The governance of the energy concept in low-energy buildings

The perceptions of housing companies and occupants

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MSc Thesis (30 ECTS credits)
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1. Abstract

Energy efficiency within the housing sector is progressing. In Vallastaden which is a newly developed city district in Linköping, Sweden, constructors together with the municipality have made attempts to create a sustainable built environment. One of the goals was to establish energy efficient residential buildings in Vallastaden. The overall aim of the study was to investigate the development of two energy plus buildings in Vallastaden and explore the potentials for the energy concept in these buildings to reduce the energy use. The perceptions of the occupants were included in the study since their views and practices play an important part for the buildings’ energy performance. Qualitative interviews were conducted with informants from two housing companies and three households. The findings show that the motives for the housing companies were try out new things and progress within the housing sector. The housing companies were however uncertain if their buildings would become energy efficient in practice since it depended on how the occupants would interact with the technology and the energy concept. There is a risk that the energy concept and the technology may not reach its full potential in reducing energy since the occupants either had no reflection about their role in the energy concept or were uncertain about the technology. The communication between the housing companies and the occupants needs to be strengthened for occupants to realize their influence on the energy use in these buildings.

Key words: energy concept, energy use, housing companies, mundane governance, occupants

2. Introduction

The energy use and related carbon dioxide emissions within the building sector in the European Union are increasing. In order to tackle the issue, energy efficiency is a key element in environmental policies at the level of governments and businesses with the building sector as no exception (Lutzenhiser, 2014). The building sector has great potential of mitigating CO₂ emissions at low costs by adopting to new technology (Mata, et al., 2013). Therefore, there is a growing trend in the building sector to develop low-energy buildings to improve the energy efficiency (Eves et al., 2010). Sweden as a member of the Union must implement the Union directive regarding energy efficient buildings. The directive states that energy efficiency in the building sector must enhance to reach the goal of a 20 % reduction in energy use by year 2020 (2010/31/EU). Hence, Sweden has adopted minimum requirements for the energy use in buildings.

Low-energy buildings have the potential to reduce CO₂ emissions by 56 % in Sweden, if compared to conventional buildings (Karlsson & Moshfegh, 2007). There are several strategies that can be applied to develop buildings with efficient energy performance. For example, the building shell can be constructed to prevent heat leakage from the interior to the outside and the ventilation system should have an effective heat recovery. The windows are often placed faced towards the south to capture the energy from the sun (Sartori & Hestnes, 2007). When a building meets all the requirements it can be considered as a nearly-zero energy building. The definition implies that the building has a high energy performance and that most of the energy comes from renewable sources. The potential to reduce energy use through low-energy buildings is considered great. However, there is a risk that the technology adopted in these building might not be enough to reduce the energy use. The behaviour of households is equally important to address in these buildings and can sometimes even outweigh technical energy
efficiency gains (Gram-Hanssen, 2013). However, occupants are seldom mentioned in policy documents despite their impact on energy use (Gram-Hanssen, 2013; Wahlström & Härsman, 2015). The occupant perspective is also in most cases ignored in attempts of making buildings more energy efficient (Karresand, 2014).

2.1. The role of occupants in low-energy buildings

The role of the occupants in low-energy buildings is very important (Gram-Hanssen, 2013). People living in these buildings are a part of the active technology since the body heat from them and their activities such as cooking and doing laundry provide much of the energy for the heating of the building. Hence, the use of appliances in the home become more than just doing chores, they become a heat source and facilitate a convenient indoor temperature for the occupants (Isaksson, 2009). The people and their activities play a major part in these buildings with an energy concept and technology that aims to reduce energy use. However, energy systems are often invisible for the users and the technology used in the domestic sphere are in many cases constructed to be understood by experts rather than the actual users (Glad, 2017). This could mean that occupants do not reflect about their energy use and their role in this type of energy concept. Previous research shows that occupants in low-energy buildings do not necessarily use less energy than occupants of conventional homes. The domestic energy use also varies a lot between households living in low-energy buildings. Some households used five times more electricity than other households in a residential area with low-energy buildings (Gram-Hanssen, 2013). Similar findings by Karlsson & Moshfegh (2007) has been reported in an area of twenty terraced houses in the Swedish west coast, where the energy use varied a lot between identical low-energy homes (Karlsson & Moshfegh, 2007). These results indicate that the behaviour and activities of occupants matters even though the building per se has a high energy performance. Technology is not efficient enough on its own for reducing energy use because it depends on the occupants and how they interact and handle the technology. The relationship between the technology and the people using it therefore needs to be considered. It therefore becomes crucial to understand the behaviour of end-users in energy efficient buildings to be able to substantially reduce the energy use (Energimyndigheten, 2015). By incorporating the perceptions of occupants in low-energy buildings you can study what happens when traditional energy systems in buildings are replaced by technology that depends on the occupants’ body heat and activities (Isaksson, 2009).

The two housing companies Stångåstaden and HSB have attempted to develop energy plus buildings in the city district called Vallastaden in Linköping, Sweden. It called for an opportunity to investigate the development of the energy concept of these buildings. The exploration was facilitated through a theoretical framework called mundane governance. The core of mundane governance is to look at how objects, in this case the energy concept, become instruments of social and political forces (Woolgar & Neyland, 2013). In other words, the reason for developing this kind of energy concept is because of the potentials to use energy more efficiently than conventional energy systems. In this case, the energy concept becomes an instrument for improving the energy performance of the buildings. However as illustrated above, in order for energy concept and related technology to reduce energy use, the role of the occupants must be addressed and acknowledged. The behaviour of the occupants and the way they handle the technology have been proven to affect the outcome of the energy performance of these types of buildings. Therefore, it is important to study how the housing companies have considered the role of the occupants in the energy concept and the ways they have tried to communicate the energy concept to the households. Communication and information is key concept in mundane governance. Mundane governance also emphasizes that perceptions of the
Object in question influence how people act and behave towards it. It is especially important to explore the perceptions of the occupants and how they relate to the energy concept since their perceptions influence the way they behave or handle the technology in the buildings. How does the occupants perceive the energy concept? Could their perceptions about the energy concept influence its performance? These are questions that are explored in the study. To include both households and experts in studies is rare, but useful since it can facilitate exploration of the socio-technological systems that they both are a part of (Glad, 2012).

2.2. Aim of the study

The overarching objective of the study was to investigate the development of two energy plus buildings in Vallastaden and explore the capabilities for the energy concept in these buildings to reduce the energy use. The aim is twofold. Firstly, it explores the process for Stångåstaden and HSB to develop energy plus buildings in Vallastaden, their motivations for developing this type of energy concept and how they have communicated the energy concept to their occupants. Secondly, the aim was also to investigate the perceptions of the occupants and how their perceptions influence the way they behave and handle the technology.

- What have been the motives for the housing companies to develop energy plus buildings in Vallastaden?
- What attempts have been made by the housing companies to communicate the energy concept to the occupants and how effective has it been?
- How is the energy concept perceived by the occupants?
- What are the capabilities for the energy concept to reduce the energy use in the buildings?

3. Theoretical framework: Mundane governance

The following section contains an introduction to the framework Mundane governance which is used in the study to facilitate the analysis of the result. An explanation on how mundane governance has been used for the study is also provided further down in the section.

In order to explore the process of developing low-energy buildings with the perspectives from both housing companies and occupants I have used a theoretical framework called Mundane governance. It resembles Actor-network theory, coined by Latour whose theory has influenced the socio-technical system (STS) research field which considers society and technology interconnected. STS perspectives can help us understand why adopting to new technology is not a straightforward process since social practices and technological artefacts are shaped by one another (Stephenson et al., 2010). Technology is understood through social, political, cultural and organizational perspectives rather than from a sheer technological point of view (Woolgar & Neyland, 2013). The social binds us all together and needs explanation. Researcher can open this ‘social world’ and make it visible. It is important to follow the actors to understand how the collective existence has been constituted by themselves (Latour, 2007). However, STS literature tends to ‘ignore’ the individual and group behaviour and their roles in socio-technical systems (Stephenson et al., 2010) which is an important aspect for this study. Woolgar & Neyland (2013) mean that STS research make assumptions regarding the definite character of objects and ignore that there can be multiple ontological realities.
Mundane governance is one of many approaches that has emerged from STS perspectives. Latour (2007) said that ‘Technology is society made durable’, implying that technology is a result of social and political processes. Woolgar and Neyland (2013) who introduced the concept of mundane governance argues that ‘objects (like technology) are governance and accountability made durable’. Governance can be viewed as the process and practice of regulation and control where the objects become instruments of social and political forces. Mundane governance emphasizes that ordinary objects, which at first glance can appear mundane and invisible in everyday-life, are in fact ontological realities constituted by people and things. By exploring the mundane you understand why certain behaviours and activities are performed in relation to it. The authors bring up waste management as an example of mundane governance. Waste can be considered as plain rubbish, but at the same time you can look at it as recycling materials. Speed cameras can be viewed as a measurement for road safety but also as surveillance and a way for governments to earn more money. There can therefore be multiple definitions of the very same thing and the mundane is treated differently depending on situation. There is no object which possess ‘natural’ or ‘inherent’ capabilities however, technical capacities of objects are often taken for granted and therefore it is important to explore the different perceptions of an object that could explain why things are taken for granted. Entities such as people and things, technologies and documents constitute the ontology of objects. Hence, you can study how social and technological entities are interlinked (Glad, 2017). Ontology in this sense should be understood through the context, in situ in which its enacted. Mundane governance as a theory acknowledges that entities can possess several ontological realities, not only one as supposed in ANT theory (Woolgar & Neyland, 2013).

Three central concepts make up mundane governance, namely governance, accountability and classification. The interconnections between accountability and classification make up mundane governance where you study how governance and accountability relations are created through the object (Woolgar & Neyland, 2013). The studied object and the people that interact with the object create accountability relations which become important to maintain in order for mundane governance to work. Accountability is an important aspect of governance and it is important to establish who is accountable for what, where and when (Glad, 2017). Classifications such as rules and information could facilitate the accountability of the involved actors. The actors then need to follow the rules in order for the object to perform governance and accountability (Woolgar & Neyland, 2013). Information and communication is therefore a prerequisite in mundane governance. These central of mundane governance concepts have influenced the research questions of the study and facilitated the exploration of the aim.

3.1.1. The use of mundane governance in the study

The benefits of using mundane governance as a theoretical framework lies in the fact that it can be apprehended in various ways (Woolgar & Neyland, 2013). In this study, the energy concept of the buildings is considered to be the mundane. By energy concept I mean the energy system and the technology that has been developed in the buildings to reduce the energy use. The framework is suitable since the energy systems in buildings are mundane in the sense that the technology often is invisible and hence, something that the occupants rarely think of. Activities in the domestic sphere such as using appliances for different purposes are often done without any reflection about energy as a resource. Domestic energy is rather disguised by routines, experiences and cultural ideas about how it should be (Karresand, 2014).
The approach was to explore the perceptions – i.e. the different ontological realities of the energy concept and try to understand how the mundane (the energy concept) frame the governance and accountability of the actors. I wanted to explore in how the involved actors, the housing companies and the occupants, perceive and act in relation to the very same thing. Are there any differences between the experts’ expectations of how the energy concept is intended to be used and how the occupants use it? And could their perceptions influence the capabilities of the energy concept to reduce energy in these buildings? Woolgar and Neyland (2013) mean that ontological constitution of mundane objects can influence action (or even inaction?) and behaviour. This is important to explore since the occupants and their behaviour regarding the technology can ultimately influence its effectiveness. Communication and information provided to the occupants could make them understand their important role in the energy concept.

For this study, I consider mundane governance as a good framework for entangling and structuring the motives of the housing companies to build low-energy buildings but also gain understanding for how occupants perceive the technology. It is also a suitable framework because of the multiple of ways the mundane can be interpreted (Woolgar & Neyland, 2013). For example, the buildings can be interpreted in a particular way by its developers, while the people who live in the building have another apprehension of it. Practically the very same thing can be perceived and acted upon differently. For example, the energy concept could be unremarkable by residents while the developers think of the energy concept as special and unique. It is to understand that the same thing can have different meaning depending on who you ask. The occupants need proper information regarding how the energy concept works in order for it to be energy efficient. In other words, the energy concept can only perform governance (reduce the energy use in the buildings) if the occupants use the technology as intended.

4. Materials and method

Qualitative semi structured interviews were used for this study. The use of qualitative semi-structured interviews is explained in this section and possible limitations are discussed. Information about the informants are also provided as well as a brief description of the context in Vallastaden.

4.1. The case study: Vallastaden

Vallastaden is an interesting case study since it is a newly developed district with an explicit vision for the district to become sustainable. Kohlbacher (2006) argues that case studies can be a fruitful research strategy for understanding complex social phenomena since it can open for holistic and meaningful understanding of real-life events. Vallastaden is portrayed as unique area and that notion can perhaps influence the perceptions of housing companies and the occupants regarding the energy concept of the buildings. For example, occupants who enjoy their neighbourhood can develop a strong place identity which can influence positive attitudes regarding the environment and sustainable consumption (Lee, et al., 2015). The aim has not been to generalize the result into a wider context. The focus of the study is perceptions regarding the energy concept of the two buildings in Vallastaden. The findings could be relevant in other contexts than Vallastaden where low-energy buildings are being developed. Energy efficient buildings are becoming increasingly popular and the study contributes to the understanding of the role of occupants in these socio-technical systems.
Vallastaden is an urban district located in Linköping Municipality in Sweden and its first settlements were established in 2017. Linköping Municipality wished to develop an urban district where key concepts such as knowledge, social sustainability and creativity were supposed to be central in the process. The planning of Vallastaden started in 2012 and involved many different actors. Firstly, the municipality held a competition regarding the layout of the district. The architectural company who won the competition created a design for the overall district which every actor needed to adapt to. The vision of the urban environment in Vallastaden was focused on variation and the buildings were supposed to be narrow and resemble small allotments. When the architecture and vibe of the urban environment was set, construction companies were invited to exploit and build in Vallastaden. However, this process was also based on competition since Linköping Municipality had established a quality program in which demands and criteria were listed for the constructors to follow. Hence, the constructors could score points for different aspects of their exploitation in Vallastaden (Linköping Municipality, 2013). As an example, additional points were given to constructors who built energy efficient buildings in which the energy use of the buildings were 25 % lower than the current requirements by Boverket at that point (Eidenskog, 2017). The quality program also emphasized creative and climate-smart ideas for residential buildings such as production of energy and installation of metering devices for electricity, hot water and tap water (Linköping municipality, 2013).

During the time span of five years, actors together with Linköping municipality collaborated into developing the new district. In autumn 2017, Vallastaden was presented for the public and business sector at a living fair. Thousand dwellings were finished around that time and the buildings differed in material, colour and design. The buildings are supposed to accommodate different lifestyles, needs and wishes. Currently, there are 250 rental apartments, 500 co-operative apartments, 50 detached houses and 200 student apartments and the district is continuously expanding. As mentioned, some of the buildings in Vallastaden have been constructed to become energy efficient. Two out of these buildings are the subject of this paper.

4.2. Description of the buildings

Since the study revolves around two buildings in Vallastaden, a short description of the buildings and their energy systems are provided below. There are several names and definitions for nearly-zero-energy buildings like passive house, low-energy building and energy plus building. The informants defined their buildings as ‘energy plus buildings’. Since it still was uncertain if the two buildings would be able to meet all the requirements of being an energy plus building during the time of the study, I will hereafter simply refer to them as buildings.

4.2.1 The building developed by Stångåstaden

The building of Stångåstaden is a multi-apartment dwelling with seventeen rental apartments in various sizes. The building is verified as a nearly-zero energy building according to FEBY12 (Forum för energieffektivt byggande) which means that the criteria have been met through theoretical energy calculations. The criteria for FEBY12 are that the building is developed with passive solutions with a weighted energy excess (Sveriges Centrum för Nollenergihus, 2012). There are multiple passive strategies that can be implemented into the building, but what kind of strategies depends on the climatic conditions in the region. Nearly-zero energy buildings need to be low in energy use and the production of energy from renewable sources must be established on-site or nearby (Rodriguez-UBinas et al., 2014). Stångåstaden’s building has solar
panels on its roof. The installed solar panels provide electricity for the operation of building and its common areas, but not for domestic energy use. The energy excess is then sold to the electricity grid. The building has a low U-value and efforts to minimize thermal bridges have been made. Worth noting is that their building has hot-water radiators connected to district heating which is not common in buildings with passive strategies. They were installed to secure thermal comfort for the occupants. I will come back to this later in the study. The building has FTX-ventilation. The overall expected energy use is 42 kWh/m\(^2\) per year, but the number excludes the electricity production of the solar panels. With the solar production in mind, the building’s weighted energy use is minus eleven thousand. However, the energy performance of Stångåstaden’s building is for the time being only theoretical since it is only based on calculations with no practical evaluation so far. The households’ electricity use has not been included in the calculations.

4.2.2. The building developed by HSB

HSB has developed three terraced houses which are characterized as energy plus buildings. The buildings have been developed as private homes and have been sold on the Swedish housing market. Each house is 126 square metres and contains five rooms and a kitchen. HSB has collaborated with the Passive House Institution to come up with the passive strategies for the three houses. The buildings are therefore certified as a low-energy building and the first ones to be certified as low-energy buildings by international passive house standards. Low-energy buildings use less energy for heating of spaces but they generally do not pass the standard for passive houses (Hauge et al., 2011). There are also more moving parts in this building than in regular passive houses. Therefore, it is hard to say if this building passes passive house standards. The heating system is based on supply air from an FTX-ventilation and the aggregate preheats the incoming air with a heat exchanger. The heat exchanger also facilitates the exhaust air to be recycled by 90%. The incoming air is pre-heated through ground heat. To provide comfort for the households, the kitchen and bathrooms have floor heating. The households’ electricity use has not been taken into consideration.

4.2. Qualitative semi-structured interviews

The material for the study was collected through qualitative semi-structured interviews. Semi-structured interviews are suitable for capturing different perceptions and opinions regarding complex issues and therefore suitable for this case study. The ability for the interviewer to ask to follow up questions is preferred since it can provide in-depth understanding of the informants’ conceptions of an issue (Barriball & While, 1994). One of the challenges with semi-structured interviews is to maintain objectivity during the interviews which is in almost any cases impossible to achieve. For example, there is a risk for the researcher to influence the interviews with his or her own values when asking to follow up questions to the informants (Diefenbach, 2009). I have tried to avoid this dilemma by not asking the informants questions that could be interpreted as leading. It is however important to acknowledge that interviews are a social production of knowledge. The researcher and informant in their social interaction (the interview situation) are together producing knowledge of intersubjectivity. Kvale and Brinkmann (2014) argues that interviews as a method should not be regarded as an equal dialogue between the involving parties. The researcher seeks to explore their research questions and always have an interpretative prerogative based upon the answers from the informants (Kvale & Brinkmann, 2014). The statements of the informants have been handled with care in the way that they have not taken out of context or been used to intentionally portray the
informants in a bad way. The interview situations are described further down in the section to give a sense of the mood and character of the situation.

My research approach was of abductive character which is an approach that acknowledges that there are several possible explanations to a given problem, but with this approach you can look at the problem from a specific and chosen angle. In my case, I explored the perceptions of the energy concept in buildings by applying the theoretical framework mundane governance. The framework together with previous studies have influenced the aim and research questions since they have influenced my perception of the case. However, a theoretical framework is preferred when conducting interview studies, since the result can be generalized and put into context in a different way.

4.3. The interview guides

Three interview guides were established for this study since there were three different groups of actors participating. The questions were formulated with the purpose and research questions in mind. Most of the questions have been formulated as open ended. Hence, the informants had the ability to elaborate their answers which can provide unthought-of perspectives (Bryman, 2011). The interviews were theory driven, but the interview guides were framed at a language that best suited the context of the informants. For example, the interview questions with the occupants were constructed in a way that was not technical. These questions were rather framed to revolve around activities in everyday life. All the interviews were conducted in Swedish and recorded with approval from the informants. After each interview I took some notes to write down my immediate memory of each interview to remember as much as possible for the analysis.

4.4. The informants

The interviews were conducted with Tekniska Verken, two housing companies and three interviews were held with occupants living in the buildings. Each informant for the study is presented below with information about their role and involvement in Vallastaden and why they were relevant as participants for this study. The result and knowledge from qualitative interviews are formed by the social interaction between researcher and informant (Kvale & Brinkmann, 2014). Hence, a short description of the interview context is also presented in the sections.

4.4.1. The interview with Tekniska Verken

Tekniska Verken is an energy company which is owned by Linköping municipality. The company’s role in Vallastaden was to establish a sustainable energy infrastructure system which resulted in a culvert system (Palm & Wihlborg, 2013). During the development of the energy system in Vallastaden Tekniska Verken organized and managed projects together with the developers in Vallastaden regarding the energy infrastructure (Palm & Wihlborg, 2013). They were a strong actor regarding the energy system in Vallastaden since their role were to lead the projects and having dialogue with the constructors and the housing companies. Hence, they were considered as relevant to interview.

I contacted one of the informants from Tekniska Verken by email. The informant agreed to be interviewed, but wanted a specific colleague to join the interview since he believed that the two of them would complement each other. I agreed to let them be together during our interview.
since they were supposed to complement one another. The first informant (referred to as informant 1 in the result) had an overview of the overall projects regarding the culvert. The informant was a civil engineer who worked at the marketing department at Tekniska Verken. The colleague, informant 2, had a background in engineering and worked with the development of district heating and district cooling in the production stage up until the customers. The interview took place in one of their meeting rooms at the headquarters of Tekniska Verken in Linköping. The duration of the interview was one hour and twenty minutes long. Just as I imagined, the informants possessed different kinds of expertise and contributed equally in the interview. It was evident during the interview that the informants were comfortable in these types of interview situations and acted in their professional role.

4.4.2. The interviews with the housing companies

Two housing companies in Linköping municipality participated in this study. Both housing companies developed buildings with the aim of meeting the requirement for energy plus building in Vallastaden. I figured that it was important to gain knowledge in how they perceive the energy concept, but also how they reflect about the role of the occupants in the energy system. Have they made attempts to communicate the concept to the occupants? That is why I considered them to be relevant for the study. It was crucial to find informants at these companies who had an overview of the whole process of building the buildings, but also possessed profound knowledge regarding the energy systems in the buildings. I interviewed one informant from each housing company. Both informants were contacted by email with information about the study and the possibility for them to participate. After their response and some communication, two interviews were booked and conducted. The interviews with each informant from the housing companies were conducted at their offices. The social context established a certain kind of relationship between me as a researcher and them as professionals. Since the interview was of semi-structured kind, they had some influence over the interview and choice of what information they wanted to convey to me. But my interview guide was constructed with many broad and open-ended questions which makes me think that I got the information in relevance to the aim of the study.

4.4.3. Stångåstad

Stångåstad is one of the biggest housing companies in Linköping municipality which administers many types of buildings throughout Linköping. My informant from Stångåstad worked as a project leader for new production in Vallastaden among other things. The interview was one hour and twenty minutes long.

4.4.4. HSB

HSB is company with residential buildings in Sweden. In Vallastaden they have developed three terrace houses which have high energy performance. Thus, the company was suitable to conduct an interview with. The informant from HSB had worked as an energy consultant at the company for about eight years. In Vallastaden, he was involved as a project leader and his main responsibility was to monitor the installations in their buildings and do the energy calculations. He was also responsible for the environmental work conducted at the company. The interview lasted for one hour and ten minutes.

4.4.5. Interviews with the occupants

In order for energy systems in low-energy buildings to be energy effective, it is important that end-users handle the technology so it functions as intended. They are the end-users of the
energy use and their behaviour are maybe the most important factor for substantial reductions in energy. That is why the occupant perspective was the focus of the study and also relevant to study. It was crucial to get their input and investigate their understanding of the energy concept.

I had several approaches to reach out to occupants in Vallastaden who lived in the buildings. My first strategy was to reach out to as many residents as possible. I recognized from the beginning that it would be tough to find a significant number of occupants who wanted to participate. My first intention was to conduct focus group with occupants. I posted information about the study through social media in a group for people living in Vallastaden. Some occupants were also contacted by email which I got hold of from a prior project I had been involved in. With this approach approximately five-hundred occupants were reached out to. As expected, the response was very low. Five people showed interest based on the social media post and one person answered the email that I sent out. In addition, the ones showing interest in participating were uncertain if they lived in an energy efficient building or not. I realized that my plan to conduct focus groups with occupants could not be operationalized because of the low response. I did not have enough participants for even one focus group. Therefore, the decision to conduct individual household interviews was taken shortly after that. To conduct individual interviews turned out to be a good idea since it provided me a richer material to work with.

The individual household interviews were conducted in the homes of the informants. Energy is quite an abstract concept and not usually reflected upon in everyday life and therefore, I reasoned that conducting the interviews in their homes could facilitate their memory of how they perceive the energy concept. In their homes they could describe it more in detail by looking and interacting with the appliances in the home related to their energy use. To walk around in the apartment also set a more comfortable atmosphere between me as a researcher and the informants and made the interview situation feel less formal. Worth mentioning is that when each interview was held, the occupants had lived in their homes for different length of time which may have affected their perceptions of living in the buildings. It takes time to adjust to the energy concept in these buildings (Isaksson, 2009). Longer time periods in their homes could probably make the occupants understand the energy system better. I was aware of this fact, but I could not have done it differently since I had limited time to conduct the study. It would of course have been favourable to conduct interviews at the time the occupants moved in and then maybe after a year or so when they would have settled in and be more familiar with the energy concept.

One of the occupants was reached out to by my first approach, the social media post. Since I wanted more residents to participate I realised I had no other choice than to ask my informants at the housing companies if they knew any households that could participate in the study. Two out of three participatory households were found through this approach. I conducted overall three separate interviews with households. Two of the residents lived in the rental apartments of Stångåstaden and one of the households had recently bought one of HSB’s buildings. Information about the occupants and the interview situation are described below. The real names of the informants living in the buildings are not declared in the text and fictitious names are used.

4.4.6. Tenant Robyn

Robyn lived in a rental apartment of Stångåstaden. He had lived there for about one year at the point of our interview. He is thirty-seven years old and lived in a single household, but with
his kids every other weekend. The apartment was a three-room rental apartment and 68 square meters large. The interview was conducted in his apartment and lasted for about forty minutes. We started off by taking a tour in his apartment and he told me what he knew about the energy system of the building. Thereafter we sat down, drank coffee and I asked him my questions. Overall, it was a relaxed interview and it lasted for forty minutes.

4.4.7. Tenant Kim

Kim lived in a rental apartment owned by Stångåstaden and was also recruited to participate in the study based on recommendations from the informant at Stångåstaden. Worth mentioning is that at the time of the interview, Kim worked at Stångåstaden herself but she had not been involved in the process of developing the building in Vallastaden since she worked at another department. We talked about this fact during the interview and Kim claimed that she was impartial and was honest about her experiences as an occupant. For clarification - Kim was interviewed as an occupant and not as an employee at Stångåstaden. Since the participation rate for the study was low to begin with, I made the choice to conduct an interview with Kim even though she worked at Stångåstaden. This awareness made me extra cautious during the analysis of this interview material.

This interview took place one evening at Kim’s two-bedroom apartment. The household consisted of the Kim and her kids who stayed at her place every other week. They have lived in the apartment for about one year. Kim was the only one present at the time of the interview. The interview went on smoothly and had the same arrangements as the previous interview with tenant Robyn. The interview was one hour and ten minutes.

4.4.8. The Larsson family

The Larsson family owned one of terraced houses developed by HSB and had lived there for about four months at the time of the interview. The household were suggested by my informant at HSB. The Larsson family consisted of two adults named John and Amanda and their two children Doris and Ruth. All of the family members were present at the interview which differed from the other interviews. The family members could help each other remember past experiences in their home and they made each other reflect upon their personal experiences and each other’s statements. The fact that the entire household was participating was just beneficial in my opinion. It was interesting to see how they interacted. The parents were the ones who talked most of the time, while the teenagers were quieter, but sometimes they jumped in on the discussions. The interview was one hour and fifteen minutes long.

4.5. Processing the interview material

The recorded interviews were after collection transliterated into written text. Everything each informant stated was literally transliterated. However, filler words such as ‘uhm’ and ‘eh’ were disregarded, but long pauses were noted since it could indicate uncertainties. After this step, I read through each transcription and searched for themes based upon what my informants were saying. The process was facilitated through the software Nvivo Pro (version 11) which works as a tool for qualitative research. I uploaded all of the transcriptions to the program and highlighted things in the text that I wanted to categorize into different themes. I made different categories in the program and put text from the transcriptions in a category where it fitted. The identified themes made me explore patterns in the data. The following process was to interpret each theme and analyse the informants’ responses. The material was also put in relation to the
framework mundane governance. The quotes used in the result section have been translated from Swedish to English.

4.6. Ethical considerations

The ethical issues were considered during the whole process of the study. According to the Swedish law 2003:460 om etikprövning av forskning som avser människor (eng. translation: about ethical examination of research with human subjects), human rights and basic liberty should be considered. Research should be conducted with respect for human values which are more important than scientific and societal needs. There are moral and ethical aspects to take into consideration when conducting qualitative studies. Ethical issues always pop up during the whole procedure, from interview to the last draft of the study. During the interviews it is important to take notice of the informants’ situation and state. During the analysis process it is important that the result coincide with the statements of each respondent (Kvale & Brinkmann, 2014). For this study, the arguments and views of the informants were respected and handled with care to make justified portrayals. In practice, this means that the informants got information about the purpose of the study at an initial stage before they decided to partake in the study. The informants received information about the study in both verbal and written form. They also had the alternative to be anonymous and the information they provided has been handled with confidentiality.

4.7. Limitations

Some of the limitations in this study have been mentioned before, for example how informants were recruited for the study. The number of the sample of the people living in the building could be considered as low. Baxter & Eyles (1997) means that credibility is not threatened by a low sample size if the experiences are recognized to be sufficient in accordance to the framework. Mundane governance should be studied in a context and does not require a large sampling size since the studies often are based on ethnography and interviews (Woolgar & Neyland, 2013). The aim was to explore this particular context of low-energy buildings in Vallastaden. Baxter & Eyles (1997) argue that the context consists of the setting, involved actors and time. The design of the study was therefore considered sufficient enough to explore the aim and research questions. Even though the low sample size was considered as acceptable, the characteristics of the households differed. Tenant Kim and Robyn were about the same age and lived as single household with kids from time to time. The adults of the Larsson family were also about the same age, but the household constantly consisted of four people. The difference in household size may have affected the result of the study since household size may influence the domestic energy use. The domestic energy use between apartment and house could also be very different. The age of the occupants was not considered as a limitation but it could probably be good to include different kinds of age groups since it also can be a factor that influence domestic energy use.

It could have been fruitful to present the characteristics of the technology in the buildings in a more profound manner. Maybe more knowledge about the technology could have led to different findings and conclusions. However, this is a socio-technical study where the focus is on the interaction between people and the technology. It was therefore more relevant to study the perceptions of the involved parts rather than the energy systems from a technical point of view.
5. Results

In this part of the study the presentation of the results is made. The findings are put in relation to previous research and the theoretical framework mundane governance. It starts off by examining the perspectives of the housing companies and the reasons why they chose to exploit in Vallastaden and develop the buildings. The occupants’ perceptions of the buildings and the energy concept are presented later in the results.

5.1. Vallastaden – a place for trying out new ideas

Throughout the interviews it became apparent that Vallastaden and the multiple criteria have created a space for actors to try out new ideas that they never had tried before. For the municipality it was crucial that the vibe of the district would be characterized by innovation throughout the whole process since it should be presented at the living fair (Palm & Wihlborg, 2013). As stated earlier in the background, a qualitative program was established for the actors in Vallastaden to follow. Through the quality program, Linköping municipality could govern the process of the development of Vallastaden by establishing rules and conditions. The constructors were held accountable to follow these conditions in order for them to exploit in Vallastaden. The municipality together with the involved actors established accountability relations which was necessary in the attempts to develop the vision of Vallastaden into practice. There were many requirements in the quality program. The informant from Stångåstaden mentioned some of the criteria such as using the carpool and connecting to the automated vacuum collection in the area. It was also forbidden to have parking lots in the allotments. The informants at the housing companies believed that the criteria and all the requirements were tough for many actors, especially since only small plots were allocated to each constructor. The criteria of the quality program made the housing companies come up with more innovative ideas. Housing companies are normally reluctant to be innovative when it comes with many risks (Thoresson & Glad, 2009). But the conditions in Vallastaden simply forced them to try out new ideas which they themselves saw opportunities in. Both Stångåstaden and HSB scored points when deciding to build buildings that were energy efficient and produced its own energy.

Informant from Stångåstaden: It is a development project which we will take with us, some parts at least… Maybe we should have better insulation in the walls or better windows. Maybe it can be worth the money. Eventually, passive house will probably be the government’s requirements. Maybe in a couple of years. Now we are here [in Vallastaden] and have tested to build to see if there are any...problems that arise.

The informant from Stångåstaden recognized the requirements and criteria as opportunities to try out new ideas that would probably be beneficial when thinking about requirements by the government in the future. The informant from HSB said that the motivation for HSB to exploit in Vallastaden was among other things to be a part of the living fair and to try new technologies. Hence, it was important for them to stay progressive within the housing sector. A study shows that housing companies believe that active environmental work, especially regarding energy, has many advantages on the housing market. It is even considered as a matter of survival on the market (Thoresson & Glad, 2009). But the efforts of reducing energy by developing buildings with better energy performance is also a matter or risk-taking. The informant from HSB emphasized the risks of developing their buildings and to try out new technology in Vallastaden.
Informant from HSB: We felt that we wanted to be a part of Vallastaden. We had never participated in a living fair before. But we concluded that we wanted to minimize the risks and do something on a smaller scale, a small project. And try out new technology. That was the goal with this project.

The company wanted to safeguard the efforts in Vallastaden by trying out new technologies on a smaller scale than what they usually aimed for. Both Stångåstaden and HSB stated that the expenses of developing these buildings became high which was a negative surprise for them. The informant at Stångåstaden said that the installation of solar panels on the roof of their building was not economically defensible.

Informant from Stångåstaden: /…/ the energy demands will only become more tough in the future. We need to be a part of the development and avoid a scenario when all the demands have passed us. We need to be a little bit in the leading edge. Maybe it is not economically defensible but we are forced to do it if we should meet all the requirements.

To summarize, the development of this kind of energy concept within the particular buildings was in many ways new to the housing companies. Vallastaden was an excellent opportunity for them to get publicity and be a part of the leading edge in the housing sector. The governance of the energy concept in these buildings was facilitated through the criteria and requirements. It spurred the housing companies’ motivation to explore and trying out new things.

5.1.1. The energy system in Vallastaden

Since Vallastaden has been developed as a dense city district, Tekniska Verken also needed to experiment with the infrastructure for district heating, sewage, fibre, electricity, water and automated vacuum collection. It resulted in an 1800-meter underground culvert (Palm & Wihlborg, 2013). The culvert system has been portrayed as a unique and innovative solution (Linköpings kommun, 2017). The informants from Tekniska Verken argued that the culvert was a necessity because of the dense cityscape. The informants stated that the culvert system has allowed for increased buildable area above ground. There is also no need to dig up the pipes when they need maintenance since all the pipes are put in the culvert.

Besides the necessities of developing this kind of system, the motivation for Tekniska Verken was to show it to the public and the business sector at the Vallastaden living fair in 2017. The informants believed that their culvert system can be applied elsewhere and not only in Vallastaden. The informants at Tekniska Verken had hopes of the culvert system to gain recognition by contractors internationally.

5.1.2. Collaboration between Tekniska Verken and the constructors

Many actors have been involved in the development of Vallastaden. Collaboration between different actors when developing Vallastaden was considered crucial by all the informants from housing companies and Tekniska Verken. The collaboration between constructors and Tekniska Verken was characterized by frequent meetings that were held every other week and it facilitated many processes such as logistics in the area. It was in many ways a new way of collaborating for all the involved actors and this process was also a bit of a challenge. Since there were forty different constructors with various knowledge and experience, it also created misunderstandings and all the wishes were not met. The informant at Stångåstaden viewed the collaboration between constructors and Tekniska Verken as necessary. He thought that everything went well, but the ability for constructors to influence the process was limited. The collaboration was mainly revolved around where the access points to the culvert’s chambers
should be located and how they should to be connected to the residential buildings. However, Tekniska Verken also experienced some neglect by the housing company in their opinion. One of the informants from Tekniska Verken meant that there was a tendency for the constructors to feel overwhelmed by all of the choices.

Informant from Tekniska Verken: There is a risk that you [the constructors] can drown in all the choices and demands and our part with the infrastructure can become a necessary evil in some situations. It is easier to choose kitchen countertops than to discuss where the connections to the culvert should be made. /…/ It can be of lower prioritization for the constructors when they are making choices.

The informant from Tekniska Verken argued that it might have been the case that all the choices became overwhelming for the constructors in Vallastaden and that things needed to be prioritized in order for it to work. The informant from HSB argued that the requirement to connect the buildings to district heating made it more difficult for HSB to develop the technology in their buildings. Since low-energy buildings run on less heat, the interest of energy companies to provide district heating to these buildings is generally low. Therefore, the fees to connect low-energy buildings to district heating become much more expensive (Thoresson & Glad, 2009). According to the informant from HSB, the requirement of district heating made the technology in their buildings more complex with too many moving parts. Instead, he would have liked to install air heat pumps which could have provided the heat for the buildings. Palm (2004) argues that municipality owned energy companies can have power over housing companies in terms of restrictions and influence on the choice of technology.

Both Stångåstaden and HSB stated that there was uncertainty of the effect from the installed solar panels since it was hard to know on beforehand if the other buildings would shadow their buildings’ solar panels. There were no height limit for the buildings in Vallastaden. The only limit was the number of floors. Therefore, the housing companies believed that the other constructions could jeopardize their calculations for meeting the requirements of energy plus buildings.

Informant from HSB: I do not believe that the solar production will reach the level that we calculated. And therefore, maybe the energy plus concept will fail. Unfortunately, it could be the case. But that is out of our control.

The informant at Stångåstaden said that they realized that they needed to take the other buildings into consideration when they did their calculations.

This part shows that the collaboration between the actors was necessary but sometimes considered as tough. External conditions such as the requirement of district heating and the risk of shade on the solar panels impacted the buildings and the technology of the two housing companies.

5.2. Citizen dialogue in Vallastaden

Previous research highlights the importance of incorporating the people living in low-energy buildings since households’ behaviour and practices often determines how well the building performs (Karresand, 2014; Wahlström & Hårsman, 2015). Vallastaden was unique in the sense that the aim was to involve citizens in the development of the energy systems (Palm & Wihlborg, 2013). However, it turns out that no citizen dialogue regarding the energy system in
Vallastaden were held by Tekniska Verken. Palm & Wihlborg (2013) mean that their informants at Tekniska Verken argued that there was no point in having direct dialogue with citizens regarding the energy system. To be a part of the dialogue required expertise and the informants also believed that the energy system would be of no interest to the people who eventually would move into the district. Property owners and developers were argued to be more suitable to consult with during the development of the culvert. During my own interview with the informants from Tekniska Verken I asked how they viewed this statement now in retrospect after the first settlements in Vallastaden. They shared the same view that constructors and housing companies were good to collaborate with regarding the culvert. The informants from Tekniska Verken had the perception that it was Linköping municipality’s job to communicate with the citizens. They also believed that it was the responsibility of the housing companies to gain knowledge of the wishes of their future occupants. It seems like it was not totally clear who had the responsibility to incorporate the citizens in the planning process. The perception of the developers was that the citizens would not understand the technology. However, if the technology should influence sustainable behaviour, the target group must be involved in the design of the technology (Jelsma, 2003). The following section brings up the ways in which the housing companies communicated the technology with the occupants.

5.2.1. Communication between the housing companies and the occupants

Technological solutions are a result of discussion and negotiation by involved participants. Shove (2003) argues that in order for technological innovations to become robust and sustainable in practice it is important to broaden the range of participants. For example, the target group should be included, not just the experts. Research focused on the occupants’ perspective have stressed the importance for the developers to frame the energy concept in buildings to facilitate understanding and the meaning for the residents (Isaksson, 2010). The informant from Stångåstaden mentioned that the company conducted focus groups with their tenants to take their wishes and needs into account when developing their building in Vallastaden. The aim was to have a discussion with prospective tenants about design, layout, energy, technology and the environment among other things. However, in the end the focus groups were not held with the tenants who moved into the building in Vallastaden. The informant from Stångåstaden stated that the focus groups were conducted at an early stage which made it impossible for them to have a dialogue with prospective tenants. The tenants who eventually moved in to the rental apartments were invited to an evening event where Stångåstaden provided information about the energy concept among other things.

HSB had no prior dialogue with prospective buyers when they developed the technology in their buildings. However, the company developed the buildings together with an organisation with expertise regarding passive houses which provided HSB with insights from an occupant’s perspective. At the living fair, HSB held seminars to inform the visitors about their buildings. When their houses were sold, the informant from HSB visited the buildings together with the buyers and had a walkthrough and informed the new occupants about the technology. After the properties were sold, the informant from HSB who also was the energy consultant of the company acted as a contact person towards the occupants and they could contact him regarding energy related matters. Most of the communication in this case was concentrated to after the purchase. How the communication was perceived by the occupants is presented in a later section of the study.
5.3. The occupants’ perceptions towards the energy concept in the buildings

It is time to present the perceptions of the occupants who moved into the buildings of Stångåstaden and HSB. The occupants stated in the interviews that the energy concept was not the main reason for them moving to their new homes. The energy concept was rather considered by the occupants as an additional bonus and they considered it as a possibility to reduce their energy costs. This is coherent with previous research which says that the energy savings and environmental factors of living in a passive house is a pleasant bonus but not the main motivator. In her dissertation which was about the occupants’ understanding of the energy concept in passive houses in Lindås, Isaksson (2009) concluded that the energy concept was not the main reason for people when purchasing their home. However, the occupants in Lindås did emphasize the positive outcomes of living in such houses, like economic savings and the environmental contributions (Isaksson, 2009). There is a knowledge gap if occupants reduce their energy use because of environmental concern (Pothitou et al., 2016). Tenant Robyn who lived in one of the rental apartments governed by Stångåstaden, meant that motives of moving to Vallastaden was the location since Vallastaden is close to the city centre in Linköping. He also stated that he rather wanted to live in a newly produced building than an old one when the price of rents was basically the same. Tenant Kim who also lived in an apartment in the same building explained how she resonated regarding the energy concept:

Tenant Kim: For me, it was not the reason why I chose this home. The fact that it generates more energy than what is used is good, of course. Then you can use that energy for something else.

The informant from Stångåstaden was certain that their tenants did not choose to move the building just because of the improved energy performance. The informant mentioned that the tenants who moved into the building were offered to buy a package with energy efficient white goods. However, there were only four households out of the total who went through with the offer. The informant from Stångåstaden meant that it indicated that the tenants were uninterested in the energy concept. He concluded that people on the lookout for rental apartments in Linköping cannot really choose where to move because of the housing shortage in Linköping.

Informant from Stångåstaden: I do not believe there is a difference for the tenants. Anyone can move here. And the fact that this building is an energy plus building is not something that motivated their choice to live here. Maybe it could have made a difference if it would have been a cooperative apartment or something, or if they had several apartments to choose from. But since there is a housing shortage here, we will never know.

It is interesting that the informant from Stångåstaden believed it could be a difference between tenants and people who buy their own home. The reason for this can be that tenants generally feel less invested in the buildings’ characteristics than owners do ( Schnieders & Hermelink, 2006). John and Amanda, the adult members of the Larsson family who recently purchased their home from HSB stated that the energy concept did not influence them to buy the house. They wanted a smaller space than before which was the main motivator. They ‘fell in love’ with the building of HSB developed because of the inside interior and the choice of materials.

Amanda from the Larsson’s: Firstly, it was the décor. It coincides with how we would have liked to have it if we would have built it ourselves. With choice of material and colours and how the kitchen looks and the space for storage. It suits us. The fact that it was a low-energy building was something that we realized first after really.
This means that the Larsson family did not even know it was a low-energy building at their first encounter with their new home. It is common phenomenon that households moving into a building lack knowledge regarding the technology and energy systems of it (Pilkington et al., 2011). Amanda said that the energy concept was a contributory factor when the family saw potentials in saving money. In Sweden, low-energy buildings will probably be less affected by increasing prices on energy (Karlsson & Moshfegh, 2007).

The informant from HSB expressed dissatisfaction with the generally low interest in the energy system from buyers. He had hoped for more engagement among the buyers. He believed that the main concern when developing buildings with this type of concept is that you can never know how the occupants will react or handle the technology. That could in the end impact the company’s efforts of making an energy efficient building since there was a risk that the occupants might handle it wrong. He got the impression that none of the buyers were particularly interested in the energy concept since not many questions were asked about it. He also based the disinterest on the selling price which became 4,9 million Swedish SEK. According to the informant it was far too low for this kind of house. Studies show that there can be a willingness of households to pay extra for environmental attributes when buying a new home, however, it is hard to conclude if is reflected in the residential property market in Sweden (Cerin, Hassel & Semenova, 2011). The Larsson family believed that they paid a fair price for the building and were not sure if they would pay extra for the fact that the buildings was energy effective. They would pay extra if they were sure that it would lower the energy costs. They thought of the environmental contributions, but stated that it would not motivate them to buy the building at a higher price. The informant from HSB believed that if the company would invest in developing low-energy buildings in the future, they would probably develop them as cooperative apartments or rental apartments. That way the company could govern the energy concept and the technology and therefore have more control.

In summary, all the occupants were motivated by other factors than the energy concept. The housing companies thought that there would be a difference in motivation between tenants and people owning their homes. However, none of the occupants interviewed for the study meant the energy concept made them choose to live there. It was rather the location, architecture and design of the Vallastaden and the buildings. To Stångåstaden it came as no surprise since tenants usually do not identify themselves with their building. The informant from HSB wished for more engagement of their buyers to gain a higher selling price, but also so that their buildings would be used as intended. When the HSB properties were sold, the housing company lost some of the governance over the energy concept in the buildings. It was now up to the occupants how they would manage the technology. I would argue that the companies’ view of their occupants is reflected in the way that the energy concept in the respective buildings have been communicated towards the occupants. The housing companies have made different attempts to make the energy concept more visible for the occupants by feedback mechanisms. This will be brought up in the following paragraph.

5.4. Strategies for making the energy concept visible for the occupants

Energy is often abstract and invisible for households since the resource cannot be seen with the eyes. It makes it hard to notice energy in everyday life (Lutzenhiser, 2014). Visualizing energy in the home is an important aspect for making occupants aware of the energy concept, especially in low-energy buildings where the technology differs from conventional buildings (Karresand, 2014). Linköping municipality wanted the residents to have access to information and communication technology (ICT) to visualize their energy use and the production of energy
(Palm & Wihlborg, 2013). HSB had together with a local tech-company in Linköping developed an interface in the form of an app in which occupants could gain a real-time feedback of the energy flows and the energy use in the building. The app could be reached through a smartphone or the provided tablet which came with the house. The Larsson’s had the ability to monitor the energy use of hot water, electricity and heating. These types of ICT could motivate occupants to reduce their domestic energy use, but it is still uncertain if these types of measures will lead to expected results (Paetz et al., 2012).

The reason for HSB to develop the ICT was to simplify the energy system for the occupants. The informant meant that the occupants could monitor and control the energy system without opening the cupboards which contained the technology. The occupants would also be alerted through the app if the energy system would malfunction. You could say that HSB developed the app in the buildings so that the households more easily could govern the technology in the building. The informant at HSB also had access to the app and could check if everything worked properly. If not, the company could send over a technician to fix the problem. However, this service was to end in a couple of years when the warranty expired. Thereafter, it is up to the households to manage the technology on their own.

Another goal of developing the ICT together with the local tech-company for HSB was that they wanted to try something new. The informant from HSB believed that in the future, it will be important to visualize the energy use. However, he was a bit concerned that the energy systems in their buildings would be hard to understand from a user perspective.

Informant from HSB: I think it [the building] resulted in too much technology. It is too many moving parts to be a passive house. I think it will be tough for the households to understand. We have tried to provide them with proper instructions regarding how it should be managed. After all, it’s not our houses anymore. But it is important for us to monitor and be of assistance and maybe we can learn from our mistakes if there are any. And do it better next time.

The informant believed that the technology became too complex, even though they provided sufficient instructions. He argued that it was very important that the occupants could manage the installations, otherwise the energy use would escalate.

Stångåstaden on the other hand, did not develop any distinct feedback mechanisms for the tenants. The tenants of the building only had a display in the living room which showed them the current indoor temperature and humidity. However, the tenants had no ability to adjust the temperature or anything by themselves. The informant from Stångåstaden meant that the company had the intention to give feedback to the tenants about their energy use by billing for hot water which is often included in the rents in Sweden. But up until this point, the company had not been able to go through with the billing yet since the organisation ‘The Swedish Union on Tenants’ did not agree on the pricing for hot water. The informant from Stångåstaden believed that a bill for hot water can be a motivation for their tenants to make energy savings. Glad (2013) argues that it could be a good way communicating the importance of energy savings in households. Tenant Robyn mentioned during our interview that he would have liked to know his consumption of hot water. Generally, households are not opposed of having more feedbacks in order to reduce the energy costs as well as caring for the environment (Paetz et al., 2012). Hence, this would probably be a good approach to make energy a bit more visible in everyday life. However, it remains uncertain when this feedback system will go through in Stångåstaden’s buildings. Furthermore, the informant from Stångåstaden mentioned that the
tenants had possibility to check their electricity use through a meter, but the meter was not placed physically in their apartments. Tenant Kim was asked if she knew about the meter.

Tenant Kim: No, I haven’t seen it. I don’t believe we have access to that room.

The feedback was only accessible for professionals such as attendants and technicians in Stångåstaden’s building. Keeping it hidden from tenants this way does not facilitate social learning about energy and makes the concept even more invisible. The informant from Stångåstaden meant there was no need for the tenants to interact with the energy system in the building. He meant that they did not need to reflect about it in their everyday life. If anything would be of inconvenience for the tenants, they just needed to contact Stångåstaden which in turn would send an attendant or technician. It could be argued that it is convenient and comfortable for the tenants to not reflect about the energy concept in their everyday lives. However, they are an essential part of the energy system since their body heat and activities provide heat to the building. Also, if the tenants cannot see their part in the system, a consequence could be that they do not reflect about their energy use. I will come back to this later.

5.5. Occupants’ interaction with the energy system

Generally, the energy concept was not something that occupied tenants’ minds. The tenants seemed unaware of the fact that they were an active part of the energy system in the building. Could this lack of awareness originate from failure of communication and feedback mechanism? Or is the energy concept just too mundane to discuss for the tenants? Tenant Robyn did not see any connections in how he could influence and interact with the energy system. If something was wrong with the apartment he could just contact Stångåstaden and they would fix it for him. The staff members of Stångåstaden such as attendants and technicians were therefore held accountable to manage the technology in the building.

Tenant Robyn: You can’t do anything by yourself.

It shows that Stångåstaden handled the total technology in the building. The tenants were only held accountable for paying the rent and not damaging the apartments. But the energy system was totally controlled by Stångåstaden. Stångåstaden remained accountable if the technology would start to malfunction. Broms and Andersson (2017) argue that the energy systems become ‘material silences’ which are hidden behind doors, cupboards and apps. However, the Larsson family who owned their home seemed to be more aware of the technology than the occupants in the Stångåstaden’s residential building. As mentioned earlier, they had more feedback of their energy use than the tenants. The technology was more visible in the home of the Larsson’s. The family showed me the storage for all the technology and it was in the space same space as their storage for cloaks and outerwear located just inside the main entrance. The space was filled with tubes and boxes. In the kitchen there was also a cupboard which contained the distribution box among other things. Hence, the energy systems with all the technology was physically present in their home in contrast to the tenants’ apartments. John, one of the adult members of the Larsson family thought it was fun to monitor their energy production from the solar panels in real-time with the help of the app. People tend to be positive to these types of smart metering (Paetz et al., 2012). He said that he usually checked it once a day. But in the beginning, John noticed that the app did not work properly and that numbers on their energy use did not add up. For example, the meter for hot water use was zero.
John: I calculated it myself during a day and I saw that our energy use did not match what the interface stated. The interface stated for example that the hot water use was zero.

Amanda: It does not add up. Especially not when you have two teenagers at home.

Doris: Yes, it would be strange to shower without hot water.

John figured out by himself that something was up with the app. According to Isaksson (2009) households usually must explore the technology by themselves and figure out if it works or not. John contacted the tech-company responsible for the app and the company was aware that the app did not work properly and they were trying to solve it. The local tech-company was therefore responsible for making the app work in order for the household to control their energy system. However, the family was still filled with concern regarding what would happen if the company would go bankrupt. What would happen to the app then? They raised this concern with HSB which had not thought about that scenario. The family’s concern was legitimate because in the future they must handle the technology in the home on their own when the warranty expired. The service from HSB and other involved parts would not be provided for free anymore after that. This means that the governance of the energy system and the technology is not clear when the warranty expires. It was important for the family to be able to communicate with the companies, as well as getting the most out of the warranty. John said that he was certain that the technology would start to malfunction at some point.

John: It is a fact; the question is when it will happen.

The family felt a bit frustrated based upon their experience with the malfunctioning app and other aspects besides the energy system that had not worked properly when they moved in. It can be very tiresome for households to figure out how technology within the home works (Isaksson, 2010). Households are often more satisfied when they understand how the technology and have a sense of control over it (Hauge et al., 2011). The Larsson family almost hoped that the technology would start to malfunction before the warranty expired so that HSB still would be accountable for the costs and reparations. The informant from HSB meant that one of the reasons for the company to develop privately owned homes was to minimize the risks for the company if the energy system would not work properly. It is quite interesting that both parts experienced uncertainties regarding the technology. Maybe it is not strange since the concept was new for both of them. However, the governance of the building and all its technology become quite vague. It is important from the beginning to be clear about the practices of managing the technologies. Should it be up to the occupants to manage it or is it the responsibility of the professionals? Isaksson (2010) argues that it is crucial that the division of responsibility is established so that practices are not neglected since neglected practices can lead to excessive energy use.

The Larsson family also brought up other aspects of the house apart from the energy system. The two teenagers of the family, Doris and Ruth where not familiar with how the technology worked. For them, the biggest difference from their old house was that their new home had bigger windows and that the space was brighter. The family also perceived the home to be noisier. Amanda believed it was the airy feeling in the house that made the sounds louder, but she was not sure if it had to do with the fact that the building was constructed to be energy efficient. It was obviously something that bothered the family.

John: Yes, that is a bit annoying. And we noticed it now during the weekend when we had guests here for the first time. It became very noisy and we were only eight people. Maybe it is because we don’t have any curtains yet.
Amanda: We should try to put something up to mitigate the noise. I thought that it would be enough with carpets. And now we have put in furniture and such, I would have hoped that it would be enough.

John: No, it is the open planning which makes it noisier. And we must live with it. I don’t know.

Ruth: I have come accustomed to it. I don’t think about it anymore.

John: Yes, we thought about it more when we moved in of course.

Amanda: And you don’t have guests everyday either. That’s the way it is. But we could try to mitigate the noise.

More noise is also something that has been reported in low-energy buildings (Hauge et al., 2011). Amanda was uncertain if it had to do with the fact that it was a low-energy building or not. For the occupants, other aspects of the house are more important than energy system. Isaksson (2010) argues that developers are focused on the function of the technology, energy efficiency and comfort rather than the everyday life of users. The Larssons were also a bit disappointed that they could not put up decorations on the walls because it could ruin the plastic on the wall which was there to prevent moisture damage. This also shows that the family needed to adapt. Glad (2017) argues that the goals of housing companies and occupants often differ. What matters for most occupants is to live a “good life” and having a comfortable indoor-temperature. Aspects of comfort in the buildings will be brought up in the next section. Before I ended the interview with the Larsson family they summed up their feelings of living in their new home.

John: In conclusion I would say that the energy concept is not something that we notice. That’s the way it is. It is not something we walk around and reflect on.

Amanda: No.

John: If it’s a low-energy house or passive house, or difficult, or inconvenient or terrific. It just is.

Doris: It’s simply a house.

5.5.1. The comfort of occupants

The evaluation of low-energy building by occupants often involves the thermal comfort since the technology revolves around heating and the ventilation (Hauge et al., 2011). A lot of the energy in buildings is used for heating and cooling to keep it comfortable for the occupants (Shove, 2003). The comfort of the tenants was an important aspect for Stångätaden when they developed their building. They chose to put in waterborne radiators in their building which is not common in passive houses.

Informant from Stångätaden: To put in waterborne radiators was our own requirement. When you build low-energy buildings or passive houses you often mean that there is no need for waterborne radiators since the people provide the heat for the building on their own. But it is also a matter of comfort, you need to feel that it is comfortable to live and therefore we don’t really believe in that aspects of the passive house concept fully. We don’t dare to jeopardize the comfort of our tenants. So, we chose waterborne radiators [long paus] which of course are not used that much but they are there and provide additional heat in cases if the temperature drops.
It is evident in this case that the comfort is not something that should be jeopardized for the tenants. The company maybe thought it would have been too radical to go all the way with the passive house concept. Missing radiators could scare tenants off since it can provoke feelings of absence of heating (Schnieders & Hermelink, 2006). The company believed that the tenants would not be willing to adjust to this type of energy concept. This way, the tenants did not need to interact with the energy system in the building. Shove (2003) argues that the concept of comfort has been developed into a universal standard of what users need which is a very narrow approach. It has been developed by researchers, manufacturers, constructors and occupants among others which have various degrees of influence during the process. Users have become accustomed to these standardised perception of what comfort entails. But at the same time, they have had little influence to contribute with their view of what comfort should mean (Chappells & Shove, 2005). To challenge this standardization for a housing company could be hard since it is hard to predict what comfort will entail in the future. Will it be based on standardisation or will it become more flexible? Isaksson (2009) argues that new technologies and energy concepts could change the perception of comfort among the occupants when they are managing the new concept.

The tenants could not control the indoor temperature by themselves since Stångåstaden controlled the temperature with the radiators. It was evident from my interviews with the tenants they did not reflect much about their role in the system. When I asked one of the tenants, Robyn about how his thoughts of adjusting the indoor temperature on his own he stated:

Tenant Robyn: No, you cannot do anything else besides increase the radiators to maximum. And when everything is steered by the temperature outside it becomes hot during the day and freezing cold during the evening.

The indoor temperature in Stångåstaden’s building seemed to vary between different seasons. The informant from the company stated that a potential problem with the building would be that it would become too hot in the apartments. The interviewed tenants in the building perceived the indoor temperature to be pleasant most of the time. Tenant Robyn thought that the indoor temperature fluctuated based on the outdoor temperature. He said that the only way he could influence the temperature was to turn up the radiators in his apartment. He had experienced some problems with the comfort in the beginning since he perceived the apartment to be cold. He gave Stångåstaden a call and a technician arrived later and fixed something up in the attic and later came down and told Robyn that everything was settled. As a procedure after this event, Robyn kept an additional thermometer in the apartment to cross check if the temperature cohered with the device on the wall in the living room. When households feel frustrated regarding aspects of the apartment and it can establish a lack of trust between the professionals and the occupants (Glad, 2013). His average indoor temperature was around 21ºC-22ºC. During the summer however, when his indoor temperature was around 24º-25ºC, he usually kept the windows open during the whole day. If you disregard the heat losses from opening the windows, it can be an effective and cheap approach, but it could be hard to combine with the ventilation system and result in comfort issues (Axell et al., 2010). Tenant Kim on the other hand perceived the indoor temperature to be of her convenience. It was much hotter in this apartment than in her former residence which she liked. Her thermometer in the apartment showed an average indoor temperature of 22,5 ºC.

The Larsson’s in their private home could decide for themselves what temperature they wanted. As mentioned earlier, the informant from HSB had the ability to monitor the energy use of the occupants through the same app that the occupants used. He could see that the occupants had set too high indoor temperatures in his opinion. He thought that they did not seem to reflect or
care about their choice of indoor temperature. He expressed resignation towards the chosen temperatures by the occupants. When they moved in, the Larsson’s set the temperature to 22º C and kept it that way. However, at the point of our interview, the real-time temperature was 23,5º C and upstairs it even reached 24ºC. Hence, the technology provided them with a warmer indoor temperature than they had wished for. The family mentioned that their aim was to reduce their indoor temperature when moving to their new home. During the winter months the family experienced the indoor temperature to be a bit cold. They had to wear slippers and put on sweaters but they still thought that it was manageable. However, John had some concerns regarding what would happen in the summer. He was afraid that the temperature would increase during hot summer days and since they had not experienced summer in the building they were uncertain of how the energy system would react.

John: My wish is that the ventilation system will cool down the house so that we don’t need to ventilate because of that [the increasing temperature]. I have wondered of what could happen if we open the windows /…/ maybe we would damage the whole system, I mean the regulation of the shack by doing it [ventilating]. That it would go bananas and start to increase or lower the temperature. I have thought about that. But we have not opened the windows yet. Or we have now a little bit these days.

This statement by John shows that he was aware of potential consequences but at the same time did not know exactly what would happen. Isaksson (2010) concludes that feelings of uncertainty regarding the technology are common for residents in low-energy buildings. The behaviour of the energy system is hard to predict, and it is difficult to adjust it since many occupants are novice to the concept. Woolgar & Neyland (2013) means that entities, as explained earlier are for example people and technology among other things, can change status from certain and uncertain. For the housing company which know how the system would react maybe it is certain how you should operate it. But for households, the same system can be very confusing. It can be argued that the housing company and occupants have different ontological realities regarding the same object. Maybe it can stem from lack of knowledge by the occupants which would probably increase after some time since it takes time to adopt and learn about new technologies (Isaksson, 2009).

It is apparent that Stångåstaden had control over the indoor temperature in their building. HSB on the other could monitor what the occupants did, but had no control over it. The behaviour of the occupants in the buildings of HSB affected if would meet the projected goals of the energy performance. The chosen indoor temperature in the buildings could probably have consequences for its energy performance (Schnieders & Hermelink, 2006). Even for Stångåstaden’s building it could have consequence for the energy performance, for example tenant Robyn used to open all his windows during whole day in summer time which may not always be suitable approach in buildings with passive house strategies. The heat recovery from the ventilation can then decrease and lead to higher energy use (Schnieders & Hermelink, 2006). However, the informant from Stångåstaden stated that they had taken some window ventilation into account when they made their calculations. Maybe there could possibly be a conflict between the developers intended idea regarding an energy efficient building and the importance for the occupants to create a comfortable home. The intended use by the developers are not always fulfilled by the households (Isaksson, 2009). Maybe it would require more awareness among the tenants? Could that be achieved through information and communication? The following paragraph will bring up how the communication of the housing companies has been perceived by the occupants.
5.6. The occupants’ perspectives on the information provided by the housing companies

It is stated in the EU directive 2010/31/EU that tenants and buyers of buildings should be given correct information and advice on how to use the building for optimal performance. All the households interviewed for the study stated that the communication by the housing companies regarding the buildings was not sufficient. Tenant Kim explained:

Tenant Kim: I don’t know, I think you make the tenants more aware of what an energy plus building actually is. That information has not been great.

It turns out that no information was given regarding the energy system when the apartments were marketed by Stångåstaden. The building of Stångåstaden was rather portrayed as a unique and innovative building in a nice neighbourhood. However, tenant Kim was not particularly interested in the energy concept and thought that she probably did not need more information. She had barely looked at the provided binder with information regarding the apartment when she moved in. Tenant Robyn on the other hand, had interest to find out more since he wanted more sense of control. He wished for more information regarding the characteristics of the building and how the energy concept worked.

The Larsson family stated that they almost bought their home before they knew that it differed from conventional buildings. During the living fair, the family talked with representatives from HSB who referred to the binder with information regarding the heating and ventilation system. They also insured the family that an energy consultant would be available after they purchased the house. The marketing brochure was also inadequate for the Larsson’s. The description of the house indicated that the energy use was efficient and that there existed solar panels. But otherwise, it was portrayed as a nice house. In hindsight, The Larsson’s would have wanted more information regarding the energy system prior the purchase. The informant from HSB meant that they had to adjust the information about the building for the occupants since otherwise it would have been too much to take in. They also tried to avoid a technical language so that it would be easier to comprehend. This is often a good approach to make communication suit the target group and make the technology more comprehensive. But it resulted in simplified instructions about replacing the filter for the ventilation and how they could adjust the indoor temperature. Written information only provides moderate understanding of the energy concept in low-energy buildings (Schnieders & Hermelink, 2006). Right before I was about to end my interview with the Larsson family, John told me an anecdote that seemed to summarize his view of the communication between the family and the professionals. It was a situation that happened during the first week in their new home. They noticed that there was no water running out of their taps and the problem continued during the whole weekend.

John: I called Tekniska Verken and made an error report and then someone came and looked around and said “No, there is no problem, everything is working properly”. Right…still no water. It was the weekend so I couldn’t get in contact with HSB either. I called the company on the following Monday and then they said “Okay, do you see the white button by the front door? It is a switch for incoming water”. Oh, so that is what it’s for?

Amanda: Sometimes you need to learn it the hard way.

Although this anecdote had nothing to do with the energy system in the building, it is still interesting. The implications for limited communication can therefore be that the occupants do not manage the technology as intended. It seems like Stångåstaden figured out there was no point in putting emphasis on the energy concept through marketing since they knew that the
apartments would be occupied anyways. It could be argued that HSB who sold their properties would have benefitted by emphasising the energy concept, but it turns out that information was given to the households after the purchase. Maybe they were afraid that the energy concept would scare people off? Instead, they saw more value of having direct contact with the households after they had moved in. Direct contact with the professionals can facilitate the social learning of the technology (Isaksson, 2010). John in the Larsson family often referred to the energy consultant at HSB and they seemed to stay in touch.

However, it can be questioned if more information giving is what the occupants is in need of. For example, maybe only interested occupants would go through the instructions. Too much information in the beginning could be hard to handle if occupants are new to the energy concept in low-energy buildings. But knowledge among occupants is crucial in order for them to manage the technology and have the ability to reduce their energy use. The question is what is the best method for providing engagement among the occupants. Isaksson (2009) argues that households need to have support in understanding how the energy concept is connected to everyday life activities. In other words, the information needs to be more relevant for the households.

5.7. The energy use of the occupants

Technology and behaviour combined are good incentives for lowering the ecological footprint of consumers (Hayles & Dean, 2015). This could mean that the technology in the buildings together with occupants could establish a win-win situation for energy savings. However, all the occupants in this study resonated that they had not changed their behaviour when moving into the building. Tenant Kim argued that her energy use had rather increased than decreased. She based this on that she now had the washing machine in her apartment instead of a utility room. Every other week when her children occupied the apartment, laundry was done every day.

Tenant Kim: It is so easy now, when I do laundry I may not fill the whole washing machine. /…/ I think it becomes like that and you are like “I pay my own rent” and then you don’t reflect. Unfortunately. Except for the electricity, I reflect about that since I pay for it myself.

She reflected more about her energy use when she lived in a house since she paid for everything there. In Sweden, the heating of rental apartments is usually included in the monthly rent, therefore the cost of heating the apartments are hidden for the tenants. Generally, housing companies are aware of the costs of heating since they are in contact with the energy supplying company (Glad, 2017). Kim explained she would be more aware of her energy use for heating if she would have paid for it herself. As for now, she had no idea of the costs of leaving the tap water running for example. Building awareness of the costs and benefits of reducing the domestic energy use could motivate the households to reflect about their energy usage (Glad, 2017). The Larsson’s did not believe that their behaviour regarding energy use had changed due to the fact that they lived in a low-energy building.

Amanda: No, I cannot recall if I have changed my behaviour. Or something like that.

John: No, we haven’t. It’s just me that have more control over it [the energy use] now. Or I monitor it almost every day because it is fun to see how it goes/…/ but I think I’ll skip it soon as well. It is the novelty that are in play here right now.
It could be argued that the technology does not motivate the family to change behaviour. The cognitive effort of changing behaviour of adopting to new technology is hard for occupants and one of the main barriers for reducing domestic energy use (Paetz et al., 2012). John believed that the novelty of the energy concept would soon wear off and he would become uninterested. Up until the point of the interview the Larsson family had only set their indoor temperature to 22°C by using the app. The neglected practices of managing the energy system in buildings, will most likely result in excessive energy use in private homes (Isaksson, 2010). The informant from HSB stated that it was very important that the technology in their three buildings functioned properly. Otherwise, he believed that the energy use would drastically increase. This means that neglected practices of the technology in the buildings may happen and it can have consequences on the energy use. Isaksson (2009) raises an important reflection regarding energy efficient technology and user behaviour. Since it is so important for users to use the technology as intended, should there be clear requirements for the occupants how they should use the technology in order to reduce the energy use? Woolgar and Neyland (2013) mean that rules and classification can strengthen the accountability relations between involved parts. In this case, rules on how to use the technology in the most sustainable way could make the building perform energy efficient. However, it would be hard to force occupants in private homes to follow certain rules and conditions. Instead, there is a need to make the energy concept comprehensive (Isaksson, 2009).

6. Discussion

6.1 The motives for the housing companies

The overall aim of developing low-energy buildings and this type of energy concept in Vallastaden was to create a climate smart and sustainable district with sustainable resource efficiency. Accountability is a central concept in mundane governance which in practice means that it is important to establish who is accountable for what, where and when (Glad, 2017). To achieve accountability in mundane governance, classifications such as rules and conditions should be established (Woolgar & Neyland, 2013). The quality program of Linköping municipality was filled with requirements in order for the vision of Vallastaden to become reality. Stångåstaden and HSB among other actors in Vallastaden where held accountable for translating the vision of Vallastaden as a sustainable city district into practice by developing energy efficient buildings as stated in the quality program. The process of developing the buildings was tough for the housing companies however, while under performance of accountability the two housing companies saw their opportunities to try out new technologies and to stay ahead of the game in the housing sector. This resulted in two buildings with an energy concept and technology which was supposed to achieve the goal of energy efficiency. Much effort and hope were put into the technology to achieve this goal as well as governing the vision of a resource efficient city district. The housing companies’ ontological reality was seemingly filled with experiments, obstacles and collaborations.

The informants from the housing companies raised some uncertainties regarding the energy performance of the buildings. It mainly had to do with the occupants in the buildings and their domestic energy use. Lutzenhiser (2014) argues that the heterogeneity and complexity of domestic energy use are often not regarded in energy efficiency measurements and policies. The energy efficiency paradigm is rather focused on the costs and technology and thus creating a missing the link between the technical side of things and the social actors such as end-users.
of energy. Gram-Hanssen (2013) argues that technology is not sufficient in reducing energy use on its own. The energy performance of buildings that have been developed to reduce energy use are highly dependent on its occupants (Gram-Hanssen, 2013; Karlsson & Moshfegh, 2007). In the case of the two buildings in Vallastaden with an energy concept which is affected by the occupants and their daily activities, it is crucial that the missing link must be bridged. Both housing companies stated that the occupants of their buildings had a big influence over the energy performance but however, domestic energy use was not considered in their calculations of the buildings’ energy use. Instead, they focused on developing good technology in their buildings without any major considerations of the future occupants and their influence.

6.2 Communication towards the occupants

Woolgar & Neyland (2013) argues the ontological status of a mundane object can differ between people and it is the perception of an object that influence the way in which people behave and act around the object. This means that people can behave very differently around the very same object. The mundane governance works if the object can provoke a behaviour that was the intention all along. For example, if a certain waste product should be placed in a specific bin bag, the people who sort their waste needs to know what waste goes into which bin bag. That is why classification is a central concept in mundane governance. Classifications are made up by rules and conditions in order for the object to be used as intended. If people recycle the waste in the right bin bag the targeted behaviour among them are achieved by the mundane bin bag. That is how the bin bag facilitate governance.

Classification becomes a bit more complex when considering the energy concept as the object since you cannot force the occupants how to behave in their own home. The housing companies did put a lot of hope and effort in developing the technology in their buildings and its performance is up to the occupants. Hence, the communication of the housing companies towards the occupants could facilitate the understanding of the energy concept among the occupants. Karresand (2014) means that occupants should know that their activities are a part of the thermal comfort in these kinds of buildings. But the fact was that all the occupants who were interviewed shared the view that they experienced a lack of information.

Stångåstaden and HSB had different strategies for communicating the energy concept to their tenants. The informant at HSB realised that the technology would be hard to understand for the occupants. They developed the ICT for the households where they could monitor their energy production and energy use. Broms & Andersson (2017) argues that exposing people to resource flows is a good attempt, but the importance is to make the resource flows meaningful for the occupants in their everyday life. It is essential for developers to consider the context where the technology is situated or otherwise, there is a risk that the occupants see no point in taking notice of the provided information. Since the daily routines and lives of occupants varies to large extents, it is impossible for developers to frame the technology to suit every possible occupant (Glad, 2012). HSB made attempts to visualize the energy flows in the private home, but the complexity of the technology could in the end be too hard for the households to understand.

The tenants of Stångåstaden had no feedback in their apartments regarding energy. They only had a binder with information about the building and their apartments. A study by Thoresson & Glad (2009) shows that many housing companies consider the tenants to play a small role regarding energy efficiency in the buildings. This could be one of the reasons why Stångåstaden
did not implement more feedbacks. The informant from Stångåstaden was of the belief that their tenants did not need to think about the technology since the tenants could not control it. It was just the staff of Stångåstaden who could operate and handle the technology. The technology and occupants can establish some kind of ‘background relationship’ in which the technology is not particularly acknowledged or influence engagement among the occupants (Isaksson, 2009). I believe that in this case that the influence of the occupants is underestimated and that much faith is put into the technology to reduce the energy.

When put into the context of mundane governance, there is a risk that the energy concept is perceived by the occupants in a different way than what the housing companies perhaps want. It is important for the housing companies to frame the technology into the everyday lives of the occupants in order to make the information more meaningful (Broms & Andersson, 2017). It means that the companies need to understand the reality of the occupants. This could be done by making occupants aware of everyday practices that have an influence on the energy concept. The connection is obviously not always clear for the occupants (Isaksson, 2009). Therefore, economic incentives like billing for hot water could be a strong motivator for occupants to feel more engaged. Smart metering for example could be a way for the tenants to become more aware of their energy use. The occupants in private homes also need instructions that are comprehensible and adjusted to their everyday life to diminish feelings of uncertainty. It is yet to be discovered if the ICT the direct contact with HSB could make the technology more comprehensible in the long run.

6.3. The occupants’ perception of the energy concept

For the tenants in Stångåstaden’s building, the energy concept was unnoticeable. It was no coincidence that they seemed to be unaware of their role within the system. The technology was completely handled by Stångåstaden and their personnel which seemed to leave no motivation for the tenants to reflect about their part in the energy system. Keeping meters and other potential feedback possibilities behind locked doors makes it harder for people to discover the energy system (Glad, 2013; Lutzenhiser, 2014).

For the Larsson family who owned their house, their ontological reality regarding the energy concept was filled with uncertainty. They knew that someday they would need to manage the technology on their own. Their experiences of the technology and the feedback from the first couple of months were educational, yet frustrating. The installed ICT did not work properly from the beginning and they had a lot of questions about how the technology would react to certain conditions, for example during hot summer days. It takes time to become familiar with new technology (Isaksson, 2009). Since the family only had lived in the building for a few months it is hard to conclude exactly how their perception of the energy concept will progress in the future. However, one thing that caught my attention was the quote where John from the Larsson’s said that the novelty of the new energy concept would eventually wear off on him. At that time, he was the only one in the family who monitored the technology through the app. This could indicate that there is a risk that technology can be neglected in the future which could probably lead to unnecessary energy use (Isaksson, 2010).
6.4 The capabilities of the energy concept

Woolgar & Neyland (2013) mean that technical capacities are often taken for granted. That is why they argue that is important to understand the ontological status of an object or otherwise these objects will continuously be taken for granted. This has been very interesting to explore in this case study of the two buildings in Vallastaden. The framework mundane governance has facilitated the understanding of if and how the occupants have been considered as a part of the energy concept. It is apparent that the housing companies are part of the energy efficiency paradigm where technology is still regarded as the main factor for energy efficiency. But the behaviour of occupants can even outweigh technical energy efficiency gains (Gram-Hanssen, 2013). But in this case the occupants had no prominent role in the energy efficiency measurements. The communication of the energy concept towards the occupants was limited and ultimately influenced the occupants’ perception of the energy concept. They either had no reflection or experienced uncertainty and these perceptions may influence the energy performance of the buildings. The technology alone will not achieve the energy efficiency goals.

As I mentioned earlier, accountability is an important aspect in mundane governance. The housing companies where accountable for building energy efficient buildings in Vallastaden but what happens with the accountability when the occupants move into the buildings? The housing companies cannot force the occupants to behave or handle the technology in a specific way, but the communication can always be improved. If the occupants become well-informed and understand their influence on the energy concept then maybe they would behave or handle the technology in the intended way which could then potentially lead to energy efficiency. The accountability relations between the housing companies and the occupants needs to be strengthened in order to reduce the overall energy use.

7. Conclusions

The study has highlighted important aspects when developing energy efficient new technologies with the aim to reduce energy use within the housing sector. To study the perceptions of housing companies and occupants through the framework mundane governance has resulted in key points that should be considered in the future when developing low-energy buildings.

The mundane governance of the energy concept has facilitated the understanding that the occupant perspective is not totally clear in these types of energy systems. The housing companies experienced a lack of control of how occupants would use the technology in the buildings. The housing companies even stated that the energy performance of the buildings was dependent on the ‘right’ behaviour of the occupants. The occupants whom participated in the study either showed no reflection about their role in the energy concept or expressed uncertainty towards it.

The study also found that there is a difference regarding the form of tenure when examining the case study through mundane governance. The informant at HSB expressed more concern regarding the performance of their privately-owned homes since the management of the buildings was totally controlled by the households living in the buildings. Therefore, the housing company tried to communicate the energy concept and the technology to the households to make it more comprehensible and facilitate their understanding. Stångåstaden
made little attempts to visualize the energy concept to the tenants. As a consequence, the tenants did not reflect about their role in the energy concept.

Despite all this, it is apparent in both cases that the mundane governance of the energy concept has the risk of failing since the communication between housing companies and occupants was perceived as inadequate. The accountability relations between housing company and the occupants therefore needs to be strengthened if the aim of reducing energy use through these energy efficient buildings should be achieved. This study shows that the role of occupants must be emphasized throughout the whole process of developing low-energy buildings. It contributes to the research about socio-technical systems where it is important to consider the interaction between technology and humans. There is need for more research about how the occupants are taken into consideration when developing these types of buildings since the performance of the technology is dependent on the user. It is also important to continue to study the end-user perspective. The impact of the occupants on these types of energy concepts cannot be ignored, or else there is a risk that the initial intention of reducing energy use through energy efficient buildings will be in vain. These types of buildings will become more frequent in number in the future and therefore, it is crucial to consider the relationship between technology and humans and how they interact.

8. Acknowledgements

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9. References


Appendix 1: Interview guide addressed to HSB and Stångåstaden

This interview guide was used during the interviews with the housing companies. It has been translated to English since the interviews were held in Swedish.

Opening questions
- Tell me briefly about your role at the company. What are your responsibilities?
- What has been your involvement in Vallastaden?

Energy plus building
- What were the reasons why you wanted to build in Vallastaden?
- Tell me about the idea of building energy plus building/passive house.
- Why did you choose to build this type of house?
- Who has been involved in the process?
- What challenges did you face?

The energy system of the building
- How is the energy system in the building constructed?
- Does it differ from how you usually construct it? In what way?
- What components are included in the energy system according to you?
- How does the energy system facilitate energy efficiency?
- What is the calculated energy use?
- How is the technology managed in the building?

Collaboration in Vallastaden
- What was the collaboration like in Vallastaden?
- What was your role?
- How do you perceive the collaboration?
- Did any problems occur? Why?

Evaluation/goals
- Did the result (building) match your initial vision?
- Have you set any goals for the building’s performance? Why/why not?
- How are the goals defined?
- How should the goals be reached?
- In what way will the energy system facilitate the achievement of the goals?
- How will this be evaluated?

Households
• What is the role of occupants in the energy system?
• In what way are the occupants affected by the energy system and the technology in the buildings?
• How does the occupants influence the energy system?
• Did you have a dialogue with occupants during the process of developing the building? Why/why not?
• How have you facilitated the occupants’ understanding of the energy system?
• How has the building been marketed towards the households?
• What kind of information have you provided to the occupants about the building?
• Do you perceive it as important for the occupants to understand the energy system? Why/why not?
• Is it possible for the occupants to influence the building’s energy use?
• What measures have been done to inform the occupants about their energy use?
• Have you considered the role of the occupants in the energy system? Why/why not?
• What has been the response of the occupants so far?
• Do you believe that Vallastaden attracts a certain kind of people?

Final questions
• What are the experiences and lessons of your development in Vallastaden?
• Do you want to add something?
• Is it ok for me to contact you if I have any further question?

Thank you!
Appendix 2: Interview guide addressed to Tekniska Verken

This interview guide was used during the interviews with the energy company Tekniska Verken. It has been translated to English since the interviews were held in Swedish.

Opening questions
- Tell me about your roles here at Tekniska Verken.
- How have you been involved in Vallastaden?

Culvert in Vallastaden
- Tell me about the culvert.
- Why was this kind of solution (culvert) implemented in Vallastaden?
- What is the purpose of the culvert?
- Does it differ from how you usually develop infrastructure for energy?
- What has been the vision of the culvert?
- What has been the response from the public so far?

The energy system
- How are the energy systems connected to the culvert?
- What components are a part of the energy system?
- Has the energy system been developed to be energy efficient? How?
- What do you want the energy system to achieve?
- What have been the challenges during the process of developing the culvert and energy system in Vallastaden?

Collaboration in Vallastaden
- What actors have been involved in the collaboration?
- How come you collaborated with constructors and housing companies in Vallastaden?
- How was the collaboration designed?
- What have been the responsibilities of the different actors?
- What was the role of Tekniska Verken in the collaboration?
- Did the actors share a common vision?
- How do you perceive the collaboration?
- What have been the challenges of collaborating this way?
- Will you continue with this type of collaboration in future projects?

Citizen dialogue
- Based upon a previous study, Tekniska Verken mentioned that they wanted the households to have control over their energy use and production. In what way have you tried to achieve it?
- Who is responsible of having a dialogue with households?
• Did you conduct a citizen dialogue about the culvert? Why/why not?’
• What has been the response of people living in Vallastaden regarding the culvert?
• In hindsight, did you see a value of having citizen dialogue regarding the culvert?
• How has Tekniska Verken communicated the energy system and culvert to the households?
• How do you perceive the occupants’ role in the energy system in Vallastaden?
• How will the occupants of Vallastaden influence the energy system?
• What kind of people move to Vallastaden do you think?

Maintenance/Evaluation
• Who performs maintenance of the culvert?
• How do you evaluate the performance of the culvert?
• What is the role of Tekniska Verken now when the culvert is in use?

Final questions
• Do you want to add something?
• Is it ok for me to contact you if I have any further question?

Thank you!
Appendix 3: Interview guide addressed to the households
This interview guide was used during the interviews with the three households. It has been translated to English since the interviews were held in Swedish.

Opening questions
- If it is ok I would like to have a tour in the apartment and talk about the energy system.

The building
- Why did you move to this building in Vallastaden?
- What do you value with the building?
- What do you think about the focus on energy?

Previous experiences
- How does it feel to live in this building in contrast to where you previously lived?
- Do you notice any differences? In that case what?

Energy use
- How does the building and the technology affect your energy use?
- Do you have control over the energy use? How?
- Has your energy use transformed after you moved into the building?
- How do you perceive your energy use today in contrast to before?

Energy costs
- Is heating and hot water included in your rent? *
- Do you pay anything extra because of the energy efficient building?
- If not, would you pay extra money for it?

Electricity
- Are you satisfied with the pre-installed appliances in the apartment? *
- Do you use the appliances differently in contrast to your previous home? What are the differences?
- Have you received information about how to use the appliances in the most energy efficient way? In what form?
- Do you usually shut off the appliances you do not use?
- How do you reflect about your electricity use today?

Heating & ventilation
- How do you perceive the indoor temperature?
- Do you have the ability to influence the indoor temperature? In what way?
• If it gets too hot, what do you do to lower the temperature?
• If it gets too cold, how do you do to increase the temperature?
• Have you received any advice of how you should achieve desired temperature? What kind of advice and by whom?
• Do you notice any differences between indoor temperature in between seasons?
• Have you been gone a longer period from your home? Did you notice any difference in temperature when you came back?
• How do you perceive the air quality in your home? Dry or humid?

Communication & information
• What do you think about the marketing of the home?
• What kind of information have you received from the housing company regarding the energy system in your home?
• At what point did you receive this information?
• In what form was the information communicated?
• What was the information about?
• Has the information been of use? Why/why not?
• Would you have wished for another type of information?
• Do you perceive the information and communication to be adequate and sufficient in order for you to understand how you can influence your energy use? Why/why not?
• How do you proceed if you need help with anything regarding the home? Who do you contact?

Final questions
• Has your new home met your expectations?
• Does Vallastaden as a sustainable district influence your perception of your energy use?
• Do you want to add something?
• Can I contact you if I have any further questions?

Background questions
• How many people live in your household?
• How many square meters does the home consist of?

Thank you!

*This question was directed to the tenants