

Compliance and Deviation: How occupants interact with a high performance zero emission building

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Paper for Workshop 10: Automating everyday life.

NB: The paper is still at an early stage, and we apologise for the unfinished findings section. We appreciate feedback/comments related to interpretations of the data and theoretical implications.

Abstract

The Trondheim living lab is a newly built detached single family home that is planned to reach a zero emission balance over the course of its lifetime. This is achieved by a broad variety of technical strategies such as passive and active energy design and efficient installations. The degree of automation of the building's environmental services (such as heating, cooling, ventilation, and light) has been left open to be able to test different control scenarios: manual, automatic and several modes combining both approaches. In the first wave of qualitative experiments conducted in the laboratory between September 2015 and March 2016 six different groups are invited to live in the house for 25 days each. During this time, the script - i.e. the programs controlling the building according to ideal indoor environmental and energetic conditions - is kept as stable as possible. At the same time a user override is provided where applicable. Based on direct observation (mainly through sensors registering temperature, humidity, CO2 levels, light levels, presence, energy use, airing), and interviews before, during and after the stay, compliance and deviation from the script is registered and analysed along the dimensions of skill, meanings, and technology. The goal of this analysis is twofold: First, we aim to provide a detailed account of which expected or unexpected occupant actions matter in which way for the resulting energy consumption of a high performance zero emission building. The second goal is conceptual: We revisit concepts like scripts and anti-programs (e.g. Akrich 1992; Latour 1992), domestication (e.g. Silverstone & Hirsch 1992; Sørensen 2006), and social practice (e.g. Schatzki et al. 2001; Reckwitz 2002) and explore their ability to shed light on occupants' interactions with automated domestic environments.

Introduction

The built environment is commonly described as a sector with a large, cost-efficient potential of climate gas emission reduction (IPCC 2014; McKinsey&Co 2009). According to the 2010 *Energy Performance of Buildings Directive* Member states of the European Union are expected to implement building regulations that force new buildings to be 'nearly zero energy' by 2020. In Norway the Research Centre on Zero Emission Buildings (ZEB) has laid the groundwork to specify and define 'nearly zero energy' as 'zero emission', i.e. not causing any climate gas emissions of the course of a buildings life-time. This is achieved by a design that reduces climate gas reductions produced during the construction, operation and demolition as much as possible and compensates for the remaining emissions through renewable energy production on the building's footprint (Marszal et al. 2010). In this paper we use qualitative experiments to examine how people use such a zero emission building. We compare six different user groups with two and two groups being similar: 2 x student groups, 2 x family group and 2 x elderly groups. By means of qualitative experiments we evaluate how occupants impact the zero emission building, on the one hand, and how the zero emission building impacts its occupants in different ways. The underlying research questions are: To what extent are established home practices impacting a new home-situation, and to what extent do existing home living practices impact the zero-emission ambitions of a house? In other words; will dwellers in the Trondheim Living Lab comply with a zero-emission 'script' or would they deviate to the extent that the house no longer could be said to fulfil its zero-emission ambition?

The paper is structured as follows. After this brief introduction, we discuss two theoretical traditions relevant for the study of everyday life and home practices; practice theory and domestication theory. We then outline the methodology and data used in this paper. Lastly, we present some very preliminary findings that shed light on occupant actions in the Trondheim Living Lab, and theoretical implications.

Theory

The design of the experiments and its analysis was informed by studies of everyday life and consumption. In particular, theories that describe and explain how technologies interact with everyday life appear relevant, as all occupants studied here moved from their low-tech home into the high-tech zero-emission building. To shed light on what happens in this transition we have selected two theories that appear to have similar ambitions, but rather subtle differences in studying energy use and everyday life. Here we are not interested in combining these two perspectives into one analytical framework (Ryghaug and Toftaker 2013). Rather, we discuss both the similarities and differences, and show how they can highlight different aspects in the context of the Trondheim Living Lab.

Practice theory

Practices have been theorised in a host of disciplines within the social sciences and the humanities, and has received increasing attention since the 1980s (e.g. Ortner 1984; Schatzki et al. 2001). The recent upsurge of practices as a unit of analysis has roots from debates

within the social sciences where the individual and society were both equally prone to explain social phenomena (Schatzki et al. 2001). Based on the works of Bourdieu, Giddens, Foucault, Garfinkel, Taylor, Latour and Schatzki, Reckwitz (2002: 245) describes practice theory as not interested in 'in minds, discourses [or] interactions' but instead in practices as the 'smallest unit' of analysis. Elements of routine or shared skills, materials and meanings constitute the core of theories of practices (Schatzki 2001). As Schatzki (2001: 12) puts it: 'the social is a field of embodied, materially interwoven practices centrally organized around shared practical understandings'. Reproduction of such practices is also a focus that is prevailing in most other studies of social practices. Practices are therefore seen as recursive, and they need to be performed (and shared) in order to exist. Routinised behaviour is also central in Reckwitz' (2002: 249) widely cited definition of practice:

A 'practice' (Praktik) is a routinized type of behaviour which consists of several elements, interconnected to one other: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge.

People are merely carriers of these practices, which are performed recursively. For practice theorists this accounts for the 'structuring' of our action; social order is social reproduction over time (Reckwitz 2002: 256). These definitions of practice have led to an analytical distinction between practice as an entity (as we face them), and practice as performance (as we perform them) (Warde 2005; Røpke 2009). This distinction makes it possible to analyse various degrees of habituation of practices, as some practices are enacted more often than other (often seasonal) practices (Shove et al. 2012). What also is prominent in Reckwitz' definition is the inclusion of things and their use, which has considerable heritage from science and technology studies (STS), and which gives agency to materials in a social realm (Shove et al. 2012).

Practice theory has received renewed attention in the domain of everyday life studies the past decade, here taken to mainly include studies of consumption, energy use and everyday coping (Røpke 2009). A highly influential way of studying social practices was developed by Shove and Pantzar (2005) who define practices as consisting of three integrated elements: materials, meanings and competence. By following these three elements over time it is claimed a better grasp of practices and how they shape, persist and fade out is possible (Shove et al. 2012). People within practice theory are seen as practitioners or carriers of practices and that have different 'careers' as practitioners, meaning the time they spend doing the practice. Examples of studies of everyday life using practice theory have are practices such as driving (Shove et al. 2012), bathing (Kuijjer 2014), air conditioning (Wilhite 2008), or residential heating practices (Gram-Hanssen 2010).

Domestication theory

Domestication theory emerged in the late 1980s and early 90s and focussed mainly on how media technologies were taken into use and 'domesticated' into everyday life (Aune 1996;

Silverstone & Hirsch 1992). The perspective has later been applied to a broader set of technologies that were found to be relevant in wider contexts than of the socialisation of the technology itself. Rather, influenced by actor-network theory and a semiotic understanding of science and technology, it was proposed to understand domestication as a co-production of the social and the technical (Sørensen 2006). Regardless of used with the wider or narrower implications, the basic tenets of domestication theory as applied here are that there is no such thing as an 'introduction' of an isolated technological artefact. Instead, an evolving process goes on between people and technologies that shape cognitive, practical and symbolic meanings connected with people's everyday life (Sørensen 2006; Berker 2011). There is, in other words, a mutual adaptation between technologies and people's everyday practices.

The semiotic version of domestication theory connects the mutual adaptation between technologies and people to the scripts that designers inscribe (Akrich 1992), and the anti-programmes that users conceive of (Latour 1992). The scripts are taken to be the representation of designers' and architects' explicit or implicit world-views within the artefact itself, whilst anti-programmes are the opposition or the adjustment of the users to that script, which also can mean a complete boycott of the technology. Designs can therefore be said to be 'political' in that they include a prefigured understanding of how they should be used (Sørensen 2006). For instance, the script of a paper cup could be 'throw me away after use', whilst the anti-programme is 'I will use this cup multiple times'. The anti-programme thus represents a kind of 'mis'behaviour on the part of the user. Similarly, we can imagine that a script is so strong that the user will not even consider the technology relevant, and thus not use the technology at all. Acknowledging the idea of scripts, we see that there are multiple scripts in play that are continuously negotiated in terms of anti-programmes. A house therefore can be said to be a 'minefield' of scripts, but the actual use of the technologies within the house, the anti-programmes, defines the domestication processes of these technologies (Berker 2011).

If we compare domestication theory with practice theory, both similarities and differences may be fleshed out. Sørensen (2006: 47) points out that domestication theory invites a focus on three main features: 1) the practices that are constructed around the use of an artefact, 2) the meanings that are constructed in connection to the artefact, and 3) the cognitive processes connected with learning a practice. Comparing this to practice theory we see that the main similarity is that each approach includes the wider implications connected with how the social and the technical are mutually shaped. The main difference, on the other hand, is the locus of analysis: Practice theory centres on a practice, such as eating or cooking, and shows how meaning, materials and knowledge are central to the formation, sustenance or dissolution of practices. Domestication theory centres on the introduction of a new technological artefact, such as the mobile phone or a car, into its users' everyday life and explores the mutual adaptation between the artefact, people's practices, meanings and knowledge.

One implication of the difference between domestication theory and practice theory is that the research questions and findings differ: studying a technology, say a car (Østby 1995), and how it has become domesticated through a series of adaptations of meanings, practices and learning is different to studying the way in which the practice of driving has involved a series of technologies, meanings and knowledge over time (Shove et al 2012). Consequently, practice theory can be applied in more different situations than domestication theory which reach far beyond the first encounter between artefact and user and the subsequent processes. Domestication involves a period of tension between the user and the technology. During the course of domestication this tension is reduced and the technology is experienced as familiar part of one's self. The study of practices, on the other hand, implies that the carriers of a practice deal with constant changes connected to the materials, meanings and knowledge associated with the practice that continues to exist outside their performance of the practice (but ceases to exist when all carriers defect). Practices may involve a broad spectrum of technologies, for instance all the things involved when cooking. This directs the attention away from one (set of) technologies and how it became a part of everyday life to overarching structures – the bigger picture – where changes in its elements may even stabilize the practice. The introduction of the freezer (and the whole freezer chain, see Finstad (2011)) introduced such a change into the practice of cooking. This change can be told as a story of normalization and domestication in which the novelty becomes gradually embedded into the fabric of everyday life (Shove & Southerton 2000) but it also can be seen as part of an ongoing transformation of cooking (Hand & Shove 2007). Both perspectives provide a slightly different perspective on the 25 days of domestic life in a zero emission building that our subjects experienced during our experiment.

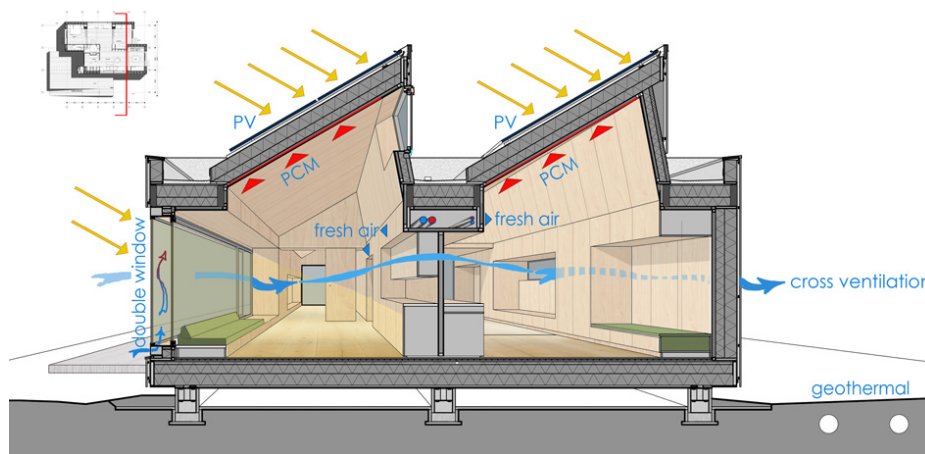
If the object of analysis is the practices then the question arises how practices established and performed routinely in other contexts change or resist change during the stay in the new building. Further, when our subjects move back, are they then just captured by their old practices again? The domestication perspective contributes similar questions only phrased slightly different: How are the scripts inscribed in the building negotiated by the occupants? How are differences in the scripts between the actual home and the zero emission buildings dealt with? In addition, however, the domestication perspective can be expected to shed light on the process of “normalization” of the strange, high-technological building. Is domestication in this sense actually happening? Is the building actually experienced as alien in the beginning? Which symbolic, cognitive and practical processes are happening while the occupants make themselves at home? Is the building in the end experienced as less strange than in the beginning? How might such a process of normalization be supported?

Methodology

The Trondheim Living Lab has been the home for six groups, each group living there for a 25-day period. The house is built with an aim to reach zero-emission over a 60 year period. This is achieved by minimizing energy demand for the operation of the house, and harvesting solar energy so that production is larger than demand on a yearly basis (Goia et al 2015).

Some of the technologies included in the house are 40 cm thick walls filled with rock wool insulation, a ground source heat pump, a balanced mechanical ventilation, LED lighting, a large south-facing double skin window, solar thermal panels, roof-integrated PV, and a complete set of the most energy-efficient household appliances, such as dishwasher, oven and washing machine. See figure 1 below. For a complete description of all the included technologies, see Goia et al (2015) and Finocchiaro et al (2014).

Figure 1: Cross section of the Trondheim Living Lab



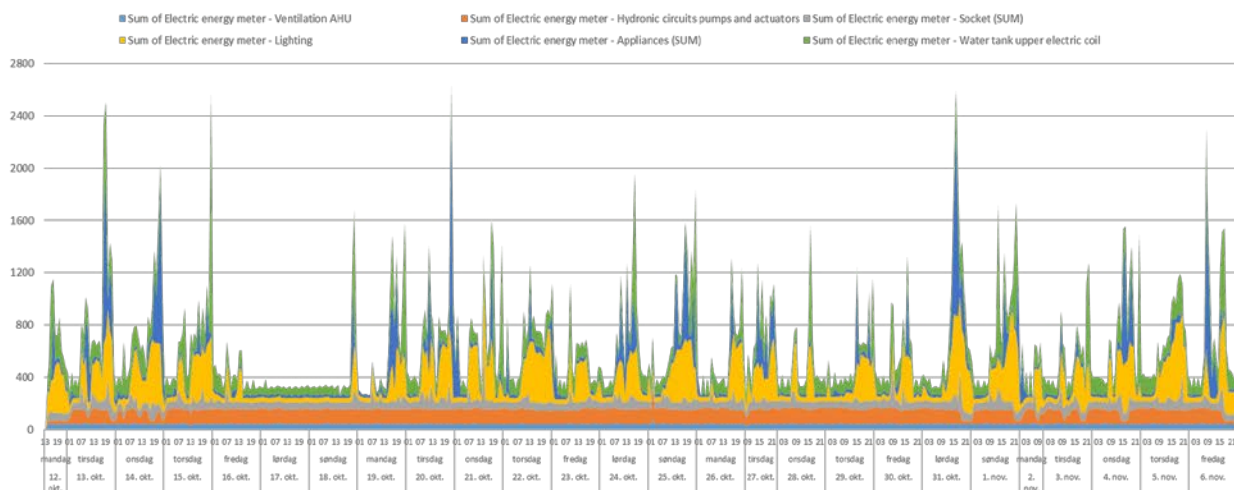
Source: Finocchiaro et al. (2014).

The research project has been set up with an experimental methodology, where the house served as a ‘living laboratory’. The data this paper is based on has been collected using a mixed-methods approach in which mostly qualitative data is complemented by measurements of energy and indoor climate logged every 3rd second during the whole 25-day period. See a sample of this data in figure 2 below. The qualitative data has been collected based on a mixture of interviews before, during and after the stays, as well as participant observation, self-filming and diary records. Interview questions before and after the stay focussed on expectations, and experiences respectively, whilst interviews during the stay focussed on comparison with their normal house, and how everyday practices were performed in the new dwelling. The interview during the stay was conducted at some point during the third week, mostly after around 16-18 days of residence. The daily diaries were kept in an effort to get an overview of the routines in the house regarding when the house was in use, and what type of activities were undertaken, such as cooking, cleaning, visits, dinners and so on. These diaries were also used in comparisons with the energy data recorded, as they allowed for a comparison of household activities and energy use at the same time. In addition to the six groups, one of the authors lived in the house for a one-week trial period before the experiment started, in order to test the technical equipment.

Table 1: Overview of the groups

Group #	1	2	3	4	5	6
Category	Student	Student	Family with children	Elderly	Family with children	Elderly
Details	Male and female couple, 22 years old. Live in a 52 m2 student apartment.	Two female friends, 20 and 21 years old. Live in a shared apartment together with three other girls, built 1905.	Mother 31 years old and father 36. Son 6 years old and daughter 2. Live in an attached house of 185m2, built 2007	Husband 81 and wife 68. Live in a detached house of 170 m2.	Mother 31 years old and father 37. Two daughters of 3 and 2 years old. Live in a detached house of 135 m2.	Husband 61 and wife 56. Live in a detached house of about 120 m2.

Figure 2: Sample energy measurement of one group



Since each group only stayed in the house for 25 days, almost like a ‘three week holiday’ as some of the occupants pointed out, their time within the house is characterised by a transition-period where new routines do not have time to form, or where a prevailing thought would be e.g.: ‘We sure can manage without a television for 25 days’. This directs our attention towards the changes that were made within the 25-day period rather than to assume that we can study a new, stable, ‘zero-emission’ practice. To explore the latter, a

longitudinal study of someone living in the house for a longer period would be a good complement to the present study.

Empirical findings

To answer the questions outlined above, we first have to identify some of the scripts that are present in the house, and that might affect the domestication process. Some examples of scripts are the choices made by the architects. Here all of the groups mentioned several issues that they were not agreeing with, compared to their own homes. For instance, the doors in the kitchen cupboards were annoying, the kitchen was too big so they had to walk a lot to get to the different appliances, there were no drawers in the kitchen, the buttons on the touch screen controlling the indoor temperature were too small, there was no door between the entry and the living room so the house got cold when someone entered, and there was no windows in bedroom (only doors). These were things that the groups in unison reacted too – irrespective of their age and present living situation. Some things were also pointed out, that had something to do with choices made by the engineers: There was only floor heating in the house, there was sometimes cold air from ventilation, the air felt dry, some loved, others disliked the LED lighting, and so on. Clearly, these were reactions to the ways in which the house functioned to the occupants, and reflected the novelty of the situation. Interestingly, several of the initial reactions were dampened after a small amount of time. For instance, the dry air did not feel dry anymore, but fresh, and the lacking window in the bedroom was not a big issue, because the temperature in that room could be set lower (16 degrees Celsius).

Other similarities across all the groups were for instance: Location of the house led to changes in routine of grocery shopping, driving to work, getting children in the kindergarten and so on. There were also changes in routines connected with the fact that this was a new setting and new situation for each group: Everyone had more visitors, as friends and family were generally interested in stopping by to have a look at the high-tech house. Most groups ended up cleaning the house more often, as the open and empty surfaces were ‘asking for it’. Also, several groups mentioned that they showered longer in the lab because the shower head was nice and comfortable. None of the groups brought their television, although they would normally use it at home – they could live without the television for 25 days.

Let us take a look at how the different experiences played out in each of the three categories of groups: Youngsters, families and elderly.

The Youngsters

One of the student groups appeared to use the stay in the lab to try a meat-free period. They wanted to try this because it would be fun, because they would have an ‘excuse to fill up the empty cupboards in the kitchen’, and also because it was good for the environment.

The house was a catalyst for change in several ways: They went shopping for groceries much more seldom than before since the shop was far away – this saved money. This was mentioned by several groups.

They noticed that their cleaning habits changed: Due to the open and empty spaces they did much more '2-minutes cleaning'. Dust was very visible on the bright wooden surfaces.

Both groups found the bright wooden interior strange in the beginning, but they got used to it after some time (domestication?). They also found the air somewhat dry in the beginning, but this also was not a worry towards the end of the stay.

The Family

The reason for engaging with the project: their six year old son wanted to do something for science.

An unfortunate start: the house was cold – the technology did not work as it was supposed to (i.e. the technology did not comply – we can ask who is complying with whom?). They set the temperature to “23 degrees” but inside was cold. The felt temperature was different to the set / displayed. There was a general suspicion to the displayed measurements: CO2 level, humidity, temperature and electricity use. The husband brought his own humidity measurement device to check the one in displayed in the house.

Felt like they were moving in too soon – they felt the house was not ready for them.

The family wanted a cosy corner, and one of the first things they did was to move the couch in the house to a corner so that they could lean on it and feel comfortable. The couch was in a way domesticated – and made to perform similar functions to the way in which their couch at home would work.

The Elderly

Missed their space: cold cellar, green house, garage for their car, they had to travel home to feed their compost etc. They had clear and strong practices from their own home. These were severely impacted by the new setting.

They also missed their microwave oven, but they quickly adapted to the new oven with steam functions that were just as good as a microwave oven.

The elderly couple also changed their habit of sleeping with an open window in the night. This was something they said in interviews before that 'they cannot live without'. After some days, however, they found out that they could set the bedroom temperature to 16 degrees, and the air felt fresh enough. Another point in this respect is that the bedroom in the lab did not have a window, but a door. This door was not so tempting to open, because people were walking close by in the night and early mornings. In a way, therefore, the elderly couple were

'forced' to adapt a new practice – and the new practice worked well (this can be called a 'tactic'? They were doing it to make the house liveable for the 25-day period?).

The zero-emission technologies were not a barrier to use – but the lacking 'functions' that they were used to in their original home were.

An 'expensive endeavour': They wanted to buy almost all the appliances in the house: induction top, dishwasher, the oven – but not the washing machine.

They did not like the 'Niagara-falls' type of shower.

Discussion

What do these findings mean/ imply in terms of energy demand and zero-emission standards?

What can we conclude with regarding practice theory and domestication theory?

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