Buildings that learn – the role of building operators

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Abstract

Energy efficiency in buildings is dependent on many different factors; the material quality of the building, and the various technologies implemented. Nonetheless, the use and the users of buildings are also of great significance. This paper analyses building operators and their role in making buildings "work". Building operators may be viewed as an important user group in buildings. In contrast with "end-users", a group that has been much studied over the last years, building operators have special competence in operating the building and thus also have a better opportunity to influence the innovation process. The paper argues that the building operators may be seen as important actors in optimizing energy efficiency in buildings. Furthermore, it argues that they hold tacit and experience based knowledge that could be utilised to a greater extent in the design and construction phase and not only in the operation phase. Building operators negotiate between users, technologies and the building, and thus, their understanding of and knowledge about the building is vital for reaching goals of energy efficiency. The empirical data consist of selected cases of non-residential buildings and are analysed within the perspectives of Science and Technology Studies (STS) (Latour 1987, Callon 1987, Law 1988) and Social Learning (Sørensen 1996, Williams et al. 2000, Lieshout et al. 2001).

Buildings and their users

Non-residential buildings can undoubtedly be more energy efficient than they are today. Calculations made by the Norwegian Energy Efficiency Center (Norsk Enøk og Energi) states that new non-residential buildings can save 800 Gwh within 2010 by "moderate extra investments" (ENOVAS byggstudier 2003). How is this goal going to be fulfilled? ENOVA (an organisation in charge of the Norwegian Energy Fund and the design of policy instruments), suggests improvements in national standards and regulative instruments for buildings. In addition, they stress the importance of information and education on energy use and energy saving amongst all actors in all parts of the building process. Implementing EUs building directive (Energy Performance of Buildings Directive) in 2006 will probably serve as an effective regulative instrument and result in technological improvements. However, as ENOVA also emphasises in order to reach a goal of energy saving there is a need to improve the building process in general and to involve many different actors.

New and improved buildings are of course crucial in terms of energy efficiency. It is however, a common misconception that energy efficiency first and foremost is about better technological solutions. Social studies of buildings show that fulfilling the "technical" possibilities of the building is dependent on how the building is taken into use (ex. Jeltsma 2003, Aune 2004, Bye 2005). This is a challenge concerning all buildings – both new and old.

The paper focuses on a study of *users* in non-residential buildings. Our aim is to explore social, cultural and technological dimensions of energy use in buildings and thus show various aspects of energy efficiency. As the title of the paper indicate we want to emphasise that energy efficiency is more than technical improvement; it is also a social learning process.

Who are the users of a building? Are the employees the most significant user group or perhaps the cleaners? This will, of course, depend on your focus. In the search for users with a special focus on energy, we found that building operators was an interesting group to study. In contrast with "end-users", a group that has been focus for social research the last years, building operators has a special position in making buildings work. They represent a group that interacts with the end-users of the building, as well as handles the technologies and the building itself. Thus, their experience and knowledge may be critical for implementing energy efficiency in existing as well as in future buildings.

The study of users and building operators is part of a larger interdisciplinary project called "Smart Energy Efficient Buildings". The main focus of this project is: "developing new knowledge, integrated solutions, and technology that renders it possible to meet the energy needs related to buildings with considerably reduced resource consumption and environmental impact."[1] The project is an interdisciplinary project where architects, engineers as well as social scientists work together. *User needs* is one part of the project. Our first approach towards exploring user needs was to interview building operators in order to get their opinion on how users behave and their experience of the contact with the end-users. During the first interviews we realised however, that we needed to include building operators in the user study and consequently gave the project a second focus: building operators and their work.

The project that this paper is based on contains data from 28 interviews of 42 respondents. The data collection has been done over a period of two years and consists of interviews of end-users, building operators, and members of the different design groups (contractors, architect, user-coordinator, building owner). Furthermore, the data material includes document studies of different approaches to building operation and building projects (Bye 2005). This paper focuses on a few specific cases, with a special focus on two schools, a regional college and a secondary school. Other cases that we refer to are two different governmental buildings and one university building. We will refer to these buildings in the text as "the college", "the secondary school", the university building", the governmental building N (north), and the governmental building M (midland). These cases, illustrate different aspects of how buildings are operated in Norway today.

The paper analyses various aspects of managing buildings, communication with between building operators and end-users with a special focus on energy use and energy efficiency. Furthermore, we discuss ways of organising building operation and the different ways that knowledge and experience within the group of building operation may be utilised in building projects.

Innovation, implementation and social learning

Through organisation and labour studies, we know much about the life within non-residential buildings. Recent studies have also provided new knowledge about the socio-material system that a building and the users together represent (ex. Rohracher 2002, Ornetzeder 2002, Aune 2002, Ryghaug and Sørensen 2002). An important contribution is Jeltsma et al. (2003) who analyse aspects of energy management, user involvement and introduction of "smart" technologies in a non-residential building. Their main finding is the existence of a mismatch between the design of the smart system – *design logic* – and the understanding and use of the system – *use logic* – and as a consequence that the potential for energy saving was not realised. Studies of users, building operation and management in non-residential buildings within a social science perspective are nevertheless few. This makes our study an explorative study with case specific, rather than general results. However, combined with relevant theories, the analysis may contribute to a theoretical understanding of the topic as well as emphasise the relevance of analysing a phenomenon like building operation and management, from a non-technical viewpoint.

The perspective of "Social Studies of Science and Technology" (STS) is a useful theoretical entrance into this topic (Latour 1987, Callon 1987, Law 1988). The STS perspective stresses the non-linearity of technological development and implementation, and the importance of combining technological knowledge with social, cultural and organisational knowledge in order to understand these processes. It challenges the popular view that new and better technology will also be used according to the developers' intentions, when made available. Studies from the STS-field, as well as numerous management studies, have shown that the belief in technology-driven development leaves out several important factors for success (Bijker and Pinch 1987, Næsje 2000, Gjøen and Hård 2002). They point out the necessity of also taking into account the "social innovation" that takes place after the technology or the product has been implemented. Analysing social practice may give us new insights into the potential of various technologies, or as in our case, building solutions.

Bruno Latour (1988) has conceptualised the "meeting" of users and artefacts through the concept of *delegation*. Many innovations occur through initiatives to delegate routine actions to technology, and this may be a way to manage human behaviour and relations. Technology is often rendered invisible, and users do not have the impression of co-acting with a technological artefact. This makes technology even more effective in its affordances of human action. The concepts of program and anti-program are also a way to illustrate the producer-user relation. Through the design of the technology the producer presents a "program" for use. These programs do not however, determine the user pattern. By developing "anti-programs" the users abolish the force of the technology and thus the intended effect (Latour 1988).

1. http://www.ntnu.no/em/fokus/smartbygg/index_e.htm

In this analysis we also want to look at how one can utilize the experience and knowledge of building operators, knowledge about end-users, as well as the building and technologies in the building. Thus we will also integrate the STS related theory of social learning (Sørensen 1996, Williams et al. 2000, Lieshout et al. 2001). Social learning focuses on learning within a system which implies co-operation, communication and reflexivity. Within social learning the concept of 'learning economy' has been used as a basis in systems where learning through projects and through co-operation is systematised and made available for actors on different levels, also political levels.

In economic history we find social learning in studies of productivity where studies show continues improvements over a long period of time without investments in new technology. Arrow (1962) calls this phenomenon *learning by doing*. Rosenberg (1982) explains a similar phenomenon as *learning by using*. Both expressions are related to the experience of using technologies over time. A third way of understanding social learning is through *learning-by-interacting* (Andersen & Lundvall 1988). Here the systemic qualities of learning are emphasised. Moreover, learning-by-interacting involves stable forward and backward linkages. Sørensen (1996) has developed the concept of *learning by regulation* which emphasise that regulatory activities represent another form of learning by using. Social learning is achieved if one is able to collect and systematise knowledge on the ongoing processes that are taking place when new technology is tried out, and one establishes arenas and networks for sharing of such knowledge. Thus, when the knowledge is established it is crucial to make it available outside of the local context so that later project might benefit from it. The time aspect is also crucial. Social learning is related to changes over time. Concerning the building industry the economical circumstances as well as the time aspect has made these processes difficult.

We will analyse our empirical material within the framework of the theories above. First, we will look at the work of building operators and how they can contribute to optimising the energy efficiency in buildings through their hands-on experiences (with technologies and systems in the building), in interaction with end-users, and within the organisational frame that they work in. Secondly, we will discuss the relevance of this experience-based knowledge in the design and construction phase in building projects, and how this can contribute to making the building work.

Making the building work: Building operators and users

In Norway in the 1980's, building management and maintenance was handled in-house. However, this was often done in a short-term perspective, and much of the work done was after it became critical or after accidents. The introduction of information- and communication technology (ICT) into building operation has however given building owners increasing possibilities in terms of management and maintenance. The main result of this is an increasing automation in the day-to-day building operation. Instead of just doing odd jobs around the building, they are now often in charge of operating advanced technical systems. Together with organisational changes like outsourcing of building management (Jensen 2001) and new models of organising building management and operations like Facility Management[2] and Continuous Commissioning[3] , it is obvious that the role of the traditional caretaker or janitor has changed over the last decades. In this paper we will however not discuss these more structural changes or professional models of organising the work. Our focus is activity of building operation and management. A building operator is in charge of the daily function of the building. This means various work like managing systems for water, heat and ventilation, ensuring necessary maintenance of the building, and servicing the end-users.[4]

How does the model of organisation imply differences in regard to the daily activities of the building operators? The college and the secondary school that we have chosen as examples in this chapter, represent different directions in how building operations and management are organised. At the college they have a small in-house staff and they rely to a large degree on service contracts with the suppliers. In the secondary school they have a large staff and they are trying to be as self-supporting as they can. They represent different aspects of building operation but they are also similar in many ways.

The secondary school keeps the building operation within the organisation. Our informant likes this model because it provides various work and makes the job more interesting:

"I am a fan of us doing as much as possible by ourselves. It makes the day much more interesting (…). Almost anyone can call for assistance, so we have to justify our jobs. We have discussed this and decided we should focus more on construction and building rather than servicing the other users, doing things that they can do themselves."

This building operator is in other words in charge of operating the building as well as doing the maintenance work. The "servicing of other users" as he refers, to means that he expects the end-users themselves performs simple tasks like administering TV/video-equipment, changing bulbs at their offices etc. The college, on the other hand, is publicly owned and rents the buildings from a governmental company that also provides building services. They have separated the functions of operation, maintenance and the small task that has to be done daily. Thus the keep their own in-house janitor that does odd jobs around the place, while the building owners have building operators that focus on running the buildings. The building operator that was interviewed explains a work day that is different from their colleagues at the secondary school. He feels more like an office worker:

"It is a lot of paperwork, reports going here and there. Basically, one person [out of three]is tied up doing paperwork. I reckon that soon the job uniform will be shirt and tie, since

2. Facility management is a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology. See http://www.ifma.org/about/index.cfm?actionbig=4
3. Federal Energy Management Program (FEMP)/ US Dep. Of Energy: Continuous Commisioning Guide Book, Oct. 2002
4. There is no standard education for building operators. Our interviewees had for instance previously worked as mechanic, carpenters and electricians

all we do is calling the plumber, electrician, carpenter or the painter when we need them."

The college is an example of what we can call "moderate outsourcing" and represents the more typical picture of building operation in the total material. The college has a staff of building operators that is in charge of these specific buildings, but they hire in the necessary expertise in order to do the repair and maintenance work. The building operators spend however their workday at the campus. The fact they have "their own buildings" and are not administering many different buildings (which is a consequence of full outsourcing), provides a day-to-day experience and thus the opportunity to learn about the systems as well as the users, over a period of time. Different to the secondary school they outsource the practical maintenance work, but since they are in charge of administering this work they collect knowledge about how different parts of the building and different systems work.

Outsourcing of building operation is part of a general trend in building management (ex. Jensen 2001). Over the last years many Norwegian Municipalities have for instance outsourced building operation in many primary schools and kindergartens. Thus, different groups with a different expertise (or no expertise as some complain about) travel among the different buildings. This organisational development has been criticised. The argument has been that this type of buildings is exposed to heavy usage and it is therefore necessary that someone takes care of the day-to-day operation maintenance as well as long term planning. Maintenance is in general, an important task for building operations. As the building operator at the college said:

"You know, this is public property. It has a certain value. We are here to uphold this value, so it does not depreciate. We are not doing our job unless we preserve the value of the buildings. This means that we need to continuously operate the building so that it does not deteriorate. You know, a building is used and everything that is used will wear down eventually. What we need to do is to add new things, to change the floors, to keep everything running. If we are not able to do this, if public administration cannot do this, you are in reality stealing from the public purse. In this sense, what we do in building operation is also useful to society".

This is an important point not just in terms of preserving the value of the buildings, but also in terms of keeping the buildings functional and thereby maintaining energy efficiency. However, in order to be able to do proper maintenance our interviewees from these schools said that is was necessary to hire people to do some of this work, in addition to sufficient funding. As the building operator at the secondary school said:

"The jobs are big and we try to handle most of them ourselves. That is why we are well manned here, so that we can do reconstructions and re-fittings and try to do them ourselves. We only hire in when there are special jobs and bigger things. We are now building a garage, and we have also built a disposal site and recycling centre. We are used to doing such things."

At the college they are of the same opinion even though they are more reliant on outside help than the secondary school. This is however, not a situation our interviewee is comfortable with: "I cannot understand what they are thinking. A building operator costs 30-50 Euro including social costs per hour, while calling in someone from the outside costs at least 75 Euro per hour." He also makes a point of not having enough in-house staff means that you will fall behind with the upkeep of the buildings: "It becomes fire fighting. Instead of having people in-house that can be on top of things, dealing with things before it becomes a problem, maintaining instead of fixing." He sees this in connection with the development in the rest of society: "In today's society it is expensive to invest in building operation and maintenance, and the economists of today think only about money in a very, very short-term perspective. My impression is that they all are near-sighted."

Even though there are differences between the ways building operation is organised in these two examples they also face many of the same challenges in their work. For instance: How can they make the buildings work optimally both in terms of the technology functioning and in saving energy? How do they get the users to behave in a manner that ensures effective energy usage in the building? Our two interviewees both express concern with energy efficiency and the building operator at the secondary school says that this is something he has been concerned with for a long time:

"We have been reading meters and filling in forms since the mid eighties, I think. So, we have been doing that forever. It has really been an exiting development. I remember the first courses where we attended in connection with energy economising, we were told to turn off things. Not much thought was given to the indoor climate."

The building operator at the college is part of a network:

"We have been part of a network (…) where we try to find out what options, what sort of equipment is necessary to able to do proper energy usage monitoring, and we have gotten some training so that we learn how we can do proper energy monitoring."

Being in charge of a building seems to create an ownership to the building. You can follow the positive consequences of the work, as well as being held responsible for the negative. Experienced knowledge is important as well as contact with users and colleagues. Social learning is developed through dialog with users, and "tinkering" with technologies and technological systems over time as well as sharing these experiences.

One of our interviewees is a very dedicated building operator represents a good example of "ownership" as well as knowledge transmission. He is in charge of the governmental building N, and works within a model of "moderate outsourcing". This building operator is very preoccupied with making the building more energy efficient. Even if he administers a building that is "not very high-tech" he still has been able to make adjustments that make it more energy efficient both in relation to users and technology. In this building there were for instance regular user meetings and emails with information on energy usage. In the canteen there was a blackboard with information on energy conservation, where different types of information relating to this were posted. He also made information sheets on energy usage in the office with examples on efforts users could make. Furthermore he spent a lot of time talking with people, and said that he was surprised by the things he could make the users agree to. It seemed like he was constantly looking for new ways to improve energy efficiency, and that he was very satisfied with how the systems for energy control and regulation allowed him to identify problematic areas. He had for instance changed the control panels in the elevators, which resulted in a 25% reduction in electricity consumption with every start and stop. In a building where the elevators are used a lot this can make a change.

By operating the building on a daily basis he was able to improve the technologies as well as communicate and "educate" the users in the building. Within the frame of social learning we can call this "learning by doing" and "learning by interacting" (Sørensen 1996). It demonstrates the time aspect of improving the function of technology, through usage and adjustments, as well as showing that technology has do be fitted into a socio-cultural frame. New technologies do not necessarily work as intended. The way it is used and the setting it is put into, is also important. Furthermore, this case as well as the two previous ones, demonstrates the potential positive effect of building operation within a model of "moderate outsourcing" or "completely in charge", where the building operators are responsible for a specific building (or buildings). Social learning is a concept that emphasises the importance of sharing knowledge, communication and thus improving technological systems. These cases illustrate how learning can be introduced on many levels. However, in order to have a general effect, there is still a need to communicate this knowledge to other parts of the building organisation. We will come back to this in the section about building operators and building process. Before moving on to this discussion, we will shortly elaborate some more on the social-technical challenges in the work of a building operator.

SOCIO-TECHNICAL ADJUSTMENTS: END-USERS AND TECHNOLOGIES

As many of our informants express, communicating with the users of the building is a necessary part of making the building work. But as one said: "there is always someone that is not satisfied". It is difficult to please everyone especially regarding indoor temperature and ventilation. One of the operators said that his goal was that "everyone should get what they were entitled to according to existing laws and regulations". However, the users may not always be happy with the comfort level that is delivered and apply what Latour (1988) calls anti-programs in order to make their day more comfortable. By applying anti-programs, users change the effects of the technologies, and thereby make the building less energy efficient. The college case provides some experiences of this kind. In this case there was an agreement between the end-user and the owners of a temperature of 21 degrees in the offices. This was too cold for some of the users and thus the office workers brought electrical fan heaters with them to work. The building operator said:

"The temperature in offices and classrooms is set to 21 degrees C. (…) Someone might find this too cold and we get the problem of people taking matters into their own hands, not that we regard this as a crime."

In terms of energy efficiency it was a concern though. However, the building operator recognised that it could be necessary with extra heating if the building was too cold. But he added: "However, when we fulfil the goals set bye the college it is their problem to inform, or make people understand, that they need to do something else besides bringing fan heaters to work. (…) If not, they can always put on a sweater or something. (…) I do not regard it as a problem as such, but fan heaters are problematic in terms of the fire hazard."

Another example of what can be perceived as a user anti-program is found in the university case. In this building the temperature in the offices was lowered when the lights were switched off, this resulting in users stopping to turn off the lights when they left their office.

However, even though there are some divergence between the building operators and users of the building, the overall picture in our cases is one of relative harmony. A common statement from all building operators interviewed for this project was that most people were satisfied, or at least they did not complain. The ones that complained did so almost by habit as some of the operators said and the complaints were most often about heating.

Our overall impression from the data is that end-users in buildings seldom hamper the process of making buildings energy efficient. More common challenges are the small socio-technological adjustments that are necessary in order to make the building work and make the end-users satisfied. Building operators are in many ways what we can call 'superusers' in the sense that they mediate between the buildings and the users. They need to understand both the building's and the users' needs.

This may be illustrated by the following story. In the governmental building N, the building operator complained about a revolving door that caused problems. In connection with building a new wing there were also built a new entrance to this particular building. This included a new hall and reception area. The architects decided on having a revolving door installed. The door was sensitive to pressure, so that it collapsed when there was too much pressure. This was necessary as a precautionary measure if there was a fire or some other emergency. However, it soon became evident that the door was a bit too pressure sensitive. The entrance was exposed to a fair amount of wind, and even though they adjusted the door to the maximum, it still collapsed easily. When the door collapsed the wind was blowing straight into the reception area making it rather difficult to work there. Also, when the door was in use there was a draft coming in through the brush at the bottom of the door, making it a freezing workplace. The first thing the building operators did was to close off the revolving door so that one had to user the extra door next to it, but in the end they replaced the revolving door with a more conventional door. They also built in the reception area in order to increase the comfort level for the people working there.

In the previous section we presented a building operator that almost took the role of a teacher. This case demonstrates the possibilities in changing energy use patterns. However, in our material he represented a rare example. The more general picture is that the foremost success criterion regarding the work of building operators in relation to the end-users is that their work is unnoticed or invisible. Thus the comparison of a housewife is more correct than a teacher. "The housewife" is, as we know, a person that ensures that everyone is given what they need, that everyone behaves well, and that the surroundings are well adjusted. The housewife adjusts parts in the network of humans and material in order to make it work satisfactory.

Building operators and the building process

As the cases we have presented demonstrate, there exists a valuable competence and experienced base knowledge amongst many building operators. Is it possible to utilise this knowledge? What do the building operators themselves think? Social learning is as mentioned dependent on systems for transmission of knowledge and experience, and channels for information. How can systems of knowledge transmission be implemented?

Some of the building operators that we have interviewed had participated in the process of planning and building and experienced this as positive. Their opinion was that the earlier they got into the process the better. Their personal experience was that they were heard and that the buildings were easier to operate properly. Whether this resulted in more energy efficient buildings depended on the interest of the building operator. As our material shows, some have made energy efficiency to a "life project" while others are not very concerned. In an STS perspective we can view energy efficiency as a socio-technical process. Energy efficient systems are very important, but the technologies work better if they are properly used, if the users are motivated and the building operation good. Involving building operators in the building process can in other words be one of many ways to improve energy efficiency. However, as studies of building processes show, many different groups are involved and the good ideas have to compete with other good ideas as well as with financial considerations (Ryghaug 2003, Moe 2005).

In this last section of the paper we want to present two examples were the involvement of the building operator has, in spite of some problems along the way, been a positive experience. If we want to develop social learning systems in building processes knowledge about processes like this can be one possible entry.

Two of the schools we introduced earlier in the paper, namely the college and the secondary school, had conducted a building project recently. The college had been expanded by two new buildings within a four year period, while the secondary school was in the process of obtaining an addition to the school in order to concentrate the school at one campus instead of two. Both building operators had been involved in the respective processes, but in varying degrees. At the college persons from building operation became involved when they started building, while at the secondary school they were a part of the process from day one, taking part in the design phase.

In what way do building operators mean they can contribute to the design phase? First and foremost they represent a type of knowledge that is otherwise missing, or neglected, in the process. The building operator at the college expresses it this way:

"A lot of things are different when you have some experience form building operations and maintenance, in the real world things are different from what it looks like on a desk in an office. (…). They (engineers or consultants) have finished school, gotten their title, applied for a job and ended up behind a desk. Then they start planning buildings. You know, they have never climbed in constructions, or had to build scaffoldings in order to change light bulbs inside a building. You can't expect them to think of everything."

He respected their specific competence, but distrusted their understanding of the practical implications of decisions they made. They did not understand the importance of thinking about use and maintenance of different installations. As an example he referred to light bulbs which were placed very high up out of aesthetic concerns. The result was the he needed a special ladder to change the bulbs. Another example of impractical solutions was an elevator shaft that was, according to him, originally built the wrong way:

"When we saw the elevator shaft was turned the wrong way, making it almost impossible to get in with a wheelchair or a trolley, we were able to stop it. However, this could have been stopped earlier and not when it was halfway built."

However, entering the process at the point when the building started meant that their suggestions were not always seen as welcome, and they were met with some opposition.

"We were able to make some changes that make our job easier, but since we entered the process after they started building we got a lot of criticism for criticising things that were already decided (…). We took part in the building process and building meetings, but I think we entered the process a bit late. We should have participated in the design phase in order to nip some things in the bud."

For him it is quite obvious that building operators possesses knowledge that would be useful in a design phase and that they should enter the process early:

"I think that experiences from building operations and maintenance can be very useful early on in the processes. (…) It does not cost anything while you are in the design phase, but it becomes expensive to do changes when you enter into the building phase."

He did however feel that his experience-based knowledge was not appreciated by the other actors in the building process. That seems to be a common view among building operators. They emphasize that they have know-how that would be valuable in a design phase, but that they are left out.

"You know building operators learns a lot through experience, through hands-on experience from real life. It should be a benefit for all involved both they who have the theoretical knowledge, designs and planning, and the ones who have to operate the buildings. It should be a team effort. You know, just because knowledge is gained from experience instead of from reading a book it should not be worth any less for an engineer, and vice versa. I think this is a good point, also socio-economically."

Over the last years this traditional way of building and designing buildings has been questioned. This has lead to experiments with other possible ways of organising the process. At the secondary school they have tried to employ a model different from the traditional one. The municipalities decided that they wanted to use what the public sector call an "integrated building process" and what the private sector call "partnering".[5] The starting point for this model is that the traditional cooperation between the actors is replaced by what they call the "extended concept of interaction".[6] The focus in this model is a stronger integration between planning, production and delivery. In addition to an extensive use of information technology an important aspect is that all participants in the project interacts in a different way than in traditional projects. An important principle is information sharing between the participants in the process. What this also means is an extended use of user participation in order to make sure that they get what they want. The building operator in the secondary school was included in this process, and he thinks this was a positive experience:

"I have participated from day one. I was anxious in the beginning, but it [the integrated building process] has worked really well. It is a really good tone and everyone gets heard. I like it. I was a bit anxious at first, I mean in terms of cooperating with architects and engineers, we all know a bit, but it has turned out really well."

He has worked at the school for many years and had taken part in many building projects over the years. Earlier he too had only been involved in building projects after they had started building. However, he prefers the new approach:

"I prefer this model, definitely. We have always been included in the building process earlier as well. We have participated in building meetings and those sorts of things. However, this has always been after construction has started, which means that most things are decided, and we do not get much say in how things should be. We get into the process too late. This time, however, the users and everyone has been a part of the process and has had the opportunity to have their say. Not that everyone can get what they want. All of us in the project group have gone a few rounds when we have disagreed on something. You win some and you lose some. On the other hand, I think that having conflicts affects the finished result in a positive way. No stone is left unturned, everything is tried to get a good result, so I think it is healthy for the building that we have been a part of the whole process."

In addition to being able to influence the project in the direction that they want, it also gives the building operators an opportunity to get to "know" the building in a way they have not been able to before.

"We have had some changes done, and we have had to accept some things that we did not want. If you for instance think about building operations I said early on in the process that we only wanted three different light sources, this building is only to have three different light sources. The advantage being that we do not need to keep a stock of all sorts of light bulbs. I mean, we have seen before that many different sorts of fixtures are put into one and the same building. The end result was more than three, but not a lot more, I think it has been in their minds the whole time. When I first said it, the architect laughed of course, but the electro-consultant said it could be something to reach for. Both he and the architect had to give a little on that one. This is different from other projects. Usually our department is completely ignored. We have been through everything, all the fixtures and everything. The end-result is good, but there are of course things we would have liked to have done differently."

As we can see, social learning is institutionalised through the integrated building process and consequently by utilising the knowledge of all relevant actors in the process. The main benefit from such a process is that the knowledge and competence of relevant actors taking part is utilised in a joint effort towards building as good a building as possible. It is important however, to evaluate building processes as well as collecting knowledge about the experiences in the user phase. Building projects are very different regarding for instance type and size of buildings and thus there is not *one* model that will be useful for all projects. However, taking use and building operation into consideration and learning from experiences seems wise in order to fulfil energy efficiency goals of buildings.

Concluding remarks – buildings that learn?

The paper have argued that building operators can be an important group in optimizing energy efficiency because they hold a tacit and experience based knowledge in operating the building. This experience can also be used in planning and designing buildings. Although they are an integral part in making buildings energy efficient this is a user group that has not been studied much in terms of how they use buildings and how they learn about the buildings. In many aspects one can compare their role to the role of the housewife, in the sense that they are doing a lot of work that is invisible for the other users. They will only notice it if it is not done.

Building operators are in many ways super users. By this we mean that they control, and use, the technology that provides the other users with comfort and well-being, like ventilation and temperature control. They negotiate between users, technologies and the building. Thus, their understanding and knowledge of the building is important for reaching goals of energy efficiency. Having the most up-to-date technology does not necessarily mean that this is the most energy efficient building. The way in which the building and the technology is used is also important. In making buildings energy efficient the building operators have to adjust technologies as well as users. Thus knowledge and competence is essential. This is also relevant in building processes, where building operators usually have been left out from the design phase. However, our positive examples illustrate that it can be very useful to integrate building operators early in the building process. Through their hands-on experience with the different technological solutions and through having a comprehensive understanding of the building they have a certain feeling about "what is good and what is not". This is also relevant in relation to energy efficiency. Having a comprehensive knowledge of how a building works, knowing what needs to be done where and when is essential if energy efficiency is an ambition. In terms of utilising the resources in an organisation seems unwise to

5. http://www.ncc.info/templates/ncc_2_eng.asp?id=2162
6. http://samspill.interconsult.com/htm/English/engtxt.asp

disregard the knowledge of building operators from the design phase.

In order to implement energy efficiency it is very important that those who work as building operators are sufficiently trained in running the systems they are set to run. At the same time it also seems important that those who work in building operation have a commitment, a feeling of ownership and resourcefulness in relation to creating a more energy efficient building. Given that the building operators have sufficient interest, commitment and competence they may make the buildings better than what they were intended to. Through use and prior experiences they may correct construction and design flaws.

The building may be viewed as a socio-technical network where materials, technology, end-users and building operators are interlinked. By studying building operators and their work we have tried to provide new insights about this network and shown some aspects of a "learning building".

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