The missing link which was already there. Building operators and energy management in non-residential buildings

Margrethe Aune, Thomas Berker and Robert Bye

Abstract

Purpose - This paper analyses the daily activities of building operators and how they mediate between end-users and technological systems in order to make “their” buildings energy efficient. Design/methodology/approach - The empirical data consists of four selected cases of non-residential buildings of different sizes. Findings - The paper argues that building operators have the possibility of improving energy efficiency with or without extensive user involvement and with or without advanced technological systems. Originality/value - Starting from the practitioners’ point of view a new perspective on the link between facilities management and energy efficiency emerges, which calls into question approaches which focus on either the behavioral or the technical side of a building’s energy consumption.

Introduction

Jack Hug and Bruce Forbes (Hug and Forbes, 2000, p. 1.7) introduce a handbook of modern facility management with a nostalgic perspective on bygone times, when building operators still:

> [. . .] practiced stewardship of the facilities and managed > financial and human resourcOJ’ entrusted to them, as if they > were their personal assets. They had pride in ownership alfa pride in workmanship. The physical plant was their baby: the organization was their family. They led by example and,
> although quite infonnally, they taught others by coaching and mentoring.

According to and Forbes, during the last several decades this type of building operation, once hidden in the building’s bowels somewhere near the boiler room, has been “thrust in the middle of things”. In this process, the “hands · on manager” of the past has quickly become outdated:

The building engineer was primarily expected to perfonn in a stable, steady, consistent, according-to-the-book manner and only occasionally to react to change.- Today, however, every successful facilities organization must be designed to respond to change as the nann, and it is even encouraged to create change (Hug and Forbes, 2000, p. 1.9).

Thus, it would seem that the operator who “would make continuous rounds, checking dials and gauges located on the equipment and recording the conditions observed”

(Hug and Forbes, 2000, · p. 1.8) has given way to highly trained white collar The missing link professionals, leaving the hands-on tasks to advanced machinery and hired hands.

While there is no doubt that profound changes building operation have occuned since the 1960s, in the present text we will argue that careful “hands-on management” in buildings stillplays an important role. Based on empirical observations in four large non-residential buildings, we will propose a positive role for building operation which combines change management with the old style “hands-on” approach in the service of energy conservation.

But before we turn to this empirical exploration of four important, yet often neglected daily activities of building operators (which we call teaching, housekeeping, managing and juggling), in the next two sections we will show how building operation can act as a link between end-users and technology and how this is connected to the reduction of energy consumption. We conclude the text with a discussion of the instances of “hands-on management”, which we have observed, their differences and commonalities and how they relate to changes towards more energy efficient buildings.

Energy and buildings: blind interplay

Users obviously shape the energy consumption of a building with their choices. Moreover, even if user interfaces are automated with “intelligent” systems, unexpected user actions, such as “creative adaption” or even outright sabotage of systems, are frequent. This class of user interferences is well known as “coping” (Heerwagen and Diamond, 1992) and as result of “anti-programs” (Latour, 1992), and active “domestication” of technologies (Berker et al, 2005; Silverstone and Hirsch, 1992). However, user behaviour - be it within or outside the expected range - is not a fixed entity but constantly influenced by a broad variety of variables many of which are directly related to the specific building and its installations, for instance the quality of its user interfaces (felsma et al, 2003; Norman and Draper, 1986), the degree to which users are able to control environmental parameters of their work spaces (Rowe and Dinh, 1999; Slater, 1995), and experiences with failures or bad indoor environmental quality (Fisk, 2002; Leaman and Bordass, 1999; Heerwagen, 2000).

This mutual relation - that a building's performance is influenced by user actions and that user actions are influenced by a building'S performance - is a common place. Architects, engineers, owners as well as occupants usually agree that the good interplay of technology and users in non-residential buildings is a desirable goal, in terms of both user satisfaction and smooth technical operation. However, the common goal is obscured by many problems.

One of the factors complicating the good interplay of technology and use is that energy consumption must be understood as indirect consumption. Energy is not consumed directly, but rather as a means to reach specific goals such as maintaining a comfortable temperature and air quality, having sufficient lighting or writing on a computer. In non-residential buildings, sufficient heat and ventilation are essential for a comfortable working space. Looking at it this way, the end-user perspective on energy consumption is not about really energy but about everything else, above all comfort management.

Since energy remains invisible to the end-user, the first challenge is to influence the users' comfort management in a more sustainable direction. Employing advanced energy controlling systems while giving end-users the possibility to manage these systems can be problematic. Unlike the case with users in private homes, the users of non · residential buildings have no personal responsibility for the amount of energy consumed, and the technologies are often complicated to manage. Besides, how are different views of comfort to be handled?

Energy remains invisible to more than just end · users. Architects and engineers usually leave the building exactly the same moment when the occupants move in. This is the reason why they have to rely on descriptions of the users' needs and actions - instead of observing them directly. Moreover, the often stated weak position of post · occupancy studies in building (Cooper, 2001; Zimmerman and Martin, 2001) indicates that standard building design prefers methods of user representation other than direct evaluation of buildings in use, such as building standards and technical norms. For instance, quantified standards about the users' thermal comfort zone "represent" the users" real experience of thermal comfort in the building. Post occupancy evaluations and other social studies of energy use of buildings have shown how occupants are forced to "cope" with thermal discomfort (Heerwagen and Diamond, 1992), meaning that they have to make up for the difference between standards and individual experience. The more frequent use of post occupancy evaluations but also more extensive user involvement in innovation and user initiatives in building processes (Barrett and Baldry, 2003, pp. 119 · 139; Rohracher and Ornetzeder, 2002), could dramatically enhance the quality of user representations in building design.

Unfortunately, however, to "see" each other does not suffice. While better representations of users and uses during the building phase - including learning from former projects - is a precondition to better building, there is no guarantee that all future uses can or should be represented during design and building. Non · residential buildings in particular are likely to become subject to new uses and users during their lifetime. Therefore, when designers and builders have left the building, the task of preparing for a good interplay between technology and users is not finished - no matter how well the designers have "seen" the users (Stewart and Williams, 2005). In this situation, in which a mutual blindness divides users and technology, a link is missing: a "user-technician" or "super-user" who "sees" the users as well as the technologies and who is managing changes of both parts. Building operators are obvious candidates for this task.

Building operation as mediation

The introduction of information and communication technology (ICT) into building operation has given building owners new possibilities for management and maintenance (Barrett and Baldry, 2003, pp. 171 · 193). The main result has been increasing automation in day · to · day building operation. Instead of just doing odd jobs around the building, building operators are now more often in charge of operating advanced technical systems. Together with organisational changes like outsourcing of building management Gensen, 2001; Usher, 2004) and new models of organising building management and operations like "continuous commissioning", it is obvious that the role of the traditional caretaker or janitor has changed over the last decades. Accordingly, handbooks of facilities management (FM) have been mushrooming, which promise to support the building operator in his or her increasingly complex work (e.g. Atkin and Brooks, 2005; Barrett and Baldry, 2003; Booty, 2006; Cotts, 1998; Langston and Lauge · Kristensen, 2002; Smith et 01, 2001). Although it is outside the

scope of this paper to assess these handbooks' ability to contribute to a more The missing link professional management of buildings, we can observe that they commonly have an overly technical view of the people involved in facilities management, both with respect to the building operations staff and the occupants. This is in spite of the occasional acknowledgement that "soft issues" of non · technical expertise have become increasingly important for the profession as FM has gained a stronger position within organisations (e.g. Atkin and Brooks, 2005, p. 193). More often, measurable aspects of work organisation like coordination, prioritization, flow (Cotts, 1998, pp. 186 · 7) and - (cid:173) productivity (Langston and Lauge-Kristensen, 2002, pp. 9 · 14) are discussed in such a way that the occupant becomes a customer who has to be satisfied as cost · efficiently and quickly as possible (Barrett and Baldry, 2003, pp. 58 · 60; Cotts, 1998, pp. 280 · 5). Energy consumption, finally, is reduced to a question of technology only (Cotts, 1998, pp. 195 · 7). These abstract professional models of work organisation, however, do not always carry over into the actors' everyday work, which often is a world apart from the prescriptive models of FM handbooks. The following real · life cases of building operation of large non · residential buildings in Norway each reveal one aspect that has been systematically rendered invisible by the handbook versions of the work of building operators (Suchman, 1995). We will argue that these "invisible" aspects of the building operator's daily work are important in the mediation between technology and use with respect to energy consumption.

Roles of building operation

The following study of building operators has been conducted as on one of the author's PhD work (Bye, 2008), which was part of a larger interdisciplinary project called "Smart energy efficient buildings", a project with contributions from architects, engineers and social scientists. Because limited previous knowledge about building operators from a social science perspective exists, this study is strictly exploratory. Our aim has been to record detailed information about the tasks and the "daily life" of building operators. The core data was collected through open · ended interviews of five building operators (there were two in one of · the buildings). Additionally we used supplementary data from the larger "Smart energy efficient buildings" project on users and building operators, including 28 open · ended interviews of 42 respondents (end · users, building operators, and members of the different design groups). The different cases will be referred to as: "the college", "the secondary school" (SCH), "the governmental building N" (GN), and "the governmental building M" (GM). In each case we will particularly focus on the mediating activities of the building operator.

Role 1: The teacher

The governmental building N (GN) was actually two different buildings, one built in the late 1980s and one built ten years later. It was publicly owned by Statsbygg. The buildings had "conventional" technology with mechanical ventilation and radiators, which were operated from two oil · based furnaces and one electrical furnace. In some rooms, lighting was controlled through time sensors, but this was not implemented throughout the whole complex. According to the building operator, the owner of the GN had good systems for general maintenance. However, there had not been much focus on energy consumption.

The building operator in charge, our informant, had a background as a carpenter and was first hired as a technical manager. Since then he had taken courses in managing heating systems, cooling systems and ventilation systems. In addition he participated in a network of building operators, which was managed by an energy efficiency centre in the region. Thus, energy use and energy efficiency was on his personal agenda. The building operator had one assistant. If needed, he could hire experts to repair and improve parts of the building or the technical systems.

Our building operator was preoccupied with making the building more energy efficient. Even though he administered a building that according to him was “not very high-tech”, he still had been able to make adjustments that made it more energy efficient both in relation to users and technology. Improving the technological systems had been a necessary component of this effort. As he said:

We often get the job to fix things ... the ones who get well paid [i.e. those who get oontracts to fix things] do not do their job properly and we have to solve the problems afterwards ...

He changed the design of the thelmostats on the radiators to make them more user-friendly and adjusted the area of user-control to three/four degrees. Thus, he influenced the comfort management of the users. However, he did not find it sufficient to delegate energy efficiency to technology alone. Instead, he began an educational campaign. He arranged, for instance, regular user meetings and sent e-mails to occupants to inform them about energy usage. In the canteen there was a blackboard with information about energy conservation. He also made information sheets on energy usage in the office with practical energy-saving tips. These types of actions can be characterised as mediating activities between use and technology for the sake of energy efficiency. According to this building operator, the users reacted positively to his activities. He spent a lot of time talking with people, and said he was surprised at that the things he could make the users agree to. It seemed like he was constantly looking for new ways to improve energy efficiency and he was very satisfied with how the systems for energy control and regulation allowed him to identify problematic areas. For instance, be had changed the control panels in the elevators, which resulted in a 25 per cent reduction in electricity consumption with every start and stop. In a building where the elevators are used a lot, this can be a significant reduction. By operating the building on a daily basis, the building operator was able to adjust i and improve energy-controlling technologies and find new ways of achieving energy, saving as well as communicate and “educate” the users in the building. Furthermore, this case demonstrates the potential positive effect of having one person in charge of, and responsible for, the building or buildings. In this building, we can characterise the operator as “teacher”. He approached the users in a pedagogical way and gave them some, but not much control. The users of the building generally approved of the way he administered the comfort management. He built strong relations between himself, the building technologies and end-users in order to achieve energy saving. These relations were characterised by personal and detailed information, as well as continuous adjustments of the technology. Additionally, the building operator repeatedly referred to the owner of the building and the owner’s interest for maintenance, which indicated that there also were associations between the owner and the building operator. The GN case demonstrates how a mediating actor such as the building operator can contribute to energy efficiency by influencing user patterns as well as adjusting technologies.

Role 2: the housekeeper

The governmental building M (GM) was built in 2000. The building was owned by two companies and rented by Statsbygg. Building operation was organised through a formal deal between the owners and a private facility management firm In this building, there were two positions in building operation: one building operator and one electrician. Work related to heating and cooling, ventilation, elevators, fire-safety and entrance control were contracted out. The building operator in charge was responsible for administering these contracts in addition to internal control and facility
management documentation. The GM had advanced automatic systems for administering and controlling cooling and ventilation. It was connected to a district heating system and was heated by radiators. The building operator could monitor all these functions from aPC and modify the system's performance.

Although the building had been occupied several years, many systems in the building still needed adjustments. In this context, our informant referred to what he called the "bathtub curve": First there are some problems getting the systems adjusted to the users and the building, then followed several years where things works as intended, and then new problems appeared after some years of use. According to our informant this - and the fact that users move in and out and that uses change over time - made continuous management and adjustments necessary as well.

The heaters were regulated in relation to the outdoor temperature. The indoor temperature was programmed between 22 and 26 degrees and users had, as in the GN, the possibility to adjust their office temperature within these settings. Still, according to our building operator, there was always someone - "especially women" - complaining: "Women are cold no matter what ... Our experience is that the women want to use these and these clothes ... no stockings in their sandals in the summer for instance." However, he also stated that the total number of complaints was few, and all in all the users seemed satisfied with the comfort management of the building. He did not include the users in his daily work in the same way as the operator in the GN, but he was determined to provide the comfort management that the users should have according to the contract. The contract stated that the building operator has to conduct a yearly user acceptance survey and sample four rooms or offices chosen by the users, where they meter temperature, humidity, etc. The contract between the building owners and Statsbygg set the parameters and through the contract period these had to be documented regularly. The building operator was in charge of conducting the analysis and was responsible for the results. Thus, if the owners did not fulfil their contractual obligations, the building operator was to blame.

An important function regarding energy efficiency was metering energy consumption continuously. The results were compared from year to year. The building operator said that energy use had been lowered by adjustments to the building and the technological systems. To prevent cold air from getting into the hallways, for instance, they actually built a whole new entrance area.

The operation of GM was built around building operator, technological systems, renter and owner. Users were treated more as customers than as active party. Comfort management on a daily basis was delegated to technology, but adjustments and control was the responsibility of the building operator. Moreover, energy efficiency was dependent on knowledge through daily experience of the building and the systems. In the previous case (GN) the role of the building operator was characterised as a' "teacher". In this building, the building operation can be characterised as a management through housekeeping. Management in this sense means supervision and administration of systems in order to make the building work according to (contractually) fixed obligations. The housekeeper ensured that everyone was given what they needed and that the surroundings were well adjusted without directly involving users.

Role 3: the manager

The secondary school (SCH) had a total of 27 buildings and four greenhouses. In addition, the building operators were responsible for six other buildings that were leased to third-parties. The secondary school was owned by the county council administration. There were three furnace rooms and a total of 32 technical installations that were controlled and run by a central service supervision system. The building operations department had, at the time of the interview, six and a half positions. The building operator in charge, our informant, had a background as an electrician and has been working at this school since 1981.

The SCH had a relatively large in-house staff of building operators, at least in comparison with other buildings of the same size. Their philosophy seemed to be to try and do as much as possible in-house, instead of having service contracts as were usual in the two previous cases. As our informant said: "I am a fan of us doing as much as possible ourselves. It makes the day much more interesting." Also, they decided to focus more on construction and building, rather than what he called "the servicing of others". By this he meant that he expected the end-users to handle simple tasks like managing TV Ivideo equipment and changing light bulbs in their offices themselves. The education and knowledge required for operating a building has changed over the last couple of decades, as buildings become increasingly more technologically advanced. Thus, the process of getting to know newer building seems to require even more tinkering and fine-tuning than in older buildings. Additionally, in many cases this means that there will be a need for further education of the building operators. At the SCH they had an administration that understood this well, and the building personnel were given the opportuuity and full support to get the training that was needed. In addition, the county council administration held a building operations seminar every year. Our informant stressed that they could get all the extra trainint' that they needed.

Our building operator had been concerned with energy issues ever since he started filling in different forms on energy usage in the mid-eighties. In the beginning, the focus was mostly on energy saving, and as he said, they: “were supposed to tum everything off, and not pay to much attention to the indoor environmenf’. He described the developments since then as”exciting“, and claimed that they were constantly looking at solutions for making the school more energy efficient. Most recently, they had changed to better insulated windows at one building and replaced some electrical panel heaters with radiators at another. Also, at the time of the interview, the school was in the process of building an addition, and building operations had been involved in the planning of this new building from the beginning. Even though they had tried hard to advocate energy efficiency, he was somewhat disappointed by the end result. Because the funding of the project was low while the initial investment costs of energy efficient solutions were relatively high, it did not become a priority in this project.

In terms of comfort management, he said that buildings operations had a very good relationship with the end users. There were virtually no complaints regarding the indoor climate, nor did the pupils cause much grief. He was very happy with the fact that there was almost no vandalism at the school The comfort management itself was delegated to the technology through the central service supervision system.

In conclusion, in this case we found a very strong building operations department that enjoyed the respect and confidence of the administration. They bad put greater emphasis on managing the buildings and technology, and keeping them running smoothly, rather than servicing the users. They aimed at being self-sufficient in terms of the day-to-day operations of the school Our infonnant was also concerned with making the school as energy efficient as possible and -enjoying support of the building owners - accepted this as “exciting” challenge.

Role 4: the juggler

Our last case was the college, which was made up of three buildings, the oldest dated from the beginning of the twentieth century and the other two from 1999 and 2002. It was publicly owned by Statsbygg, and the approximately 30,000 square metres were leased to the college. The main heating source was district heating, which was bio-fuelled. The two older buildings had conventional ventilation systems, while the most recent one had a hybrid ventilation system.

In a period of just four years the college added two large new buildings. This was part of a process in which the college moved all their activity to one campus. The building operator said that the 1999 building did not live up to expectations and that there were several problems with it. A miscalculation of the dimension of the heating system led to a lot of problems: “We found that we could only get the temperature up to 14 degrees Celsius in some classrooms, only because the consulting engineer did not do his job”. These and other problems with this building caused some grief among the end users, but he said that the users were very patient with the building operators, who did their best to keep the occupants informed. Another problem with this building was that the supplier of the central service supervision system went bankrupt just after the college moved in. This resulted in a lack of support and training of the building operators. At the time of the interview they were in fact about to replace the system. Based on their experiences from the first building, they wanted to try something different in terms of ventilation in the newest building. After a while they decided to go for hybrid ventilation, i.e. the combination of natural air flows and mechanic ventilation. One year after they started using the building, the building operators had still not received any formal training on how to use the central service supervision system; they only had the written documentation to reference. In spite of this, it turned out that the technology involved was actually less complex than conventional systems and easier for the building operators to maintain. The energy usage was lower compared to the other building. Our informant reckoned tbat with some fine tuning of the system they wonld get it down even further. Thus, compared to the 1999 building, this one was described as a success.

In general terms, the building operator was concerned with energy efficiency and the college had been part of an energy-saving program initiated by Statsbygg. At the time of the interview, the operators were waiting for some additional equipment to be installed so that they could monitor energy nsage even closer.

According to the building operator, the end users of the first new building were frustrated by the shortcomings of the first building, but he felt that by providing sufficient information they did not take their frustrations with the building out on them. However, there were still quite a few complaints, most of them concerning heating. This was the case with the second building as well. The building operator said that they were obligated by contract to deliver 21 degrees Celsius to the offices, and that they almost without exception did so. Still, this was too cold for some tenants, who would bring electric fan heaters to their offices. In the building operators view, the main problem with this was not the additional energy use, but rather the fire hazard concerned with these heaters. If the college administrators thought the buildings were too cold, they would have to pay the extra cost for the extra energy usage, he said.

The building operation at the college could be called moderately outsourced. They had three full time positions and several service contracts with the suppliers of the different systems installed. According to the manager it was almost a full time job handling the paper work that came with these contracts:

It is a lot of paperwork, reports going here and there. Basically, one person is tied up doing paperwork. I reckon that soon the job unifonn will be shirt and tie, since all we do is call the plumber, electrician, carpenter or the painter when we need them.

In this case building operation presents itself as a complex task, involving different buildings, and comprising both in · house activities and management of outsourcing. The way in which they were organised suggests that one of the main challenges was to keep the buildings together in a way that ensured their quality. The various tasks had to be juggled to keep everyone reasonably happy. The situation at the college appeared at times as fragile and as a continued struggle for the building operator. When the end users were having problems caused by malfunctioning technical installations the operators had provide information, suggesting workarounds and sometimes even joining the end-users in complaining about bad building management.

Day-to-day experience as resource for more energy efficiency

Our four cases imply little difference in regard to the daily activities of the building operators: They spent their workday at the buildings being in charge of building operation and responsible for the results. They could collect knowledge about how different parts of the building and different systems worked. Even if practical maintenance work was outsourced, they were in charge of administering this work.

The first two roles which were observed here (teacher, housekeeper), built on the special knowledge our building operators had acquired after years of practise within "their" buildings. The "teacher" got to know his users through interacting with them, and the "housekeeper" knew his installations after having repaired and adjusted them year after year. While "best practise" usually refers to experience from a large number of trials, we encountered another meaning of "best practise" here: the continuous improvement of a building, which is built on intimate knowledge of its particular conditions, possibilities, and challenges. Both dimensions, the comparative one (as outcome of many independent trials) and the experience-based one (as outcome of incremental adaptation) - we maintain - are important to create the best possible building within a given situation. The teaching and the housekeeping role bear clear resemblance to the "hands · on" management which - as quoted in the introduction -

today is easily dismissed as a thing of the past. However, our building operators were The missing link eager to learn, they attended courses, they were networked with colleagues from other huildings, they welcomed the new ("if it works"), and they acted as change agents both on the technical and the user side.

The two other roles which we have called "management" and "juggling" were not by coincidence encountered in the operation of larger sites comprising a more heterogeneous building stock. Those operating the secondary school with its 27 buildings enjoyed support from the organisation's management and were able to build - - - - - - - (cid:173) up solid in-house competence, while the college operation - endowed with fewer resources - was forced to rely to a larger degree on external contractors. As result, the latter had to deal additionally to the usual housekeeping, with a different kind of task: the hiring and monitoring of external expertise. Consequently, whereas building operation and the organisation's management were tightly aligned in the secondary school, the operators of the college's buildings were forced to juggle between the various actors and technologies, acting as a glue between elements which otherwise might dissipate. In the latter case, the operators' role as change agents was much less prominent than in the first one. However, this was not because they were still in the grip of an outdated understanding of their work as "hands on" management, but rather because of conditions which were outside their control.

More specifically in regard to the buildings' energy efficiency, all our building operators had multiple roles as administrators, service personnel and teChnicians. Therefore, broad knowledge was essential. Building operators needed sufficient training in running the buildings' systems to fulfill their mediator role. At the same time, we have seen that it could be important for those who worked in building operation to have a commitroent towards users (the teacher role) and technologies (the housekeeper role) as well as a feeling of ownership and resourcefulness (the manager role) and the competence to organise complex organisations (the juggler role) in order to create a more energy efficient building. Through their continued presence within the building, the operators encountered here had the possibility to come to realistic representations of users and thus to go beyond schematic images underlying the design of the building.

As our cases show, building operators have the possibility of improving the interplay between technologies and users with or without extensive user involvement, and with or without advanced technological systems. The four roles which were described here are most likely only examples for many more activities in which building operators as "hands-on" managers (which does not exclude acting as professional change agents) have an underestimated potential of contributing to energy efficient buildings. This is because being able to "see" both users and energy, they were in a unique position to improve the interplay between technology and use and to contribute to more energy efficiency. Therefore, we strongly recommend rethinking the role of careful "hands-on management". It should still be considered as integral part of professional building operation.

References

Atkin, B. and Brooks, A. (2005), Total Facilities Management, Blackwell, Oxford.

Barrett, P. and Baldry, D. (2003), Facilities Management: Towards Best Practice, Blackwell

Booty, F. (Ed.) (2006), Facilities Management Handbook, 3rd ed., Elsevier, Amsterdam. Technology, Open University Press, London.

Berker, T., Hartmann, M., Punie, Y. and Ward, K. (Eds) (2005), Domestication of Media and

Bye, R. (2008), “L,”,ende bygninger - n0kkelferdige brukere?: bruk, brukermedvirkning og energieffektivisering i yrkesbygg“, PhD thesis, Norwegian University of Science and Technology, Trondheim.

Cooper, 1. (2001), ”Post-occupancy evaluation - where are you¿‘, Building Research & Information, Vol. 29 No.2, pp. 158-63.

Colts, D.G. (1998), The Facility Management Handbook, AMACOM, New York, NY.

Fisk, W. (2002), “How IEQ affects health, productivity”, ASHRAE Journal, Vol. 44 No.5, pp.56-60.

Heerwagen, J (2000), “Green buildings, orgsnizational success and occupant productivity”, Building Research & Information, Vol. 28 No.5, pp. 353-67.

Heerwagen, J and Diamond, R.c. (1992), “Adaptations and coping: occupant response to discomfort in energy efficient buildings”, in American Council for an Energy Efficient Economy (Ed.), Proceedings of ACEEE 1992 Summer School on Energy Efficiency in Buildings, Vol. 10, pp. 83-90.

Hug, J and Forbes, B.K. (2000), “Introduction and historical perspective to facilities engineering and management”, in Smith, P.R., Seth, AK., Wessel, R., Stymies~

D.L., Porter, W.L. and Neitlich, M.W. (Eds), Facilities Engimering and Management Handbook: Commercial, Industrial, and Institutional Buildings, McGraw-Hili, New York, NY, pp. 16-11l.

Jelsma,]., Kamphuis, R. and Zeiler, W. (2003), “Learning about~ smart systems for comfort management and energy saving in office buildings”, paper presented at the 2003 eceee summer study in Athens.

Jensen, P A. (2001), Handbag i Facilities Management, Dansk Facilities Management netverk, Taastrup.

Langston, C. and Lauge-Kristensen, R. (2002), Strategic Management of Built Facilities, Butterworth and Heinemann, Oxford.

Latour, B. (1992), “Where are the missing masses? The sociology of a few mundane artifacts”, in

Bijker, W.E. and Law, J (Eds), Shaping Technology/Building Society, MIT Press, Cambridge, MA, pp. 309-26.

Leaman, A. and Bordass, B. (1999), “Productivity in buildings: the ‘killer’ variables”, Building Research & Information, Vol. 27 No.1, pp. 4-19.

Norman, DA. and Draper, S.w. (1986), User Centered System Design: New Perspectives on Human-computer Interaction, Lawrence Erlbaurn Associates, Hillsdale, NJ

Rohracher, H. and Ornetzeder, M. (2002), “Green buildings in context Improving social leaming processes between users and producers”, Built Environment, Vol. 28 No.1, pp. 73-84.

Rowe, D. and Dinh, C.T. (1999), “Experience with occupant control of supplementary cooling in a naturally ventilated environment: some preliminary results from work in progress”, IEA Energy Conservation in Buildings and Community Systems (ECBCS) Annex 35 (ed), Proceedings of Hybvent Forum ’99, Sydney.

Silverstone. R. and Hirsch, E. (1992), Consuming Technologies: Media and Information in Domestic Spaces, Routledge, London

Slater, A. (1995), “Occupant use of lighting controls in offices”, Building Services: The CIBSE Journal, Vol. 17 No.8.

Smith, P.R., Seth, AK., Wessel, R., Stymiest, D.L., Porter, W.L. and Neitlich, MW. (Eds) (2001), Facilities Engineering and Management Handbook: Commercial, Industrial, and Institutional Buildings, McGraw-Hill, New York, NY.

Stewart, J and Williams, R. (2005), “The wrong trousers? Beyond the design fallacy: social learning and the user”, in Howcroft, D. and Trauth, E.M. (Eds), Handbook 0/ Critical In/ormation Systems Research, Edward Elgar, Cheltenham, pp. 195-22l.

Suchman, L. (1995), “Making work visible”, Communications 0/ the ACM, Vol. 38 No.9, pp. 56-64

Usher, N. (2004), “Outsource or in-house facilities manageroent: the pros and cons”, Journal of Facilities Management, Vol. 2 No.4, pp. 351-60.

Zimmerman, A. and Martin, M. (2001), “Post-occupancy evaluation: benefits and barriers”, Building Resem-ch & Information, Vol. 29 No.2, pp. 168-74.

Further reading

Shove, E. (2003), Com/art, Cleanliness and Convenience: The Social Organization 0/ Normality, Berg, Oxford.