

The absence of a conventional heating system – from the perspective of the occupants

Charlotta Isaksson
M.A. Sociology, PhD Candidate
Department of Technology and Social Change
Energy System Program
Linköpings University
SE- 581 83 Linköping
Sweden
chais@tema.liu.se

Keywords

Low energy houses, occupier satisfaction, everyday activities, comfort, thermal climate, usage of the heating system

Abstract

This paper presents the occupants' experiences of purchasing and living in low energy terraced houses in an area south of Gothenburg, Sweden. The houses are built with the aim of showing that it is possible to 1) maintain a good indoor climate in a house that 2) uses less than half of the energy of ordinary buildings in cold climates. It is predominantly emissions from household appliances, occupants' body heat and solar irradiation that should heat up the house, but during cold days an integrated heater could be used. Semi-structured interviews have been conducted with 16 out of 19 households and this paper raises issues related to the non-conventional space heating.

Results show that the households questioned are positive towards the low energy profile but it was not the main reason for buying the house. Both the position of the houses and the price were more important. In the early use of the heating system, many proceeded by trial and error, which resulted in an uncomfortable indoor temperature. Apart from that, many are satisfied with the function of the heating system. However, the indoor temperature still fluctuates and the floor on the ground floor level is described as cold, but that does not trouble occupants, since the indoor temperature rises quickly when household appliances and candles are

being used. Moreover, the number of members in the household, if they live in a gable or a middle house, and the amount of time they spend at home are determining factors in their opinions of the indoor temperature.

Introduction

In Sweden, 39% of energy use originates from the building sector.¹ In order to reduce the amount of energy use in the sector, energy utilisation, particularly in residential buildings, must be much more efficient. This paper highlights one such attempt. Terraced houses that use approximately 7 000-8 500 kWh are examined. This can be compared to an "ordinary" terraced house in Sweden, which uses around 16 000 kWh of energy for heating purposes alone.²

In an area south of Gothenburg in Sweden, twenty low energy terraced houses were constructed in the spring of 2001. The idea behind these houses was to reduce heat loss, by means of a well-insulated building construction. Emissions from household appliances, occupants' body heat and solar irradiation should alone manage to maintain a comfortable indoor temperature. However, during cold days an integrated 900 W heater could be used to heat the air that is distributed through the ventilation system. Moreover, the houses have windows consisting of three layers of low-emission glass and each house has a 5 m² solar collector that is designed to cover 50% of the energy supply for hot water use. The separate technological artefacts are not new, however

1. Stern (2002)
2. Ruud, Lundin (2004)

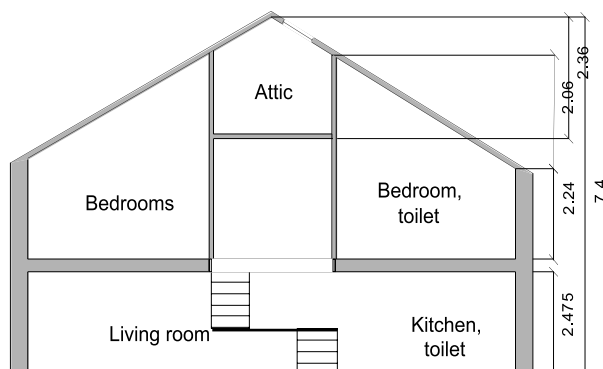
the specific combination of the different technologies has not previously been implemented in Sweden. The term innovation often implies combining existing components in new ways and in this sense the low energy houses may be regarded as an innovation.³

The houses are built with the aim of showing that it is possible to 1) maintain a good indoor climate in a house that 2) uses less than half of the energy of ordinary buildings.

It is evident that the occupants of these houses ought to be the best people to judge if this double aim has been achieved. In this paper their experiences regarding the space heating of the houses will be presented. In Sweden, the heating system is generally a crucial element of low energy buildings, for instance it can be necessary to question if it is comfortable enough to live in these houses during the winter? Moreover, space heating is the most energy intensive process in buildings, and therefore an appropriate subject for careful examination.⁴

The purpose of this paper is to describe the occupants' experiences of the heating system of the houses and their perception of the indoor temperature during the winter. In this paper the heating system mainly comprises an integrated 900 W heater located in the ventilation system. However, the household appliances, the occupants' body heat and solar irradiation are also important heating sources, with household appliances being looked at in particular detail.

The presentation begins by describing why the occupants chose to purchase a low energy house. It examines what they thought about the low energy profile of the houses, especially the space heating, before they moved into the houses. Subsequently, the occupants' use and opinions of the heating system from the first winter in the houses is considered. In the last section, the everyday activities of the household and their effect on the indoor temperature will be discussed. Furthermore, their use of household appliances, and perception and opinions of the indoor temperature will be described.



Side view of a house

Empirical Research

In the section below, the design of the buildings, the outline of the empirical research and the composition of the households are presented.

THE DESIGN OF THE LOW-ENERGY BUILDINGS

The terraced houses are 120 m² each and consist of a ground floor, an upper floor and an attic. The entrance is situated on the ground floor, on the north side of the house. When opening the outer door the occupants face an unheated entrance hall. Then, they open another door and enter a small hall. Immediately to the left or right⁵ there is a smaller kitchen. On the opposite side of the hall is a bathroom. The hall leads into the living room, where the stairs to the upper floor are located. On the upper floor, one first enters a hallway, leading to three bedrooms with high ceilings and one bathroom. The south side of the house has large window areas, facilitating sun radiance to heat the building, while the northern side has much smaller windows (13.6 m² compared with 3.5 m²).

EMPIRICAL PROCEDURE

In November 2002, qualitative interviews were conducted with 16 out of the 19 households.⁶ The interviews took place in the occupants' homes and lasted between one and two hours, depending on how many family members were present during the interview. In six of the interviews, two adults from each household were present, while in the remaining ten interviews, only one adult participated. In all, 22 people took part in the study. All interviews were audio taped and transcribed for analysis.

The aim of interviewing the households was to investigate how they feel about the building and how they use the building in energy-related ways. Topics taken up during the interviews included the occupants' previous homes, the procedure of purchasing a low-energy house, general opinions about the house and the area, their experiences and opinions of the indoor climate, activities at home, in particular those related to the use of appliances and the heating system, and finally the occupants' awareness of and interest in the environment, energy and technologies in the home. In this paper, results mainly related to the space-heating of the building will be presented.

The qualitative interviews, also known as in-depth open-ended interviews, were based on semi-structured questions. In keeping with the empirical method chosen, the interview situation was more similar to a conversation rather than straightforward questioning. The main advantage of a qualitative interview is its ability to capture a variety of opinions and it gives a multi-faceted and more comprehensive picture of the phenomena studied. Compared with quantitative methods based on questionnaires, qualitative interviews are more successful in promoting a user-centred

3. Edquist (2001)

4. Stem (2002) In warmer countries cooling is an important contributor to energy use.

5. Half of the houses the kitchen is situated to the left, the other half to the right.

6. One house is uninhabited; it has been used as a test house by SP (Swedish National Testing and Research institute). The test house is identical to the other terraced houses except that it is uninhabited and is not furnished. To simulate occupancy and activities, the test house is equipped with thermal mannequins. SP has measured power requirement and indoor temperature in all the houses. Technical measurements of physical parameters such as temperature, humidity and air velocity, have been conducted in the test house. See Ruud, Lundin (2004).

approach which takes the context and everyday life of the occupants into consideration. Despite the advantages of qualitative interviews, distribution of questionnaires is the most common research method when evaluating a building from the point of view of the occupants. Relatively few studies in the area are based on qualitative interviews. This paper will briefly highlight one such study, in which energy use in Japan and Norway has been compared and analysed.⁷

THE HOUSEHOLDS

When the interviews were carried out the sizes of the 16 households were as follows:

- Six of the households consist of four or five people,
- six of the households consist of three people and
- four of the households consist of two people.

Altogether, there are 29 adults in the households and twelve of the households are families with children. 22 children or young people live in the houses, although some of them only stay there every other week. Seven of the interviewed households live in gable houses and nine live in middle houses. Fourteen of the interviewed households have been living in the terraced houses from the beginning, since the spring of 2001, while two families moved in afterwards, one of them in the beginning of June 2002 and the other in September 2002.

The occupants participated anonymously in the investigation and the quotations have been given fictitious numbers, which make it possible for the reader to see if the person quoted lives in a gable house (Hg) or a middle house (Hm). Also, the individual person in the household is presented. e.g. female (F) or a male (M).

An interviewed household's former home is often used as a point of reference when considering the new home, and the households often make comparisons with how they lived before. These comparisons are of value since they provide a picture of how the low-energy buildings function in relation to other buildings. Half of the households had previously lived in rented flats, five in detached houses, two in terraced houses, one in a semi-detached house, and one household lived in a tenant-owner flat.

Theoretical approach

The theoretical approach mainly comprises the domestication model, developed by Silverstone et.al.⁸ The model may be used as an analytical tool for describing how a new technology is gradually integrated into the domestic life of the household. The social and cultural process between the actual artefact and its user has been developed into four different phases (or elements). The first phase, *appropriation*, occurs when a commodity or service is brought to the do-

Hg1	Hg2	Hg3	Hg4	Hg5	Hg6	Hg7
M F	F	M F	F	F	M F	M F

Hm1	Hm2	Hm3	Hm4	Hm5	Hm6	Hm7	Hm8	Hm9
F	M F	F	M F	F	F	F	F	F

mestic environment. Also, as in this paper, appropriation may include the purchase of the object and the different reasons for that purchase.⁹ For an object to be accepted, it has to be physically found a space at home. This symbolises the second phase, *objectification*. The individuals now begin to use the technology. In the third phase, *incorporation*, the household more frequently uses the technology. The object has now been integrated into the daily life of the family. Now, the focus is on how it is used. The fourth phase describes the relationship between the household and the outside world, for instance, how and in what way do they talk about the technology outside the home.

In this paper, the different phases are not analysed in detail and the domestication model is only briefly used in order to structure the empirical results. Silverstone et. al. use the model when analysing information and communication technologies, like the computer and the television. These technologies are objects as well as media. Here, the object in focus is the space heating of the houses, which also has a tangible and non-tangible dimension, consisting of the integrated heater, the household appliances and the indoor temperature, (i.e. the technology and its function). However, when describing the first phase, appropriation, the focus is widened slightly and the whole building is included, since they purchased a house, not only a heating system. Some parts of a theoretical model developed by Sikisö are used, which consider people's possibilities to be active in the housing market.¹⁰ In his model Sikisö highlights factors bound to the individual households, which are either their preferences for housing or their material, cognitive and social resources.¹¹

This paper mainly considers the preferences of the households. The term 'preferences' implies something we prefer in relation to something else, in this case what the households give priority to when purchasing a house. According to Sikisö, there are four different preferences. *Economical* preferences, in this paper, describes the investment of the houses. The second preference is, *The quality of the building*, where the type of house, design, and standard will be highlighted. The third preference, *The quality of living*, is the social and physical surroundings of the area. Finally, the fourth preference, the *priorities of everyday life*, the connection between the position of the house and the place of work is one important factor while the social network in the area is an-

7. Wilhite, Nakagami (1996)

8. Silverstone Hirsch (1992), see also: Silverstone, Haddon (1996)

9. Aune (1996)

10. Sikisö (1991) In the model, Sikisö differs between factors connected to the individual household and factors bound foremost to the local housing market. The local housing market depends for example on principles of distributions as political guidelines, rules, and building norms as well as market regulations, availability and demand. Factors connected to the households are their preferences for housing and their material, cognitive and social resources

11. Material resources are mainly income and capital. The social resources are possible social contacts with the housing marketing. The cognitive resources are the formal and informal knowledge of the household. Formal knowledge is level of education and present employment, and the informal knowledge is related to the households' knowledge of the housing marketing, and their experiences of building construction in general and living in and running a house in particular.

other. The resources of the household will not be discussed here. However, a lack of a particular cognitive resource is briefly examined; more specifically, the way in which the households managed to deal with the fact that they lacked previous experience of living in a low energy house and that the specific combination of energy-related achievements of the houses were untried and new.

Results

THE PURCHASE OF A LOW-ENERGY HOUSE

The terraced houses were advertised for sale in the newspaper in the autumn of 2000. In addition, information about the houses, their intended design and function were available on the housing company's website. Many of the occupants visited the website in order to download further information. Some of them actively searched for advertisements for houses on the Internet, and therefore ended up on this particular website. Others first saw the advertisement in the morning paper and became curious and wanted to know more. Two families first heard about the houses from relatives, and some of the families who already lived in the area noticed that something was going on. In this section, the phase of appropriation is presented.

The buyers purchased their houses, before they were built. They had to make their decision based on drawings, plans and pictures. Some say that they liked what they saw and the drawings and plans seemed well thought-out. Hence, the *quality of the building* was important. The prospect of moving into a recently built house attracted many of the buyers, and some said it was a reason for purchasing the house. However, not all were very fond of terraced houses, and previous bad experiences with sound levels were mentioned. Some of the households, now living in gable houses, explicitly state that buying a middle-house was not an alternative.

"this is something new and fresh" (Hg1, F)

"It looked very nice on the drawings" (Hm6, F)

The low energy houses were sold as co-operative flats. Most of the occupants were positive towards this type of ownership because of the economical advantages (the initial price of the house is much lower). The maintenance of the surroundings and the exterior of the houses is carried out by the housing co-operative. This is mentioned as a positive factor in terms of lower responsibility for the individual household. A few have opposing opinions, and according to them, communal maintenance involves too many demands and a level of control they do not wish to have. Also, some explicitly state that they would have preferred to have purchased a freehold property, especially since the monthly rent is fairly high.

Moreover, according to the majority of occupants, the terraced houses were good value for money compared to other houses in the area. One occupant had compared the new terraced house with a terraced house in that area that was built 30 years ago. The costs of living between the two houses were the same and he pointed out that they would rather

live in a new house than an old one. Many people had been looking for a house in the area and they described it as a very expensive place to live. The relatively low price was of great significance in their decision to buy the low energy house.

"I got best value for money here!" (Hm6, F)

"It was mostly a financial decision when we decided on this house." (Hm4, M)

The *economical preference* above is closely connected to the socio-spatial context of the houses. If the houses had been built in a less attractive area, it is not certain that interested buyers would have regarded the low energy houses as low in price. The preferences *Quality of living* and *priorities in everyday life* both refer to aspects related to the position of the houses; the social contacts in the area, the content and the shape of the physical surroundings, and these are the most important preferences of the households.

Consequently, the main reason why they initially became interested and thereafter decided to purchase the low-energy house was the location. More than half of the households either have relatives living southwest of Gothenburg and/or they have grown up there or lived there before. Therefore, many already had a network of social contacts in the area and both relatives and friends are mentioned. Moreover, some mention in particular the good opportunities for commuting to work, either by public transport or car, since the area is located close to a larger road. The natural surroundings are also mentioned as attractive. The houses are situated close to the countryside and the sea, but are still no great distance from the heart of a big city, only 20 km south of Gothenburg.

"We were attracted to the area." (Hm2, F)

"We wanted to live in the south; I guess it was because of that." (Hm2, M)

The significance of the energy solutions

What did the low-energy solutions of the house mean for the household? Did they have any significance in the purchase? Were they worried about the unconventional heating system? The terraced houses were clearly advertised as low-energy houses. In the brochure that was given out to interested customers you could read:

"With energy in focus Egnahemsbolaget is building 20 terraced houses in Lindås Park. A conventional heating system has been replaced with a solar collector in combination with a very well insulated building construction. The terraced houses in Lindås Park are a joint project between Egnahemsbolaget, Chalmers University, Swedish Council for Building Research, Lund institute of technology, and the Swedish National Testing and Research Institute."¹²

For the majority of the occupants, the low energy profile of the houses was not an important reason for purchasing the house. The location of the houses, the high standard and the fairly low price compared to other houses in the area, played a greater part. However, many regarded the low energy solution as an "additional bonus" and most of the occupants considered the focus of saving energy as positive. Mainly preferences related to what Sikisö labels *economic* considerations and *quality of the building* are mentioned. In particular, advantages such as lower service costs and greater control

12. Egnahemsbolaget (2000) *Sol och skön natur*, The text is translated by the author.

over energy use seem to be important issues for those who before lived in a private house with high energy bills. Moreover, many mentioned that a probable higher building quality was to be expected, due to the fact that the houses were built and developed within the framework of a research project.

None of the buyers had any former experience of living in a low-energy house and therefore gaining more knowledge of the energy solutions was for many a necessary part of the purchase process. Some of the buyers consulted experts in the field, to gain more knowledge of the energy solutions and many asked the building proprietor to obtain guarantees of its function. A couple of the questions concerned the heating system. Was it going to be warm enough? How did the ventilation and heating system work? Why can't we have a fire place in the living room or floor heating in the bathroom? Another question concerned the insulation and its effect on air as well as sound-levels. In addition, many asked their closest relatives for advice before they decided to purchase the house.

One couple felt uncertain about the unconventional heating system and they were a bit worried about its function. However, no one was very anxious. Many reasoned that it is always possible to install an additional radiator. They trusted the building company and the researcher, and some mentioned that in the end the ultimate responsibility lay in the hands of the company, since the households received a two year guarantee. It also felt like the involved parties strove to do the best work possible, especially since the project had received a lot of attention in the media.

"It was an extra bonus." (Hm8, F)

"It could not be such a great risk for us; it must be a greater risk for any of the builders. I mean we have a guarantee for two years." (Hg3, F)

"We argued like this; if it would not work, we could always put in an additional radiator. If problems had come-up we would have been able to solve them." (Hm5, F)

Some of the buyers carefully considered the different energy solutions. However, many of the occupants mentioned that they did not consider or ask very much about the energy solutions of the houses. They remember the purchase of the house as a very quick process. Some were in acute need of a place to live, while others had to make a quick decision since the house would otherwise have gone to someone else. Moreover, some said there was not much to ask, they trusted the information received. Consequently, for many, the decision process did not occur over a long period. The phase of appropriation, however, was stretched out in time and now the household had to wait a couple of months before they could move into their new house. Practical questions concerning energy solutions were also raised over time after they had moved into the house. That brings us to the phase of objectification.

THE USE AND OPINIONS OF THE SPACE HEATING

In the spring of 2001, when the owners moved into the house the heating system was not the only new feature for them. The building, as well as the physical and social structure of the surrounding area, was unknown. For some it was not until the indoor temperature in the autumn became too low that they started to take a deeper look at the integrated heater which was located in the ventilation system. In this section the phase of *objectification* is described, foremost by briefly describing their early use of the integrated heater and their opinions about the location of the system. Then, use and opinions related to the phase of *incorporation* is addressed and finally the mediation of the space heating is highlighted.

The early use of the heating system

"I think you have to learn to live in a house like this",¹³ one of the occupants says when the heating system is discussed. Many of them describe that they did not know how to use the integrated heating system during the first weeks of the winter. Several households point out that they were not given sufficient information about how to operate the system.

"Their information was lacking, I think, that we hadn't been informed of how to use it. It was as if we wouldn't need it at all, only in extreme circumstances. So we spent our time here, like everyone I think, or most of us, feeling cold and I bought, I had a fan wherever it is, that I used a lot here." (Hm6, F)

Instead of having the integrated heater on all the time, many of the occupants turned the heater on and off depending on the temperature outside. This procedure made it difficult to maintain a comfortable and adequately uniform indoor temperature. Many proceeded by trial and error, which resulted in a variable indoor temperature and unnecessarily high energy costs. In addition, 14 out of the 16 households lived in the houses during the past winter. Nine of them say that they often used a separate heater in order to achieve a comfortable indoor temperature.

"Last year there was a great lack of knowledge as everybody consumed extra electricity by having 2 000 W electric heaters here by the breakfast table. To be able to sit by their table and eat breakfast. A lot of extra energy was used then [...]. Financially it would be better to keep it switched on and have an even temperature." (Hm9, F)

Furthermore, some mention that the difficulties of maintaining a comfortable indoor temperature during the first winter could be due to the building moisture, from the construction of the buildings. After some time, many worked out how to handle the system, which simply was to have it switched on during the whole winter. However, some explicitly state that this procedure was not at all the method of use the building constructor had informed them of. Rather, they got the impression that they only on rare occasions should switch on the heater.¹⁴

What about the location of the system? In the low energy terraced houses the location of the technological systems

13. (Hm9, F)

14. When the houses were initially planned they lacked an integrated heater. Boström et al. (2003) pp112-113. Even if this plan was never realised, the early ideas had consequences for the households' earlier use of the heating system.

was already defined. The ventilation system and the integrated heater are located in the kitchen, hidden inside a cupboard. Compared with, for instance, the television and the stereo, the energy system is supposed to be invisible, and nothing you show to relatives and friends. In one sense, the space heating is even more hidden in these houses than others, since there are no visible radiators in the rooms. Practically and aesthetically, many were very satisfied with the invisibility of the heating system, since they removed ugly radiators and the rooms became easier to furnish.

In another sense the heating system and the whole idea of the space heating of the houses is more visible than usual. It is visible in the topic of conversation and in a way also in the perception of the indoor temperature, since the indoor temperature fluctuates more than they are used to from their former homes. Both issues will be addressed later on in the text.

Where the phase of objectification ends and the elements of incorporation begin is very difficult to tell. First, this differs between the households (for instance, some had not entered the incorporation phase when the interviews were carried out). Secondly, you need to look at their use over a longer time period, not only during the first year and a half as was done in this study. However, in spite of this, issues connected to the phase of *incorporation* will be addressed.

Different opinions and uses of the heating system

When the integrated heater is switched on it is automatically regulated. This means that the heater automatically switches off when it reaches the reference value (the desired temperature). When the temperature decreases too much it then switches on again.

Most of the households have the reference value at 21-22°C during the winter, some a bit warmer, approximately 23-24°C. The reference value can be seen on a display located by the heat recovery system and is adjusted by a system of regulation. The value does not seem to correspond exactly with the indoor temperature in the house. The temperature is usually 1-3°C below the reference value many of the occupants indicate.

Some of the households switch on the integrated heater when the temperature outside is 8-10°C, others at 4-5°C and a few wait until it is around zero. Then, many of the occupants have it switched on (i.e. automatically regulated) until it gets warmer at the beginning of the spring. It is a time-scale which ranges from occasional weeks to six months.

Many of the households think that the heating system functions quite well and that the houses maintain an acceptable indoor temperature during the cold season if the heater is switched on. However, many also pointed out what they consider to be shortcomings. When the indoor temperature rises above the reference temperature, cold air blows from the supply devices in the bedrooms and in the living room. Consequently, the system tries to maintain the reference temperature, which many of the occupants experience as unpleasant.

Him: "It's the single worst thing about these houses"

Her: "That you try to warm them up and then they cool down by themselves" (Hg 6, M, F)

It is also clear that the heating system alone is not able to maintain an acceptable indoor temperature, but needs as-

sistance from other sources of heat such as people, appliances or radiators. However, these heating sources are not constant and they vary within the household during the day, as well as between different households. This will be dealt with in the next chapter.

"The heating system works really well. It was difficult to understand it before you experienced it, that it actually works. Then we switch on the extra heating when it gets cold outside so that we set the temperature we want in the house." (Hm5, F)

"It's an experiment, this [...] and it doesn't really work perfectly, it doesn't even work well, it works poorly." (Hg 3, M)

If the occupants were able to decide and choose themselves, would they have changed anything concerning the heating? Half of the occupants are of the opinion that a fireplace would contribute to increased comfort and well-being as well as keeping the house warm. Several have also asked if it would be possible to install a fireplace. They received a negative answer with the explanation that the house would not be as well sealed. When it is not in use, the loss of heat might be too great. Other things they would like to see are under-floor heating, a more stable indoor temperature, and a timer for the air heating system.

Another important question is who in the home controls the ventilation system, in particular the integrated heater. Experiences of running the system differ between the households as well as between the members of the household. Many of the respondents are women and some of them refer to their husbands when questions about the integrated heater and the ventilation system are being asked, as it is he who has taken care of that part. Another household has not been looking at the technical system at all. So far, the housing company has run the system. Some point out that they ought to learn more about the function of the system, but at the same time they say they do not need to, since their partner already takes care of it, or it is not a necessity, since they are satisfied with its function and nothing needs to be done. It is when problems arise that the occupants look for further information and knowledge of the system. The phase of incorporation will be looked at further in the next chapter, when the everyday habits and use of household appliances and the occupants' perception of indoor temperature are described. First, the phase of conversion is briefly presented.

The mediation of the space heating

In the phase of conversion, the relationship between the household and the outside world is addressed. Silverstone et.al. describe the four phases as non-discrete elements. This is particularly true when it comes to the phase of conversion. In this paper, the phase of conversion is seen as an ongoing process, which begins at the moment the object enters the door of the households' homes. Then, the members of the households gradually mediate meanings and different kinds of use to the world outside. However, in this case, the mediation of technology is a feature evident particularly in the phase of objectification.

From a socio-spatial point of view, the nearest world outside of the individual household is that of the neighbours. Many describe the indoor temperature and the use of the heating system as a common topic of conversation with the

neighbours. The following questions are frequently asked: Have you switched on the heater yet? Is it cold in your house?. The chat about the heating system of the houses has replaced the ordinary small talk about the weather, one occupant says. Since they share the same energy solutions, they have also asked each other for help. They compare the settings of the system, and discuss procedures. Also, they often explain its function to friends and relatives who are curious.

The houses have received a lot of attention in the media and many of the occupants have participated in interviews with journalists. Especially during the first year, a lot of people visited the area to have a look at the houses. This is described with somewhat ambivalent feelings. On one hand they are proud of living in a house which receives a lot of attention, on the other hand, when busloads of people enter the area, the situation is described as quite trying. It is evident that the "outside world" wants to know the occupants' opinions. It is mediation that often, but not always, is reciprocal.

THERMAL CLIMATE IN LOW-ENERGY HOUSES

By describing a day in January, the households' different perceptions and experiences of the thermal climate in the buildings are presented. Moreover, different uses of household appliances and the ways in which everyday activities of the households affect the perception of indoor temperature are highlighted. In the description, all data originate from interviews with the occupants.

The thermal climate is technically defined as a function of four physical parameters, i.e. temperature, operative temperature, air velocity and humidity. The section below focuses on the thermal environment from the perspective of the occupants and examines their perception of temperature fluctuations during the day, differences in indoor temperature between levels and rooms and strategies that affect the indoor temperature. Also, air velocity, i.e. draught will be addressed. However, perceptions and opinions do not always correspond, for instance, the household may perceive a fluctuated indoor temperature, but it does not necessarily mean they are troubled by it.

Experiences and activities on a winter day

Early one morning in January, when the occupants of the low-energy houses wake up, the temperature in the bedroom is fairly comfortable. One after the other they enter the bathroom for a shower lasting five to ten minutes and for some up to 20 minutes. Compared to the other floors upstairs, many feel that the floor in the bathroom is cold. A couple of the households describe cold air blowing into the bathroom from the narrow opening under the door.

When the morning arrangements are finished, it is time for breakfast. In the kitchen and the living room on the ground floor it is noticeably colder. The majority experience a temperature difference between the two floor levels. Some consider it to be an "enormous difference", others rather large, and one couple think that the difference is hardly noticeable. Generally there is no agreement as to which floor is warmer or colder. This depends partly on which floor the individual households spend most of the time, and where they keep appliances such as televisions and computers.

"It is much colder down here, and warmer upstairs. The bedroom is much warmer. It is almost too hot in the room upstairs". (Hg5, F)

"Usually it is warmer where you are. But that is nothing that I think of or find irritating." (Hm7, F)

The respondents prefer an indoor temperature of about 20-21°C during the winter, though some would like it to be warmer, approximately 22-23°C. However, what is considered a comfortable indoor temperature differs between different individuals even in the same household.

Him: "Around 20-21°C, I don't want it colder."

Her: "19,5, lets say 20°C. You can always wear more clothes. On the whole, it isn't good to have it too warm."

Him: "But, also, it's unpleasant to be cold."

Her: "Well, I mean in that case you but more clothes on." (Hg 1, M, F)

The opinions and experiences of indoor temperatures may also vary for an individual and factors such as clothes, activities and the time of the day matter. The actual and experienced temperature might differ. One occupant describes the actual indoor temperature on the ground floor as being the same, approximately 18-19°C, in the morning, as when he enters the home in the evening. However, it feels different to him. The morning temperature feels colder.

"The morning is worse, but that is because you come from a warm bed. And if you come from the outside you are [already] wearing a sweater." (Hg 6 M)

The description of the household shows that the terraced houses do not manage to reach the preferred temperatures without the integrated heater. The heat from the occupants, appliances and lightening is not sufficient. Despite the integrated heater, the indoor temperature differs between the two floors. Some households, but by no means all, are concerned about the differences in temperature. The reason why not so many are concerned is because it does not take such a long time to warm up the house. The use of appliances definitely speeds up this time. Breakfast is being made and the family is gathered in the kitchen. Nearly all the families are using the coffee percolator or the kettle. Some use the stove to make porridge. After breakfast many members of the households go to work or to school. In eight of the households no one is at home during the daytime. In six of the households someone is often at home and in two of the households all of them usually stay at home. Those that stay at home during the day and use different appliances like the washing machine, the tumble-drier, the dishwasher and the stove, experience a fairly comfortable indoor temperature.

"If you are inside the house, and you keep moving, using the washing machine, the dishwasher and cooking food and things like that. Then I think the circulation of the heat is good, you feel that there is heat." (Hm 3, F)

However, the everyday activities differ between the households. Some use the washing machine once a week and hardly ever use the tumble-drier, while others do laundry one to three times a day and some also use the tumble-drier every day. The majority do laundry two to four times a week. When it comes to the use of appliances in the kitchen, some of the households often make a hot meal twice a day, while others only three to four times a week. For some the frequency of cooking is somewhere in between. The dishwasher is being used 3-4 times a week by a number of the

households, a few use it 1-2 times a week while others use it every day.

The variations depend partly on the number of members in each household. For instance, the families with children do laundry more often than others. Moreover, if many people are at home, more appliances are being used at the same time as each individual generates heat. However, the use of appliances seems to be necessary, as the occupant's body heat alone is not sufficient to warm up the house.

"If you don't do anything, if you just walk around and don't use any machines, it [the body heat] doesn't matter very much, unless there are like six people or something like that. Then, it [the body heat] could contribute to heating it [the house] up. We often say, you are welcome to come and warm up our house, House warming party." (Hm 3, F)

"One clearly notices if there are only two people at home, or if four of us are at home. Because you warm-up the house yourself and then, maybe more lights are on, you stay in more rooms and things like that" (Hm 5, F)

Some of the households have a greater use of appliances, while others have much lower. Yet, this division is not always correct. For instance, the household that uses the washing machine fewer times is one of the households that most often makes hot meals. The use of appliances also depends on where the occupants happen to be during the day. Those that are often at home use more appliances in the kitchen.

In empty houses the indoor temperature goes down a little during the day. This is something that most of the occupants clearly notice when they come home in the evening. The perception of a colder indoor temperature might be emphasised by the cold floors on the ground floor. One place mentioned in particular is the floor in the hall (which is made of paving tiles). Some feel that the cold floors are quite negative and mention them as a less good aspect of the house, while others always wears slippers and/or are used to cold floors from their former home. It is likely that the floors are not much colder than in ordinary houses, a few point out.

The former houses of the occupants are experienced as draughtier. Discussions related to draught are often related to the thickness of the windows and nearly no one experiences draught from the windows in the low-energy houses. Moreover, the large windows facilitate sun radiation, which contributes to the warming up of the houses. This is particularly the case on sunny days in the autumn and the spring, but not so much during the winter.

When the members of the households are at home, the indoor temperature rises relatively quickly while the dinner is being made, washing is being done, and television is being watched. They watch television, varying from one hour each evening to the whole evening. One of the occupants mentions that she has the television on the whole day, while another occupant usually has the radio or the stereo on during the day.

Many of the households describe things they do in order to take advantage of heat from the appliances. For instance, one occupant states that it is noticeably warmer in the house when the tumble-drier in the bathroom is being used and to facilitate the spread of heat they leave the bathroom door open. Other strategies that have been mentioned include leaving the inner doors open (also in order to facilitate the spread of heat), leaving the oven door open after it has been

used, and leaving the hot water in the washbasin after washing. In addition, many light candles each evening, which they say contributes to increased well-being as well as warming up the house.

"I often light a lot of candles and then we manage to heat it up quite quickly. The candle account is expensive [...], well, candles make it cosy so it doesn't bother us." (Hm 3, F)

Lamps also contribute to the heating. The lighting in the low-energy houses mostly consists of 40 or 60 W (Watt) bulbs, which are sometimes complemented with low-energy bulbs (9 or 11 W). Three of the households mention that they have mostly low-energy bulbs. One household had switched from low-energy bulbs to 40 W bulbs. This change was due to information received in a meeting with the housing company. They were informed that it is more suitable to use ordinary bulbs, since they contribute better to the heating. Many point-out that they have received the same information. Still, two of the households say they do not notice any greater difference between the two bulbs in terms of their ability to generate heat. Despite the information, they have chosen low-energy bulbs. Some households are not fond of the light given off by the low-energy lamps and have therefore not chosen them.

Later the same evening it is time to go to bed. A couple of the occupants say that sometimes, too much cold air blows from the supply devices, located on the floor in the bedrooms, especially when the automatic regulation system is used.

One house is empty and the integrated heater is switched off. The family has been away over Christmas. When they enter the home the next day it is cold inside and it takes a long time for the indoor temperature to rise, significantly longer than if the integrated heater had been switched on. To raise the temperature they light a lot of candles and switch on a separate radiator. Similar experiences have been witnessed from other households. One talks about their return from a two weeks holiday abroad. The indoor temperature was then only 14°C, which was not pleasant, since they were now used to a temperature of around 30°C. It took between half a day and one day to warm-up the house again, which they did with the help of separate radiators. Another household says that it was only a little colder than usual when they returned home from their holiday. They had left the integrated heater on while they were away. A third household had received help from a neighbour, who had switched on the integrated heater the day before they returned home.

Her: "It took quite a long time to heat this place up too. Because the house has got a long time factor, hasn't it? When you are supposed to heat it up. It doesn't warm up very quickly."

Him: "Yes, I remember that."

Her: "Yes, it was cold, we needed to have our jackets on indoors." (Hm 2, F, M)

"We think it's better to keep it switched on even when we're away so that you have, so that you keep the heating even." (Hm 5, F)

The well-insulated building structure could store heat for a long time, which means that the air can be heated quickly after a day without people heating the building. On the oth-

er hand, it will take longer to heat the house if it has been empty for a longer period.

General opinions about the houses

The presentation above describes the households' preferences regarding the thermal climate of the buildings. But as highlighted in the purchase process of the houses, there are other preferences that might be more important than the heating system and the thermal climate. For example, the location is regarded as pleasant and the design of the houses is popular among the households. The large windows towards the south and the open floor plans are also appreciated. Moreover, many describe the air-quality as very good. Negative aspects mentioned included the fact that the storage room situated close to the house was not insulated and there was no water tap in the garden. Many of the occupants had asked for an outside water tap but were told that a tap would mean interference in the insulation of the house, which could lead to energy losses. Indoor sound-levels were also described as too high. But in general, the majority are very satisfied with their new house.

Conclusions

The design of the building and its climate installations can be looked at as a compromise when it comes to comfort. Standardised solutions are implemented, which try to meet the needs of most people. Even if individuals try to adapt to the construction there will, as Star highlights, be misfits between standardised or conventional technological systems and the needs of individuals.¹⁵ Also, needs are not constant, they change over time. In one household a member became ill and the indoor temperature suddenly did not meet the new needs. They had to use an additional radiator.

Therefore, it is not strange that opinions about indoor temperature and the heating system differ slightly between the households. The number of members in the household, if they live in a gable or a middle house, and how much time they spend at home seems to partly explain why.

The producers of the building have an obvious impact on comfort because their ideas were implemented in the design solutions. In the case of the low-energy terraced houses south of Gothenburg, the architect had a family consisting of two adults and two children in mind when he constructed the houses. Also simulations have been done that are based on this composition. Their estimations partly correspond with the results from the qualitative interviews. The household consisting of four people who live in one of the middle houses does not experience any trouble with the indoor temperature. On the other hand, households consisting of less than three people have trouble maintaining an acceptable indoor temperature during the winter, if they live in one of the gable houses and spend a lot of time outside the house.

The fluctuation of the indoor temperature is not a problem to many of the occupants, since the temperature rises quite quickly when household appliances and candles are

used. On rare occasions, when the indoor temperature is too low, it is always possible to complement with an extra radiator, many reason. In comparison with the findings on space heating habits among households in Norway and Japan (the cross-national study mentioned above), this system seems to function more like the Japanese energy solutions than the Norwegian. The Japanese households tend to heat only the room they usually occupy, while the Norwegian households heat almost every room in the house.¹⁶ In a way, the space heating in the low-energy houses is restricted to the occupied zones in the house, since the occupants themselves and their use of technology have a considerable impact on the space heating of the houses.

The low-energy solutions had a prominent place in the marketing of the houses. However, the low-energy concept was not of great significance to the occupants, rather the design, the price and especially the position of the houses had a greater impact on the purchase process. This indicates that in order to be able to establish a market, (which, with regard to the environmental problems is of high concern) and to make the low-energy solutions more common, one strategy is to start building these houses in attractive areas, where the demand for houses is high. Then, the possible higher costs for building insulation etc., does not play a great part, since they may be cheaper than other houses in the area anyway.

Taking the experiences of occupants into account when developing the next generation of low-energy houses is of great importance. It makes it possible to improve the design and the technology in use and in the long term, it also makes it possible to work out how to stimulate a market with low-energy solutions in the built environment.

References

- Aune, M (1996) The computer in everyday life. Patterns of domestication of a new technology. I.M Lie & Sorensen (red) Making technology our own? Domesticating technology into everyday life. Scandinavian University Press, Oslo.
- Bostöm, Glad, Isaksson, Karlsson, Persson, Werner (2003) *Tvärvetenskaplig analys av lågenergihusen i Lindås Park Göteborg*. (Interdisciplinary analysis of low-energy house in Lindås Park) Arbetsnotat Nr 25. ISSN 1403-8307. Original in Swedish.
- Edquist C (2001) Innovation Policy – A systematic Approach. Archibugi D and Lundvall B (Eds) The Globalizing Learning Economy. Oxford University Press, Oxford.
- Egnahemsbolaget (2000) *Sol och skön natur*. (Sun and lovely nature) Brochure from Egnahemsbolaget. Original in Swedish.
- Kvale S. Den kvalitativa forskningsintervjun (The qualitative research interview), Lund: Studentlitteratur, 1997. Original in Swedish.
- Ruud, Lundin (2004) Bostadshus utan traditionellt uppvärmningssystem – Resultat från två års mätningar (Residential houses without a traditional heating sys-

15. Star (1991)

16. Wilhite, Nakagami (1996)

- tem. – Results from two years of measurements.) SP Swedish National Testing and Research Institute. SP Report 2004:31
- SCB. Energy statistics for one- and two-dwelling buildings in 2001. EN 16 SM 0201, Örebro: Statistics Sweden, 2002.
- Sikisö (1991) Bostadsvalet ur ett sociologiskt perspektiv. (The choice of living from a sociological perspective) Research report. Statens institut för byggnadsforskning. Gävle. Original in Swedish.
- Silverstone, R. Hirsch, E. (1992) *Consuming technologies Media and information in Domestic Spaces*. Routledge, London.
- Silverstone, R. Haddon, L.(1996) Design and Domestication of Information and Communication Technologies: Technical Change and Everyday Life. Mansell, R. Silverstone, R. (Eds) *Communication by Design The Politics of Information and Communication technologies*. Oxford University Press, Oxford.
- Star, S. L. (1991) Power, technology and the phenomenology of conventions: on being allergic to onions, in John Law (ed) *A Sociology of Monsters: essays on power, technology and domination*. Routledge, London. pp. 26-56
- Stem, Energiläget i siffror. (the Energy state in numbers) ET 19:2002, Eskilstuna: Swedish Energy Agency.
- Wilhite H, Nakagami H (1996) A cross-cultural analysis of household energy use behaviour in Japan and Norway. *Energy policy*. Vol. 24, No9. pp795-803.