Technology, Users, and Sustainable Social Housing

Jan Johansson, PhD
Senior Lecturer, Copenhagen School of Design and Technology, Denmark

Abstract

This paper aims to contribute with results in relation to the challenges that users encounter with regard to technologies in sustainable social housing. The results are significant and show that in modern Danish sustainable social housing consideration is not taken for the users in relation to the technologies implemented in the buildings. The consequences are that the intentions of the technologies supporting economic, environmental, and social sustainability do not work for the users when the buildings are taken into use. The paper argues that developers and architectural practice should in future use simpler technologies that give residents the opportunity to individually regulate their homes' indoor climate. At the same time, architecture and technology should reflect the consideration towards the climate in the local context and the users' funda-mental living conditions. The paper argues for the development of a more user-oriented architecture, where the interaction between architecture and technology can work for the users and to a greater extent support the intentions with regard to sustainability.

Keywords: technology, sustainability, architecture, users, interviews, phenomenology

Introduction

If our own culture can be changed as a consequence of environmental problems, then sooner or later it will influence architectural design as a reflection of our cultural and social values (Bech-Danielsen, 2005, p. 14). Over the years, Danish architects and the social housing sector have provided different architectural answers to these complex challenges in the form of sustainable social housing in order to meet a sustainable transition.

The challenges are however that sustainable social housing is typically different in its design than ordinary construction. Sustainable construction can be different in terms of heating, ventilation, the technologies used, tectonics, etc. It implies that these homes are different with regard to the necessary knowledge and handling of the operating conditions (Jensen, Jørgensen, Elle & Lauridsen, 2012, p. 21), as well as the functionality of the building's sustainable intentions (Jensen et al., 2012, p. 99-100).

The Danish social housing sector has in general considerable expertise and better conditions for carrying out sustainability goals in the running of their buildings in relation to other forms of ownership (privately owned and privately rented). There is strong engagement in sustainable issues amongst administrators, who have experience in relation to being entrepreneurs for both many and large units. The weaknesses are that the residents' ownership of the building is often small and often has a short time frame in relation to long-term investments, which is a requirement for sustainable construction (Nielsen, Jensen & Jensen, 2012, p. 12).

Sustainable architecture should be simple, since it is so-called "ordinary people" who will live in it (Bordass & Leaman, 2013, 34:44-36:22) because they want to live as "ordinary" a life as possible without being particularly interested in the environment or showing particular interest in sustainable ways of living (Jensen et al., 2012, p. 19). The users' consumption and behaviour (Shove, 2003, p. 1-20) – and hence lacking or unintended consequences of this in relation to the intentions – must not be used as an excuse by the architects and other experts when sustainable construction does not work. The users' behaviour must be understood and influenced in a respectful way. If long-lasting sustainable solutions are to be met, then architectural practice must approach the task with a humble, respectful approach to the users (Bordass & Leaman, 2013, 34:44-36:22).

Complex requirements are placed on architectural practice, with a comprehensive understanding of all aspects of sustainability. In this regard, architectural practice must be able to professionally engage in a broad range of disciplines and specialities. At the same time, design requirements are also made in relation to the users' role (Bordass, Leaman & Willis, 1994, p. 1-8) and that the users' role gives rise to requirements for the building's operation (Leaman & Bordass, 1993, p. 4-14; 1997, p. 1-10). Architectural practice should therefore direct its focus towards the users' role and requirements for the building's operation in order to be able to achieve intentions for sustainability's so-called "triple bottom line" (Twinn, 2012, p. 128).

Buildings, Users, and Qualitative Evaluation

There is a need for the development of more sophisticated assessment strategies in the interaction between the human factors and buildings' physical capacity. Quantitative assessments of construction cannot stand alone but should instead be supplemented with qualitative assessments of residents' expectations, meanings, perceptions, and behaviours (Stevenson & Leaman, 2010, p. 571). This supports a need for new methods and new knowledge with a greater focus on the process as well as making the qualitative (soft) values of existing construction visible (Madsen, Beim, Reitz & Bang, 2015, p. 74-78).

More knowledge about the interaction between residents, administrative staff, and operating staff is valuable for those developing new housing as well as its subsequent operation (Leaman, Stevenson & Bordass, 2010, p. 575). We should focus on the building as it is used so that the experiences can be utilised in the design process of future constructions (Stevenson & Leaman, 2010, p. 571), where residents are often the best judges of buildings and can contribute with valuable feedback (Grierson & Moultrie, 2011, p. 632).

In this connection, this paper would like to contribute to the discussion with results as well as in relation to the challenges the users encounter with regard to technologies in sustainable housing architecture. The paper suggests challenges that could also have an impact when developers and architects develop new buildings. The contributions to the discussion are based on the results from a qualitative evaluation of sustainable housing from the author's PhD project (Johansson, 2017) entitled: "Sustainability in Danish social housing – with a user focus".

Theoretical Aspects

In using a phenomenological approach, the PhD project's study design has taken its starting point in the early Husserl's epistemological preoccupation of investigating people's realisation and describing their experiences of the phenomena (Zahavi, 2006, p. 12-18). The task has been to go "to the issue itself" without preconceived opinions and theories (Rendtorff, 2003, p. 279-281). There is no objective, independent research object but in contrast a subjective experience and the attribution of meaning in particular life worlds (Justesen & Mik-Meyer, 2010, p. 26; Mo, 2003, p. 57-59).

In principal, phenomenology was chosen in order to have an open and unbiased opportunity to capture people's life worlds. At the same time, this approach has an impact on the methodological research method, where the use of the interview as a method (Kvale & Brinkmann, 2015, p. 48-55) can contribute to the issue with many spontaneous, rich, and specific answers, as well as an ideal of achieving "thick descriptions" (Geertz, 1973, p. 3-30).

Research Question

The guiding research question for the PhD project is: Does the sustainability in sustainable social housing work for residents, operating staff, and administrative staff? And this also included the sub-questions: What are the users' experiences of sustainable social housing? How can the users' experiences be used in the development of future sustainable social housing?

Criteria for Case Selection

The study is limited to including three family-friendly and sustainable terraced social housing buildings in Denmark. The buildings are experimental constructions that have neither been renovated nor rebuilt after being taken into use. The choice of buildings that have not been renovated and/or rebuilt after being taken into use is because the aim is to capture the users' experiences with buildings that have been taken into use over a longer period in relation to the original intentions regarding sustainability. The choice of multiple cases is made in order to strengthen the precision, validity, and stability of the results (Neergaard, 2010, p. 21-22).

The three case studies are chosen based on the criteria of *maximum variation*. By choosing a small number of cases with maximum variation, the data gathering and data analysis will give two kinds of result. Firstly, it provides detailed descriptions that can *document unique features* in the individual cases. Secondly, it can *identify important common patterns* across the cases, which has vital importance (significance), because they occur on the basis of heterogeneity (Neergaard, 2010, p. 21-26).

With reference to *"identifying important common patterns"* in the three cases, the following criteria are chosen: Danish buildings; social housing sector; terraced houses; family-friendly homes; innovative/experimental construction; terraced houses that have not been renovated after being taken into use; the same types of user groups to be interviewed (residents, operating staff, and administrative staff) – semi-structured deep interviews; the same types of user groups to be interviewed (residents, operating staff, and administrative staff) – semi-structured focus group interviews; the same types of architect groups and developers – structured deep interviews.

With reference to *"documenting unique features"* in the three cases, the following criteria are chosen: Case 1 – sustainability: low-energy construction (little) with ecological initiatives (Ikast, West Jutland); Case 2 – sustainability: low-energy construction (a lot) according to the Passive House standard (Lystrup, East Jutland); Case 3 – sustainability: low-energy construction (medium) sustainable building operation with increased self-management (Copenhagen, East Zealand).

Methods

For each of the three case studies, the following three combinations of methods are used: semi-structured deep interviews (method 1), semi-structured focus group interviews (method 2), and structured deep interviews (method 3). In this way, the strength of validity was sought with the help of three subsequent follow-up methods as the basis for a triangulation of methods (Halkier, 2008, p. 15-18; Barbour, 2007, p. 44-47). Seventeen semi-structured deep interviews, three semi-structured focus group interviews, and six structured deep interviews were carried out.

Residents, operating staff, and administrative staff are chosen as interview subjects because the subject matter of the research question is the operational issues relating to the use of the sustainable construction. Initiators/developers and architects are chosen as the interview subjects, since the aim is to create new knowledge that can partly frame the users' experiences but also put the results into perspective with a view to real development potential.

In method 1, the residents (snowball sampling), operating staff (key people), and staff from the operating administration (key people) were interviewed individually using semi-structured deep interviews. Here, it has been relevant partly to ask about the project's main question and sub-question: "Does the sustainability in sustainable social housing work for residents, operating staff, and administrative staff?", as well as ask about the sub-question: "What are the users' experiences of sustainable social housing?" The essences of phenomenological analysis (Brinkmann & Tanggaard, 2010, p. 51) have been used to formulate the questionnaire for method 2.

In method 2, the same users were invited to participate in semi-structured focus group interviews (Barbour, 2007, p. 38). Where residents have cancelled, these participants have been replaced by other residents (snowball sampling). The essences from the phenomenological analyses from method 1 and method 2 were used as the questionnaire when carrying out method 3. The coupling of identical results from method 1 and 2 contributed to a further strengthening of validity and potential generalisability in relation to typical features (Dahlberg, Dahlberg & Nyström, 2008, ch. 4; Giorgi & Giorgi, 2003, p. 243-273). The qualitative focus group interview is chosen in order to be able to see patterns and general processes, categories, and dynamics in the user groups. It is based on these elements that generalisations can be made (Halkier, 2008, p. 111-112). The criterion about communicative validation (Kvale & Brinkmann, 2015, p. 325-337) was furthermore brought into play in method 2, since parts of results from the analysis are presented to the interviewees, who have contributed to the empirical material and in that way are a part of validating the analysis' results.

In method 3, both the developers (key people) and the architects (key people) were interviewed individually using structured deep interviews (Justesen & Mik-Meyer, 2010, p. 56) with a view to whether the users' experiences could be used in the development of future sustainable social housing. The essences from the phenomenological analyses (methods 1 and 2) gives rise to new questions to be used in preparing the interview guide and carrying out method 3. In method 3, questions are primarily chosen that can point forward with reference to the research's sub-question: How can the users' experiences be used in the development of future sustainable social housing?

Case 1: "Økohus 99"

The "Økohus 99" settlement was finished in 1998, and is the result of an architecture competition for the construction of what could be called first-generation, low-energy terraced houses with ecological initiatives.

Typical sustainable characteristics are the zoned house, exploiting the passive heat from the sun in the "sun house". In addition, the buildings have ecological initiatives in the outside areas in the form of a lake collecting rainwater with a root zone system and water channels. The water channels are an integrated part of the homes' cooling system. In order for the intentions behind the architecture to work, a high degree of user involvement is required.

Ecology as a principal goes back to the beginning of the 1970s, where the grassroots environmental groups tried to transform a sustainable way of thinking into an architectural mode of expression. The grassroots groups' structural answer has been based on environmental sustainability with an ecological basis. The ecological construction attached importance to the incorporation of "natural" building materials, reusable materials, and alternative building forms. The ar-chitects chose to build according to traditional building methods, with the use of so-called "clean" building materials based on simple production (Beim, Larsen & Mossin, 2002, p. 10-11). This approach to sustainable architecture is defined as the "ecocentric logic", which originates from the belief that the solution to the environment question is founded in a radical rethinking of values. It is a metaphysical, holistic discourse with a view of "getting back to nature" generated through the natural science paradigm (Guy & Farmer, 2001, p. 142-143).

The "ecocentric logic" also represents an architecture that, with a holistic way of thinking, has the goal of having an educative effect and contributing to a particular culture of living for the users. The physical form forces the users to relate to, for example, consumption habits, heating opportunities, recycling, and reusability (Beim et al., 2002, p. 10-11).

In "Økohus 99", the zoned home is divided into two zones. The first zone is the "sun house", which is a low-tech technology that generates passive heat from the sun. In addition, "sun house" functions as a hallway and dividing space with stairs to the first floor. The other zone is "the receiver" of the accumulated passive heat. This zone consists of a ground floor of bedrooms and on the first floor a kitchen and living room.

The thought was that when it was cold outside, then the "sun house" would only be used briefly, since the room should only be used when moving from one level to another. However, some residents use the "sun house" for a different purpose than what was intended; for example, they use it as an office all year round. In the winter time, the "sun house" thus has limited usage possibilities. It is difficult to keep the room warm in the winter, and the resident has therefore installed an extra radiator. This leads to a high electricity consumption equivalent to 150 kWh/m2. It means an electricity consumption three times greater than estimated. According to the architect, this use of the home is against the intentions and is decidedly "incorrect" use. It does not encourage economic and environmental sustainability.

In the "sun house", there is a concrete wall painted blue, which in itself is a low-tech solution that is able to accumulate the sun's heat directly from the solar rays. In the evening, the accumulated heat from the concrete wall is released to the bedrooms behind it on the ground floor. On the first level, the stored heat is transported from the "sun house" into the living room and the kitchen by opening the door to the "sun house" or opening the internal folding windows. The mechanical ventilation technology supplies the colder north-facing rooms on the ground floor with the accumulated heat from the "sun house". It is therefore important that the mechanical ventilation technology is either set to its "summer setting" or its "winter setting", depending on the time of year. At the same time, the residents are aware that when the mechanical ventilation technology is connected, it leads to an increase in electricity consumption. In order to save on that expense, some residents turn the technology off completely.

The residents' experiences are that when it is warm outside, it heats up in the "sun house", and when it is cold outside it becomes correspondingly cold. In the summer, it can easily be 30°C in the "sun house". If the living room and the kitchen on the first floor are to be cooler when the residents come home from work in the summer period, it is absolutely crucial that the opening glass partition into the "sun house" and the door to the stairs are closed during the day, so that the accumulated heat stays in the "sun house". If this heat-generating functionality is not used correctly, if the door and the internal glass partitions are for instance left open at the wrong time of day, it means that the residents are not able to stay in the kitchen and living room. However, the challenges are that the residents do not know the function of the blue-painted concrete wall, and neither do they know when they have to open and close the internal folding windows.

Since it was difficult for the residents to regulate the heat via the sunlight in the “sun house’s” south-facing facades, an automatic window-closing technology was set up inside, as well as manually controllable sun shading. However, these technologies broke easily and some children’s fingers became stuck when the windows closed automatically. The large south-facing glass partitions also led to privacy issues, which is why several residents constantly rolled down the internal sun shading.

Evaporative cooling is yet another technology that is indispensable for the functionality of the “sun house”. This natural ventilation technology was intended to work using the cooler water from the outside water channel. The intention was that residents would open the small window in the south-facing angled facades. This was with a view to accelerating the chimney effect and creating a faster circulation of fresh air through the home, precisely in order to avoid overheating. The location of the small window was, based on the architect’s drawings, just above the surface of the water. However, this was changed in the project design and moved higher up, since Bomidtvest were afraid that small children could crawl out of it and, in the worst case, drown. It can be argued that this change, where the window close to the surface of the water was moved further up, reduces an effective evaporative cooling as natural ventilation.

But the residents do not know the actual purpose of the water channels and their connection with the homes’ opportunity for natural ventilation. It can therefore be argued that the lack of information about the use and the functionality of the natural ventilation as a technology is not exploited optimally due to the higher placement. This leads to a poorer indoor climate, and the lack of information about the natural ventilation thus becomes a barrier for social and environ-mental sustainability.

The “sun house’s” sustainable technologies are often used inappropriately or outright incorrectly. The heat-accumulating functionality with the internal windows and doors is often used incorrectly. The natural ventilation with cooling from the outside water elements is used randomly. Residents find that regulating the temperature in the home is particularly difficult and they ask for “tools” to deal with this problem.

One of the important reasons for the large number of people moving from “Økohus 99” is that many residents could not work out how to regulate the temperature in the “sun house”. According to “experienced” residents, it is necessary to incorporate routines where the “sun house” is used when the season allows it. There is an example of one family being able to live their lives in collaboration with the technologies by taking account of the daily weather forecast as well as the seasonal variations.

Overheating in the homes thus becomes an important problem as a result of incorrect use. This incorrect use of the “sun house” as low technology increases energy consumption used for heating in the wintertime, which it can be argued contributes negatively to the environmental sustainability. And the overheating reduces the quality of the home’s indoor climate and thus the residents’ well-being. It can be argued that they contribute negatively to the social dimension of sustainability.

Furthermore, it can be argued that insufficient knowledge and information about the “sun house’s” functionality is the reason why the residents are not able to regulate the home’s temperature and indoor climate. It can be claimed that the extent and complexity of the sustainable initiatives have been too ambitious.

Case 2: “Lærkehaven III”

The “Lærkehaven III” settlement was finished in 2010, and is the result of an international project competition, with the goal of being able to display sustainable residential architecture according to the Passive House standard. The buildings have green common areas and a lake that collects rainwater, with adjoining water channels as additional environmental, sustainable initiatives. Its function is to counteract flooding and unnecessary loads on the sewer system.

Typical sustainable characteristics are the highly insulated, low-energy house and represent the first larger terraced social housing in Denmark in accordance with the principals of the Passive House standard. The requirements are that the houses, without help from renewable energy sources, are allowed to use a maximum of 15 kWh/m2 per year on heating and cooling. In addition, there is a requirement regarding the building’s airtightness, which is not allowed to be greater than 0.6 m3/h/m3 (Jensen, Jensen & Gram-Hanssen, 2014, p. 76-77; Beim & Vibæk, 2013, p. 210-216). This approach to sustainable architecture is defined as the “eco-technical logic” (Guy & Farmer, 2001, p. 141-142), which is characterised by having a top-down view of environmental changes that occur with the help of integrated energy-efficient high-tech solutions in the construction.

The intention with a passive house is primarily that the building is constructed with highly insulated external walls, floors, and roofs. Heat reutilisation occurs using solar energy, people, and the appliances in the home. This happens in an interaction with the external sun shading. The intention with "Lærkehaven III" is that the heat given off by people, combined with the energy given off by household appliances (e.g. lighting, when cooking food), should be sufficient to heat the home.

The houses in "Lærkehaven III" use a passive climate control that is built according to the passive standard, where the mechanical ventilation with passive heat recovery is an important sustainable initiative. This technology produces both heat to warm up the rooms and hot utility water. This is achieved with the technology's heat exchanger drawing in cold air from outside and injecting the home's warmed-up air, which circulates and is reused. The intention is therefore that the residents do not need to air out the home by opening the windows or doors.

The operating staff have the opinion that the residents can control their consumption themselves and are thus also in control of the rental costs. The operating staff claims that the intention with regard to the residents' operating economy is in principal good in some of the houses, but the reality proves to be something different – there are in fact large differences in the use of electricity. The administrative and operating staffs' experiences are that it is expensive to use the mechanical ventilation with heat recovery as a technology in terms of operating costs. The more frequent replacement of the technologies' filters increases the operating costs and thus the residents' rent.

The residents have experienced that they have a large electricity consumption in the wintertime. There is an overconsumption of electricity, which some of the residents do not completely understand. Residents receive electricity bills for extra consumption, which indicates an electricity use that is much greater than the average for a normal family. The reasons are operating errors in relation to the heating surface in the mechanical ventilation with passive heat recovery and because the technologies have not been set up correctly. This means that the residents subsequently receive a large additional bill that is not their fault. However, the residents have given up trying to get the administrative staff to admit that it is not the residents who have an overconsumption but that it is caused by system errors in the technology. It does not encourage economic and environmental sustainability.

Hence, there are residents who are now against using the mechanical ventilation with heat recovery. They have developed a behaviour that works against the intentions of the technology. There are now residents who do not change the settings of the heat recovery technology in relation to the summer and winter halves of the year. This is because it is difficult for some residents to get the technology to work at all. Therefore, if the residents have had problems with their mucous membranes at the same time, they choose paradoxically to use the same settings all year round in order to avoid adjusting the technology, which could potentially worsen the problems with their mucous membranes.

Due to the high electricity costs, some residents therefore attempt to save on their electricity consumption by turning down the temperature in the house in the wintertime. But the residents' experiences are that they cannot reduce the temperature in the house if the consequence is that the family freezes. In the winter, the heat produced is supplemented with the help of a heat cartridge in the mechanical ventilation, but according to the residents this is not enough to stay warm. In order to improve the comfort, the residents add extra heating by using candles, oil radiators, or electric fan heaters.

There are requirements for the residents to be particularly aware of the annual and daily climatic variations in order to counteract the home's overheating in the summer or its cooling in the winter. It is thus crucial that the residents regulate the heat from the sun's rays with the help of the external shutters on the south-facing facades. The challenge is, according to the residents, that even though they use the sun shading correctly, the house still overheats. In the summer, it becomes overheated on the first floor. And when the home has become overheated, the temperature increases even more when the external sun shading on the large south-facing windows is rolled down. In the winter, the opposite occurs. The residents' experiences are that they still freeze on the ground floor even though the sun shading is up in order to enjoy the sun's rays. In the winter, the heat gathers and stays on the first floor in the double-height room. It is in this way difficult for the residents to regulate a steady temperature all year round.

It can be claimed that there is a connection between the large south-facing windows and the disproportionately larger contribution of heat from the sun's rays than is needed – especially in the summertime. Therefore, it is argued that one should program and design for greater user-friendliness as well as easy building management in the future. This is reasoned based on that it gives a more resilient and sustainable architecture in the long term (Bordass & Leaman, 2013, 34:44-36:22).

The results suggest that the passive houses with highly insulated building constructions, high airtightness requirements, as well as ventilation technologies contribute negatively to the residents' well-being and living quality. The user experiences suggest that the residents are willing to move because of the above-mentioned problems with the technology in "Lærkehaven". It can thus be claimed that the architecture and the technologies become a barrier to the life lived and do not support social, economic, and environmental sustainability.

Case 3: "Grøndalsvænge"

The "Grøndalsvænge" settlement was finished in 2012, and is the result of a concept that mainly combines reducing the cost of production with the residents' increased self-management in running the building.

Typical sustainable characteristics are the highly insulated, low-energy house built according to energy class 2020. The buildings are built with mechanical ventilation with heat recovery. In addition, the residents' "do-it-yourself" involvement in the home's flexible layout, operation, and maintenance, as well as the building's operation is a representation of social sustainability. "Grøndalsvænge" seems to represent two trends at the same time. On the one hand, the "eco-technical logic" with a focus on the construction and energy efficiency. On the other hand, the "eco-social logic" with a focus on the users' social dimension in the form of "do-it-yourself" and involvement in the operational aspects (Guy & Farmer, 2001, p. 141-146).

The mechanical ventilation technology with heat recovery does not have a cooling function. In this way, it can be difficult to maintain a coolness when the residents have to sleep. In the summer half of the year, the residents find that the highly insulated homes become overheated – an experience the administrative staff share. According to the residents, the technology actually heats the air a little – even in the summer. When the home is already overheated, the mechanical ventilation technology makes the indoor climate even worse.

Overheating makes it difficult for the residents to spend time in the homes in the summer half of the year. The large glass areas in the facades increase the overheating. As sun shading, there are room-high perforated plates on the facades. The residents use the external facade perforated plates or their blinds as sun shading. This is excellent for reducing the view into the building and improving privacy, but according to the residents it does not reduce the homes' overheating. In order to counteract the accumulated heat in the summer, approximately 30 families have bought a cross flow heat exchanger for the mechanical ventilation with heat recovery. A cross flow heat exchanger does not have a specific cooling function, rather it ensures that the technology does not generate further heat for the home. The users' experiences show that the homes and the technologies have caused the residents a number of problems with overheating as well as a dry indoor climate, with a drying out of their mucous membranes and hands, which has not worked for the residents. This does not support social sustainability.

In order to achieve a cost-effective level of consumption, it is necessary for the different technologies to be set up correctly (e.g. the mechanical ventilation with heat recovery and the heating technology). Apparently, only small adjustments in the technologies are needed to ensure that the equipment works optimally and thus avoid large utility bills. According to the developer, the technologies are conceptually fine, and the reasons for the lack of energy savings are a combination of the technology and the correct behaviour of the residents. The user experiences show that the mechanical ventilation with heat recovery has not worked optimally for the residents. The mechanical ventilation technology with heat recovery has not been set up correctly, which may have caused unfair additional expenses for the residents. The intention of combining a highly insulated building construction with a technical ventilation technology has not reduced the heating costs and thus has not reduced CO2 emissions. It has not to a sufficient extent made a positive contribution to the economic and environmental sustainability.

One can argue that the homes are dependent on an overcomplicated technology. In addition, the required operational monitoring of the homes' technologies has not been reduced in "Grøndalsvænge". On the contrary, due to the increased self-management the running of the complicated technology has been left to the residents, the result of which has been energy waste. The residents are unsatisfied and are concerned about self-managing the technologies. It does not support social sustain-ability.

Discussion and conclusion

A pattern emerges between "Økohus 99", "Lærkehaven III", and "Grøndalsvænge" in relation to the implementation of complicated building-integrated technologies, whose aim is to ensure that residents have a good indoor climate and to encourage economic, environmental, and social sustainability. The results show a connection between overcomplicated technologies that have not worked for the three user groups in the operating phase in terms of environmental or social sustainability.

The reasons have been, amongst others, that residents, operating staff, and administrative staff do not know about the technologies and the functionality, that the technology has been shown to have defects, that the technologies have not been set up correctly when taken into use, and that the residents use the technologies incorrectly. The resulting effect is, amongst other things, an increased energy consumption, which can have imposed unfair additional expenses on the residents in the operating phase.

If the administrative staff have not received the necessary knowledge and information about the technologies (e.g. from the developers, advisors), then it can be said that they are not able to pass on the know-how to the operating staff. For the operating staff, this means that if they cannot get basic information about the technologies from the administrative staff, then they are dependent on getting technical information from somewhere other than the housing organisation (e.g. external service providers, calling the supplier). Finally, the residents are dependent on getting information and insight from the operating staff or the administrative staff. If the residents cannot get the necessary background information from one of these two user groups, then they are dependent on getting the technical insight from other sources (e.g. the Internet, neighbours, friends, family).

On the one hand, it can be claimed that the three user groups themselves have a responsibility to acquire sufficient basic knowledge. They could certainly be more insistent internally in the housing organisation and in relation to the building's external partners in order to get the necessary basic knowledge required to operate and live in the sustainable terraced houses.

On the other hand, it can be claimed that the results essentially show failure with regard to the housing organisations' efforts to ensure that the residents, operating staff, and administrative staff receive sufficient knowledge about the technologies in the sustainable buildings. This shows an underestimation of the negative impact that the users' lack of basic knowledge has on the environmental and social sustainability. It can be argued that technology, architecture, and sustainability are dependent on each other. At the same time, this indicates that the technologies have become overcomplicated and unusable for so-called "ordinary" users.

It is possible that the developer is not aware that the users' lack of knowledge about the technologies is a hindrance in terms of the environmental and social sustainability. Conversely, the author believes that the developer, on behalf of the three user groups, has the overall responsibility to ensure that a social housing development is well run – also with regard to the issue of technology. Therefore, it should be the developer who finds solutions to this issue. Could complaints be directed at the advisors, entrepreneurs, etc.? Should the developer not be more interested in an actual solution to the problems that are close to the users?

It has been established that there are defects in the technology and that the technologies were not set up correctly when first taken into use. In addition, the combination of a highly insulated building construction and the technology has consequences in the form of poor indoor climate (e.g. overheating, dry indoor climate causing eye irritation, the drying out of residents' mucous membranes or hands). There is furthermore a common pattern, where the residents move out of the buildings for the above-mentioned reasons.

Also, the consequences have been that the residents, because of their reluctance, have developed a behaviour that works against the technologies. The administrative staff in believe it is worth noting that when working with renting out social housing, the building should not be so complex for the residents as it is in "Økohus 99". The complexity of, for example, self-regulating heat management and ventilation should instead primarily work automatically. Otherwise, according to the administrative staff, it will not work. Bordass and Leaman suggest that it is difficult to dictate to users that they should do something in particular. They point out that it is, in general, our buildings that are dictatorial, since they consume more energy than they need just to be inhabitable.

On the one hand, defects and the incorrect settings on the technologies lead to additional expenses, frustration, and poor indoor climate for the residents. The defects lead to frustrations for the operating staff and administrative staff, as well as unexpected operating costs for external service providers, the changing of filters, greater operational vigilance, etc. On the other hand, defects and the incorrect settings of the technologies must be directed to the suppliers, since the developers must expect to receive the faultless technology that has been paid for. The incorrect setting up of the technologies must be directed to both the entrepreneurs and the advising engineers, since this is their area of responsibility.

Administrative staff, operating staff, and developers suggest that the technologies' lack of functionality is caused by the residents' behaviour and incorrect use. It is true that some of the residents use the technologies incorrectly. However, this is an oversimplified causal explanation. The results of the study instead paint a picture of other and different types of issue that have made it impossible for the residents to use the technologies correctly. The reasons have primarily been a lack of knowledge and information, lack of user involvement, as well as a lack of communication. And if one or more of these parts has not been present, it can lead to the residents losing their motivation in relation to the technologies, the result being incorrect behaviour and use.

At the same time, there is a worry that Danish social housing is influenced by the supplier's desire to sell their products on the pretext of "sustainability". Who says that sustainable construction has to have, for instance, mechanical ventilation with heat recovery? Who says that you have to have a technology so complicated that it makes it difficult to use in practice? When do the developers put their foot down to the suppliers, the entrepreneurs, and the advisors?

User satisfaction is increased the less complex the technology is and the less the technology requires in terms of operational vigilance. In addition, user satisfaction is increased the more context-dependent the architecture is, in combination with the users' opportunity to be able to regulate the architecture's technologies themselves, and in that way be able to adjust the home's indoor climate (Leaman & Bordass, 1997, p. 1-10). In conclusion, it is thus argued that the three cases are representative of complicated technologies, where significant results from the three user groups' show a context that has not supported the planned economic, environmental, or social sustainability of the buildings in the operating phase. The lack of interest, knowledge, and information about the technologies amongst the user groups thus shows important common patterns across the cases and can therefore be vitally important (significant), because they occur on the basis of heterogeneity.

The results indicate the importance of the residents working with routines in interaction with the climatic seasonal variations in order to get the homes' indoor climate to work appropriately for all cases. In addition, there is also a need for new methods of passing on information and knowledge to the three user groups with regard to the use of the building-integrated technologies. In order to meet a need in relation to a more resilient and sustainable architecture, one possibility could be to find inspiration in the interaction between the constructions and building-integrated technological solutions found in traditional climate-adapted architecture (Dahl, 2010).

The goal in the development of future Danish social housing could benefit from investigating and using the experiences of the users in the local context, and in that way designing simpler architectural and technological solutions with a greater opportunity for the residents to individually regulate their home's indoor climate. The point is that the shaping of sustainable housing should go "hand in hand" with user satisfaction. Here, simpler architectural and technological solutions could contribute towards a more resilient architecture and thus a more user-oriented sustainable architecture.

References

[1] [1]Barbour, R. (2007). *Doing focus groups*. The SAGE Qualitative Research Kit. Thousand Oaks, CA: Sage Publications.

[2] [2]Bech-Danielsen, C. (2005). *Ecological reflections in architecture: architectural design of the place, the space and the interface*. Copenhagen: Danish Architectural Press.

[3] [3]Beim, A., Larsen, L. & Mossin, N. (2002). *Økologi og arkitektonisk kvalitet* [Ecology and architectural quality]. Copenhagen: Arkitektskolens Forlag.

[4] [4]Beim, A. & Vibæk, K.S. (2013). "The Construction of Affordable Low-Energy Prefabricated Housing". In: Trubiano, F. (ed.*), The Design and Construction of High Performance Homes: Building Envelopes, Renewable Energies and Integrated Practice* (p. 203-216). Abingdon: Routledge.

[5] [5]Bordass, B. & Leaman, A. (2013). *Part 2: Building Performance: The Bigger Picture. Building professionals and the challenge of sustainability.* Located 17. September 2018 on

[6] https://www.youtube.com/watch?v=92L0IDGWi3U

[7] [6]Bordass, B. Leaman, A. & Willis, S. (1994). "Control Strategies for Building Services: the role of the user". Conference. Buildings and Environment Conference, BRE.

[8] [7]Dahl, T. (ed.) (2010). *Climate and Architecture*. London: Routledge.

[9] [8]Dahlberg, K., Dahlberg, H. & Nyström, M. (2008). *Reflective Lifeworld Research*. Lund: Studenterlitteratur.

[10] [9]Geertz, C. (1973). *The Interpretation of Cultures: Selected Essays*. New York: Basic Books.

[11] [10]Giorgi, A. & Giorgi, B. (2003). "The Descriptive Phenomenological Psychological Method". In: *Qualitative Research in Psychology – Expanding perspectives in methodology and design*, (ed.) Paul M. Camic. Washington (p. 243-273). DC: American Psychological Association.

[12] [11]Grierson, D. & Moultrie, C. (2011). "Architectural Design Principles and Processes for Sustainability: Towards a Typology of Sustainable Building Design". *Design Principles and Practices: An International Journal* 5(4), p. 623–634.

[13] [12]Guy, S. & Farmer, G. (2001). "Reinterpreting Sustainable Architecture: The Place of Technology". *Journal of Architectural Education* 54(3), p. 140–148.

[14] [13]Halkier, B. (2008). *Fokusgrupper* [Focus groups]. Frederiksberg: Samfundslitteratur.

[15] [14]Jensen, J.O., Jensen, O.M. & Gram-Hanssen, G. (2014). "Omstilling til bæredygtigt byggeri" [Transition to sustainable construction]. In: Holm, J., Søndergård, B., Stauning, I. & Jensen, J.O. (ed.), *Bæredygtigt omstilling af bolig og byggeri* [Sustainable transition of housing and construction] (p. 73-106). Frederiksberg: Frydenlund Academic.

[16] [15]Jensen, J.O., Jørgensen, M.S. Elle, M. & Lauridsen, E.H. (2012). "Has social sustainability left the building? The recent conceptualisation of 'sustainability' in Danish buildings." *Sustainability: Science, Practice & Policy* 8(1), p. 94–105.

[17] [16]Johansson, J. (2017). *Bæredygtighed i danske almene boliger – med et brugerfokus* [Sustainability in Danish social housing – with a user focus]. Copenhagen: The Royal Danish Academy of Fine Arts Schools of Architecture, Design and Conservation.

[18] [17]Justesen, L. & Mik-Meyer, N. (2010). *Kvalitative metoder* [Qualitative methods]. Copenhagen: Hans Reitzels Forlag.

[19] [18]Kvale, S. & Brinkmann, S. (2015). *Interview: Det kvalitative forskningsinterview som håndværk.* [Interview: The qualitative research interview as craft] (3. ed.). Copenhagen: Hans Reitzel Forlag.

[20] [19]Leaman, A. & Bordass, B. (1993). "Building Design, Complexity and Manageability". *Facilities* 11(9), p. 16–27.

[21] [20]Leaman, A. & Bordass. B. (1997). "Strategies for Better Occupant Satisfaction". Fifth Indoor Air Quality Conference. London.

[22] [21]Leaman, A., Stevenson, F. & Bordass, B. (2010). "Building evaluation: practice and principles". *Building Research & Information* 38(5), p. 564–77.

[23] [22]Madsen, U.S., Beim, A., Reitz, A. & Bang, H.L. (ed.) (2015). *Værdiskabelse i bygningsrenovering – En minianalyse af udvalgte koncepter for vurdering af egenskaber og kvaliteter i byggeri* [Value creation in building renovation – A mini-analysis of selected concepts for the evaluation of properties and qualities in construction]. Copenhagen: Bygherreforeningen and Akademisk Arkitektforening.

[24] [23]Mo, L. (2003). *Vitenskapsfilosofi for arkitekter* [Theory of science for architects]. Oslo: Kolofon.

[25] [24]Neergaard, H. (2010). *Udvælgelse af cases i kvalitative undersøgelser* [Selection of cases in qualitative studies]. Frederiksberg: Samfundslitteratur.

[26] [25]Nielsen, S.B., Jensen, P.A. & Jensen J.O. (2012). "The strategic facilities management organisation in housing: Implication for sustainable facilities management." *International Journal of Facility Management* 3(1), p. 1–15.

[27] [26]Rendtorff, J.D. (2003). "Fænomenologien og dens betydning" [Phenomenology and its importance]. In: Fu-glsang, L. & Olsen, P.B. (ed.), *Videnskabsteori i samfundsvidenskaberne: på tværs af fagkulturer og paradigmer* [Theory of science in the social sciences: Across subject cultures and paradigms] (p. 133-167). Frederiksberg: Roskilde Universitetsforlag.

[28] [27]Shove, E. (2003). *Comfort, Cleanliness and Convenience the Social Organization of Normality.* Oxford, England; New York: Berg. Located 30. May 2013 on http://site.ebrary.com/id/10060563

[29] [28]Stevenson, F. & Leaman, A. (2010). "Evaluation housing performance in relation to human behavior: new challenges." *Building Research & Information* 38(5), p. 437–441.

[30] [29]Tanggaard, L. & Brinkmann, S. (2010). "Interviewet: Samtalen som forskningsmetode" [Interview: The interview as a research method]. In: *Kvalitative metoder – en grundbog*, [Qualitative methods - a basic book] (ed.) Brinkmann, S. & Tanggaard, L. (2. ed., p. 29-53). Copenhagen: Hans Reitzles Forlag.

[31] [30]Twinn, C. (2012). "Professionalism, sustainability and the public interest: what next?". *Building Research & Information* 41(1), p. 123–28.

[32] [31]Zahavi, D. (2006). "Edmund Husserl - Hvordan verden træder frem" [Edmund Husserl - How the world emerges]. In: Thau. C. (ed.), *Filosofi & arkitektur i det 20. Århundrede* [Philosophy and architecture in the 20th century] (p. 7-18). Copenhagen: Kunstakademiets Arkitektskole.