social Science, 1*, 56–54.

Warde, A. (2005). Consumption and theories of practice. *Journal of Consumer Culture, 5*(2), 131–153.

Westskog, H., Winther, T., & Sæle, H. (2015). The effects of in-home displays: Revisiting the context. *Sustainability, 7*(5), 5431–5451. https://doi.org/10.3390/su7055431

Wilhite, H. (2012). Towards a better accounting of the roles of body, things and habits in consumption. In A. Warde & D. Southerton (Eds.), *The habits of consumption. COLLeGIUM: Studies across Disciplines in the Humanities and Social Sciences 12*. University of Helsinki, Helsinki Collegium for Advanced Studies.

Wilhite, H. L. (2016). *The political economy of low carbon transformation: Breaking the habits of capitalism*. Routledge.

Woods J (2006) Fiddling with thermostats: Energy implications of heating and cooling set point behavior. In *Proceedings of the 2006 ACEEE Summer Study*. American Council for an Energy Efficient Economy.