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Ambitions at work: professional practices and the energy performance of non-residential buildings in Norway

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Abstract

Globally, buildings are considerable energy users. Stricter regulations and instruments such as energy performance standards aim at raising energy performance ambitions and reducing energy use. They rely on the implementation and use of efficient technologies, but technical efficiency improvements do not guarantee low consumption. A gap between estimated and actual building energy performance represents a common challenge.

Over the building lifecycle, multiple professionals influence energy performance levels: architects, engineers, contractors and facilities managers, but also building users. This article concentrates on the building use phase, and how building managers and end-users contribute to increasing or reducing the energy performance gap.

Capturing the relations between formal standards, technologies and actual professional work requires interdisciplinary research. Taking professional practices as the starting point, the article draws on facility management and social practice theory, and case studies mapping energy management and use practices in buildings with high performance ambitions in Norway, informed by interviews with owner, facilities management and user representatives. This article presents and compares results from two office buildings. It demonstrates and discusses how characteristics of and relationships between professional practices and standards influence the realisation of ambitions, pointing out opportunities for actually achieving and sustaining the targeted energy performance levels.

Keywords: standards; professional practices; energy performance gap; non-residential buildings

1. Introduction

In line with technical developments and following national and international commitments to mitigate climate change and reduce greenhouse gas emissions, the energy efficiency and performance ambitions of new and retrofitted buildings are steadily rising. European governments, for example, are bound to implement stricter energy goals in building regulations by the 2010 Energy Performance of Buildings Directive (EPBD) (EU, 2010). The directive requires all new buildings to be nearly zero-energy by the end of 2020. While such regulations and standards are developed to influence energy performance ambitions, for example through technical specifications, they do not necessarily address actual use. In practice however, many buildings do not succeed in living up to their ambitions (Bordass et al., 2004; Menezes and Cripps, 2012; de Wilde, 2014). The gap between the predicted, calculated performance of buildings and their actual levels of energy use is frequently referred to as the energy performance gap. Two lenses from which this gap can be appraised are: firstly, the gap as a technical mismatch between the models we use to simulate energy use and the methodologies by which we measure energy consumption. This could for example be a question about failure to account for the energy used by occupants' equipment in design estimates of energy use (Bordass et al., 2001a). Many studies have focused on narrowing the divide between prediction and measurement models (Norford et al., 1994; Bordass et al., 2004). Secondly, the gap as a sum of influencing factors occurring at different stages throughout the lifecycle of buildings. For example, changes and errors during construction, bad routines during commissioning, and, building use deviating from design intentions (Bordass et al., 2004).

The PROBE studies (Post-occupancy Review of Buildings and their Engineering) is one of the most important investigations providing both evidence of the gap as well as insight regarding the factors that influence it. Running from 1995 to 2002, this project assessed the performance of 23 buildings of energy efficient design. Results suggested buildings often consume up to two times more energy than predicted during the design phase. Furthermore, it highlighted the importance of addressing the management routines that take place once a building has been occupied (Bordass et al., 2001b). This includes, but is not limited to, resolving conflicts between the needs of the different stakeholders who take interest in the building once it has been commissioned. For example, meeting the occupants' need for comfort versus achieving the building´s energy efficiency goals.

In this paper, we take building use and management as the starting point for exploring how buildings can realise their energy performance ambitions.

When we concentrate on the operational stage, a different set of standards becomes relevant than those technically describing energy ambition levels during design and construction. Professional building and facilities service management and commercial or public use of buildings also involve rules and standards, as well as professional practices which relate in different ways. This includes the daily activities of and interactions between building users such as the managers and employees of the organisations owning or renting buildings, and service suppliers involved in the day-by-day building and facilities service provision. This can in turn be expected to affect energy use levels. Theory on facilities management describes the management of this interaction as happening at a strategic, tactical and operational level (EN 15221-1) (European Committee for Standardization, 2006a). In practice, there is large variation in organisational models and how responsibilities are distributed. Facility managers are however often the ones who are in charge of activities such as the monitoring of building systems, management of relevant staff and following up of third-party contractors (IFMA, 2012). That said, depending on the characteristics of the building and the organisation(s) that manage(s) and use(s) it, completely different professional groups do also influence the resulting performance as they carry out their everyday activities. This for example goes for building users such as managers and teachers in schools, and the managers and employees of the public and private organisations using office buildings. Their professional targets and standards may or may not be aligned with performance ambitions and the ideas about intended building usages embedded in the theoretical specifications of building performance. Discussing the 'social potential' of the built environment, Janda (2014) argues that interdisciplinary research on the relationship between occupants, organisations and efficient technologies is needed.

In order to theoretically capture such issues, we draw on social practice theory, and report on empirical data from an interdisciplinary project combining perspectives and approaches from facility management, sociology and design. Social practice theory is promoted as an alternative to the individually oriented and systemic or structural perspectives that have dominated sustainable consumption policy and research (e.g. Shove, 2010; Spaargaren, 2011), but failed to take into account the relationship between individual agency and structure, and between the social and the technical. Social practice theory turns attention towards the social and the material side of energy use. It makes it possible to explore how the professional practices and standards of building occupants influence energy use and the prospects for achieving and sustaining energy performance standards. Here, we are particularly interested in the relationship between energy management practices and practices carried out by building users or occupants, and between the professional practices of different occupant groups and goals about achieving energy ambitions.

By concentrating on a different set of standards than those specifying ambition levels, namely those that guide the everyday practices of building managers and users and set the standards for work and working environments, we are able to explore what is seen as normal, how it varies between occupant groups, and importantly, how it influences the prospects for achieving energy ambitions.

To do that, we further draw on data from case studies mapping energy management and use practices in eight non-residential buildings in Norway (the Authors, 2014). The case studies have been conducted as part of a larger project aiming to map approaches and practices in non-residential buildings with ambitious energy performance targets, identify the potential for improvement and develop methods that can help align energy performance targets with actual energy use levels. The selection of cases covers four school buildings and four office buildings located in south and mid Norway. The buildings have varying degrees of ambition in relation to energy efficiency, with the least ambitious building aiming at using 20 % less energy than prescribed in the Norwegian building code, and the most ambitious one being designed as plus-energy building. The technical solutions chosen in the case buildings represent the international state of the art for energy efficient buildings in temperate climates (increased insulation, building automation, efficient installations). In this sense there is reason to believe that our observations can be generalised to other, comparable national context. Limiting the scope to the Norwegian context ensures that the cases face similar conditions, e.g. in terms of regulations, energy access and prices. In this context it allows for concentrating on and comparing the relationship between building energy performance targets and the ambitions of professionals managing and working in the buildings, the similarities and differences in approaches and practices. Shedding light on the interplay between building and practice-level ambitions, between theoretical predictions and the daily work of humans, to understand what affects actual energy use and the opportunities for achieving performance ambitions has relevance beyond the specific cases and the national context, as do the insights and recommendations resulting from the study.

This paper focuses on data from two of the office buildings. One is owned by a general contractor of building services, and the other by a private environmental research institute. The two are interesting to study in-depth due to organisational and material similarities which allow for comparisons at the level of local practices. Both are presented as reference buildings in the Norwegian context. They are privately owned, partly owner-occupied office buildings in which facility management is done in-house and space partly is rented out to other organisations. The kinds of professional practices undertaken in the buildings do however vary. We focus on the professional practices of owner representatives, facility managers and building occupants, the relationship between them, and their relationship to building-level ambitions and standards.

By doing so, we contribute to ongoing research in the field of energy research in the social sciences. More specifically, this practice-oriented, qualitative study contributes to the cultural studies of energy management and use described by Sovacool (2014), and to debates about processes of normalisation, standardisation and change in energy service conventions, and what are relevant approaches to fostering change.

The article is structured as follows. First, we introduce an overview of building standards and standards for facility management, and then social practice theory, looking at how it can be used to theoretically capture professional work and the professional standards guiding it. Second, we introduce empirical data from the two case studies on Norwegian office buildings. Third, the results are discussed in light of theory, and with regards to their implications for the development of instruments to reduce the energy performance gap.

2. Background: standards and professional practices

2.1 Building standards and standards for facility management (FM)

The avenue by which buildings are designed and constructed is paved by the needs of those who own, use, manage, and operate them. However, the full range of expectations that a building must meet well surpasses the functional and comfort requirements of these stakeholders. For example, aspects regarding the health and safety of building occupants, as well as expected energy performance of facilities are also directed at regional, national and even international levels (e.g. the OSH Framework Directive (EU, 1989) and EPBD (EU, 2010)). In this sense, the delivery of high performance buildings can be deemed as a reflection of the demands of a complex globalised market.

At the national level, building regulations serve to specify unequivocal conditions to which the construction industry must oblige. In Norway, like in other countries, current building regulations such as TEK10 (KRD, 2010) mainly focus on specifying building materials and structures and are inscribed within the boundaries of the planning, design and construction phase of buildings. Even though section 4.1 of these regulations refers to the use-phase of buildings, orientation is limited to highlighting the responsibilities of contractors in providing the necessary support to ensure adequate operation of the facilities (DiBK, 2010, p. 16): *"Responsible designers and responsible contractors shall, within their areas of responsibility, provide responsible applicants with the documentation necessary to satisfactorily carry out the start-up, management, operation and maintenance of the structure, technical installations and systems."*

Norway further introduced its own Passive-House standards for residential buildings (NS 3700) in 2010 and for non-residential buildings (NS 3701) in 2012 (Standard Norge 2010; 2012). Content from the latter extends up to the commissioning phase of buildings and focuses primarily on defining permissible levels of energy use for heating, cooling and lighting. In that sense, this standard does not provide solutions that can help to achieve the criteria for Passive-House buildings in the operation stage.

This does not mean that facility managers responsible for ensuring the optimal performance of a building structure and related systems operate in a world without standardised procedures and routines. They contribute to energy management in three main areas – organisational, technical and architectural: organisational improvement measures (i.e. improvements to building usage and operation), technical improvement measures (i.e. improvements of the building´s heating systems) and building modernisation (i.e. improvement of the building´s heat insulation and structural elements) (Junghans, 2013, p. 179).

Although the profession of facility management is well defined, there is high variation in how facility management is performed, as well as in the background and knowledge of those persons performing it. "Facility manager" is not a protected title.

One of the cornerstones of current FM standards is the adequate provision of “Service Level Agreements” (SLAs) (EN 15221-2) (European Committee for Standardization, 2006b). SLAs express a formal concord between a customer (e.g. building occupants) and a service provider (e.g. in-house or outsourced facilities management team) on issues regarding the performance, measurement and conditions of the service to be delivered. Other groups of standards of equal importance to how buildings are operated and used in the context of energy management include: quality management standards (e.g. ISO 9000), environmental management standards (e.g. ISO 14001) and energy management standards (e.g. ISO 50001) (see ISO, n.d. a-c). These standards are guiding the management of buildings only to the extent that they are adopted at national, regional or at the level of the individual building. Thus, much in the same way that the use of non-residential buildings is characterized by its heterogeneity, so is the spectrum of practices by which the service of energy management is delivered in different organizations. Understanding the interrelations between different organizational approaches to energy management and their contribution to high energy performance is of upmost value.

2.2 Social practice theory

Many actors are involved in the design of buildings and the infrastructures and technologies that go into them, influencing their resulting designs and the potentials for use and resource consumption they open up for. Scholars such as Akrich (1992) have elaborated on how imagined uses or frameworks for action are inscribed into artefacts, shaping their designs. Expectations about use are certainly also inscribed into building standards and the theoretically specified energy performance levels of buildings. Here, we are interested in what actually goes on in the buildings once they are commissioned and occupants move in with their own expectations and standards. What will it take to realise technically inscribed ambitions or professional standards in sites where multiple and possibly conflicting ambitions and standards are at work?

To dive deeper into the relation between the social and the material side of the routinized, ordinary activities people carry out in their everyday life at work, we turn to social practice theory. According to Schatzki (2001, p. 11), practices can be seen as 'embodied, materially mediated arrays of human activity centrally organized around shared practical understanding.' These shared skills or understandings form the meeting point between individual and society, and processes of social learning are premises both for the reproduction and the transformation of social life. Individuals are in practice theory conceptualised as 'carriers' of practice. They do not only carry routinized behaviour patterns, but also, in the words of Reckwitz (2002, p. 250), 'certain routinized ways of understanding, knowing how and desiring'.

Pantzar and Shove (2010) suggest that the elements of practice can be summarised as pertaining to three broad categories, in which the mentioned shared 'skills' are supplemented with those of 'material' things, and 'image' or mental activities. The three groups have later been referred to as 'competence', 'materials' and 'meanings' (Shove et al., 2012). In order to exist, practices must be performed, and it is in the situated performances of practice that the elements are integrated and the links between them made (Pantzar and Shove, 2010). The performances are routinized, guided by and reproducing conventions, but they are also dynamic and internally differentiated, providing sources of change (Warde, 2005). Warde (2005, p. 140) suggests that performances of familiar practices happen in ways that are 'often neither fully conscious nor reflective'. The dispositions people have to act in the ways that they do are 'entrenched *and* embodied' (Warde, 2005, p. 140), but at the same time they never act in exactly the same way. How the practice of 'writing' is performed will for example vary from person to person, but also, from time to time. The extent to which people strive to excel in a practice will also vary, and with their own investment in a practice, people's ability to recognise the positions and dispositions of others varies. Discussing the value of different practices, Warde (2005) suggests that rewards that are internal to practices relate to how complex the practice is, and that external ones relate to the prestige of the practice.

Office buildings are sites in which many different activities are performed. Buildings, fixtures and fittings may themselves for example be part of managing, meeting, analysing, writing, cooking, maintenance and cleaning practices. As professionals carry out the practices that are assigned to them, resources are consumed. Their practices will in most cases involve energy-consuming equipment such as automatic blinds, lamps and heaters, servers, routers, PCs and monitors, printers and projectors, fridges and freezers, coffee-makers and dishwashers. Such tools are used and interacted with in ways that reflect and reproduce shared standards, for example on when and for how long to work, what constitutes acceptable output, proper office conduct and suitable office attire, or a comfortable working environment in terms of air quality, temperature and lighting levels.

Practices do further form systems in which they influence each other, conflict or integrate and form interdependencies (Pantzar and Shove, 2010; Watson, 2012). This may be a question about connectivity in space and time, and about differences in obligation and commitment to different practices (Blue and Spurling, 2017). Blue and Spurling (2017) suggest that connections between practices may influence the reproduction and development of entire practice complexes, such as the sum of activities that take place in a hospital. In office buildings, energy management may require pre-programming of daily temperature levels to allow for night-setbacks, which can conflict with preferences for being flexible and for example be able to spontaneously and comfortably work from the office the night before a deadline. Certain practices may further have higher priority or more commitment than others.

Standards for proper conduct may vary between professional groups, and between organisations. Buildings may be home to different organisations, and organisations both internal and external to a building may be involved in its operation. The organisation owning the building may not be the (only) one to occupy it, in turn possibly influencing how occupants relate to the building. To capture organisational characteristics and dynamics, social practice theory can also be helpful. Schatzki (2005; 2006) argues that organisations too can be seen as bundles of practices and material arrangements. By material arrangements, he refers to 'assemblages of material objects' (2006, p. 1864), such as call centres or classrooms, which may include people, organisms and things.

Over time, practices follow a development trajectory (Warde, 2005). In society at large, and in the 'careers' of single practitioners, they form, are reproduced, and die out (Pantzar and Shove, 2010). This means that the past influences what is done now, as do ideas and expectations for the future. In the social processes in which the practices of professionals are formed, reproduced and transformed, energy may not be a concern. Further, while new building types, technologies and interfaces appear, practices may conserve 'old' skills, or know-how developed in other settings. Moving into a new office building, practitioners may bring with them 'outdated' practical knowledge, e.g. for how to regulate air quality, temperature or lighting levels. On the other hand, a new building with high energy efficiency ambitions may also change the way people perceive and use the building.

In the following sections we will continue exploring these issues drawing on empirical data on how the professional practices of occupants influence energy use levels, how they relate to energy management practices, building standards and other standards, and goals about achieving energy ambitions.

3. Methods

In total, the study includes eight cases, covering schools and office buildings located in Norway. The buildings were selected according to a set of criteria: they were all buildings with high energy efficiency ambitions. They were further non-residential buildings, which in Norway represent 15 % of the energy use (NVE, 2016). For the study, publically owned school buildings and privately owned office buildings were selected. This paper concentrates on two of the office buildings. One, case A, is owned by a general contractor of building services, and the other building, case B, is owned by an environmental research institute.

The building in case A is the largest, with a heated gross area of approximately 13,500 m^2. It also has the lowest predicted net energy need, with approximately 65 kWh/m^2 per year. The estimated supplied annual energy level is about 25 % lower. The building in case B has an area of approximately 8,000 m^2 and a 12.5 % higher calculated net energy need which equals its predicted level of energy supply. Both buildings were opened in the period 2012-2013, and aimed for the passive house standard (NS 3701) introduced in section 2.1. The two are selected as they share some similar characteristics: they are built in the same period, aiming for the same standard. They are owner-occupied but with parts of their spaces rented out to other organisations, and facility management is done in-house. These similarities at the material and organisational level enable us to compare issues related to use and operation and to zoom in and compare context-specific characteristics and dynamics. The differences in the professional activities taking place in the buildings do further make the cases relevant to compare. The comparisons are however done based on qualitative data. In both buildings, energy data is collected at the building level, and no quantitative data about the actual energy consumption at the level of spaces or functions was therefore available.

The data material comprises documentation on energy performance ambitions and interviews conducted in 2015, each lasting approximately 45 minutes. Interviews were conducted with building owners, facility managers at the strategic and operational level, and with building occupant representatives. Data was collected through semi-structured interviews aided by graphic elicitation tools such as a timeline and cards, both empty and with ‘strengths’ and ‘weaknesses’ and names of actor groups, activities and related skills and tools printed on to them, allowing interviewees to visualize, rank and discuss different issues. The interviews covered topics related to energy use and management of the building, and aimed at mapping energy efficiency ambitions, actors and activities with impact on energy use and management, as well as methods and tools, competences and skills connected to the mapped activities or practices. In addition, the interviews included questions about how practices have developed over time, offering insights into changes in professional practices and standards over the lifecycle of the building. Covering all these topics in each interview made it possible to gather the perspectives of each of the actor groups.

In the two cases selected here, a total of nine interviews with 11 key informants were conducted (Table 1). All the interviewees were employed by the organisation owning the building. In case A, four interviews were conducted with six individuals. These were the building owner, the strategic facility manager, the total technical support service (TTS) manager responsible for the relationship between building occupants and facility managers, the energy management system (EMS) manager, and two employees from the owner organisation, here representing the building users. The TTS and EMS managers were interviewed together, as were the two user representatives.

In case B, five interviews were conducted with an equal number of individuals. These were the building owner, two facility managers, and two users employed by the research institute owning the building.

Table 1 Interviews

	Building A	**Building B**
Interviewees	• Building owner • Strategic facility manager • Total technical support service (TTS) manger • Energy management system (EMS) manager • Two employees, owner organisation	• Building owner • Two facility managers • Two employees, owner organisation

Interviews were transcribed, coded and analysed using an inductive approach with a set of preliminary themes established based on the interview structure. The analysis was done aided by the qualitative data analysis software tool NVivo. NVivo was used to manage interview transcripts, code and classify citations, to examine relationships across interviews by comparing and contrasting quotes, and to develop categories based on them. The data was analysed according to emerging evidence on and mentioning of practices. This includes practices and standards directly related to energy management and use in the building, as well as other professional practices and standards of occupants: how things are done in everyday life at work and why. Moreover, the analysis focused on how these different practices and standards influence each other and the energy performance of the building.

4. Results

This section describes the two cases with regards to building energy performance targets, energy management practices, other energy relevant professional building occupant practices, and related standards.

4.1 Case A

The first case building provides office space for the organisation that owns it, a contractor of building services, with parts of the area rented out to other organisations. The building is however equally important as a show-case for existing and potential customers of the owner organisation. The building ambitions are the energy label A ('light green'), the Norwegian passive house standard (NS 3701), and BREEAM Very Good. For non-residential buildings, the energy label ranges from A (best) to G (Energimerking.no, 2009). The energy score characterises the condition of the building compared to similar buildings. An A or B score indicates that the building satisfies stricter requirements than what is specified by building regulations. In addition, buildings are awarded a colour code according to their heating source. A light green score indicates the use of waterborne heating with heat pumps, solar thermal collectors and electricity for peak loads. When it comes to the BREEAM rating, construction projects are in the Norwegian context ranked from "Outstanding" via "Excellent", "Very Good", "Good" to "Pass", according to their environmental performance in the categories management, health and indoor climate, energy, transport, water, materials, waste, use of space, ecology and pollution (Norwegian Green Building Council, 2015).

Through the case A building, the organisation wants to demonstrate what it is capable of, and what can be done by combining commercially viable, 'off the shelf' and standardised energy solutions in combination with offering employees and other building users a high quality, comfortable indoor working environment. The firm representatives underline that the firm's strategy is to implement technical standard solutions that can be adopted in high numbers of buildings, and in that way make a greater positive environmental impact than what the deployment of high-end solutions in 'prototype buildings' would have made.

Energy management is organised in-house, with responsibilities, tasks and competences distributed between different employees. Over the years, the firm has developed its own professional standards for energy management, including a standardised process, methods, tools and measures that focus on organisational and technical improvements, leading into professional practices for energy management. These are applied in the firm's own building, and are at the same time offered as a service package to organisations owning or occupying other buildings.

For the work on energy management in the building, a key practice is the detailed and constant follow-up on building energy data that feeds into further energy management. Energy data is tracked on an hourly basis and automatically collected in an EMS system. This system visualises the most relevant energy data in four graphs which the EMS manager and his team see on a large TV screen on the wall in their office. This ensures that they look at the energy data on a daily basis, in the background of other activities, and can react immediately in case deviations are shown.

> EMS manager: *"It is very clear that we want to keep the energy use of the building as low as possible. I work on this every single day. In our office – that of the 'energy gang' – we have a large TV screen that shows the energy monitoring. It is in a way in the background and it is seen every single day by me and several others. So we see it quickly if there are any deviations in the energy data."*

When problems need to be solved or some of the technical energy systems in the building, e.g. the ventilation system, need fine-tuning or adaptation, colleagues within the organisation possessing the relevant expertise are contacted to make the operational changes happen. This way of working is possible because experts are available in-house, covering the fields of constructing and managing buildings. Sometimes however, employees experience time conflicts between the follow-up of the energy performance of the organisation's own building and work for clients, who in practice often have to be prioritised.

On top of the daily monitoring, the energy management team sits together on a bi-weekly basis to go through the energy data in further detail. In general, employees are described as interested in new technology, and the management as strongly supporting a focus on energy management. Good energy management in the building can support the commercial activities of the organisation by proving that *'it works well'*.

Other professional practices that support the organisation, its building and its energy management performance are a) regular tours for (potential) clients and other interested people, b) the testing and monitoring of new technologies – e.g. new types of solar panels, products and services indicating that the firm is a technology leader in the building sector, c) external documentation of solutions and technologies by partners providing an objective and standardised view of their performance, d) visualisations of energy data on a large TV screen in the entrance hall targeting employees, customers and visitors, e) a focus on internal communication and close contact between different departments and individual employees, f) research projects performed by students on specific aspects of energy management in the building, e.g. a project on possibilities for local user-steered heating and ventilation systems, and g) cost-benefit analyses of all new solutions and products before they are taken into use.

The building's controls are not following fixed schedules but are demand driven using various sensors (movement, temperature, solar radiation, CO_2 levels), which sometimes leads to tensions between other non-energy management related professional practices such as office work and users' experience of comfort.

> Employee: *"We notice that the building is demand driven, […] mostly from the automated lights. […] When people leave for home, we notice that from the amount of light in the building, and when you sit entirely still at 5pm it becomes totally dark inside. […] Another system the users notice well, especially those with an office at the sunny side of the building, is that of the blinds. […] The blinds are disliked the most in winter time, when the days are short and dark. Once you get a bit of sunlight in – which is nice, the system decides to suddenly close the blinds. And then we are sitting in the dark anyway."*

The owner organisation representatives see the tenants of office spaces as less interested in the energy performance of the building. Examples provided include how tenants wanted to install extra heaters, installed highly energy-using equipment without notifying the building owners, and how they, according to the TTS manager, generally complain more often than the employees of the owner-organisation do, especially when it comes to office temperature levels. Such complaints are however said to be taken seriously: the temperature is measured, individuals are encouraged to put on an extra layer of clothing, and minor temperature adjustments of 0.1 degrees, described as placebo changes, are made where needed.

4.2 Case B

The building in the second case serves as an office building, mainly for the research institute owning it, but parts of the spaces are rented out to other organisations. The building contains several meeting rooms, laboratories, an auditorium, a restaurant, and a gym accessible for everyone working in the building. Both the building owner and the interviewed employees talk about the building and its qualities with pride. The building is meant to support the image and culture of the environmental research organisation that owns it. The building's ambitions follow the Norwegian passive house standard (NS 3701). It is built with local materials and materials described as environmentally friendly, thought to offer an excellent indoor climate and comfort level, and to create an atmosphere of openness, friendliness and light.

Two in-house facility managers are responsible for the management of the building. This includes energy management. The two are responsible for the whole range of facility management activities, from the strategic to the operational level. No specific formal standards are mentioned by the interviewees as providing guidance for the energy management of the building. Professional practices rather emerge based on learning-by-doing. Like the building in Case A, it is demand driven, with most of the energy systems automated. The data indicates that this high level of automation affects how the building is used and managed. For the facility managers this means that they monitor the building's energy systems on a daily basis, mostly as a daily check-up of the energy data, and with more detailed analysis and problem-solving when alarms go off or deviations occur. In addition to a good understanding of the building and the different technologies in the separate energy systems (e.g. district heating, ventilation, lighting and electricity), one of the facility managers emphasises ICT competence and knowledge of the EMS software as essential for facility managers. Assessment of the energy performance of the building over a longer period of time has so far not happened; the needed energy data could not be gathered yet because the building only is in its second year of use. This implies that, up to now, energy management has mostly focused on monitoring, problem-solving and fine-tuning the different energy systems of the building at an operational level. This also includes the management of complaints from users, mostly on differences in temperature between different offices and rooms.

The facility managers further engage in other practices that support the energy management of the building, such as training and staying up-to-date on new technologies, EMS system innovations and changes in technical standards. Communication between the facility managers, employees and other users generally happens in person or through e-mail. It mostly focuses on comfort-related and practical issues in the building, and rarely on its energy performance.

The representatives from the users of the building – the employees at the research institute, also experience the effects of the demand driven, highly automated energy systems. Some employees feel that the building and the automated systems make it possible to fully focus on their job, whilst one user expresses the feeling of a lack of control of different comfort-related aspects, as well as a passive attitude towards the energy-efficiency of the building.

> Employee 1: *"There is not so much that I need to know about the building, because it pretty much 'fixes itself' [through self-regulation]. I don't feel the need to do a lot of things manually. I can probably count on one hand the number of times I felt that I needed to, for example, open or close a window manually. Or the light above my desk: if I leave my desk I don't have to shut the light down or anything."*

> Employee 2: *"I think a lot of us expect from the building to take care of a lot, and that might make us more passive. […] I don't think it's very good, really. You get this feeling that the technology, the design of the house will take care of you. And actually it should be your own actions in your daily life that is the most important thing."*

Qualifying the latter statement, building occupants are in fact equipped with some opportunities for making individual adjustments, e.g. through desk lighting and temperature regulation. The interfaces for making temperature adjustments are however described as unclear. Regulating the temperature is also experienced as too slow a process, in practice favouring the quicker solution of opening the window to let fresh air in. Overall the data indicates a low level of understanding of the building amongst the users. Basic knowledge about the building is mentioned as interesting and helpful, but not necessary for them to do their job in a good way.

Most of the employees in this case have an intrinsic interest in environmental issues. Since the organisation moved to the new building, employee-led initiatives related to environmental issues have formed, such as a committee working on improving the waste management in the building, encouragement of colleagues to take the stairs instead of the elevators, and a growing number of employees walking and cycling to work.

Some common and energy-related practices of the interviewed building users include desk work, laboratory work and meetings, including video conference calls with other divisions. Several examples demonstrate how needs related to lighting, ventilation and temperature differ depending on the activity performed. In some situations, the circumstances needed to perform the practice conflict with the standard parameters of the automated energy systems. In the laboratories for example, a separate ventilation system is installed that does not include a heat exchanger (to prevent air getting mixed), and that can be used 24/7. Lab work forms an important part of the work done within the organisation, but it counteracts the energy performance goals of the building, and is an example of areas in which different goals and standards may conflict with each other. Another example is that of video analysis of a research experiment, where the automated lights in the offices do not support the need for a dark room while analysing. The employee came up with a solution for this specific situation, namely to attach a post-it note to the movement detector that controls the light in the office, and applied the same solution also in other occasions.

> Employee 2: *"We assume that this automatic system is fine, but I once actually made a little system where I put a post-it note over the little detector. […] Because I don't always feel that it's necessary to have light on during the summer when I have a window."*

In meeting rooms, notes attached to the wall ask visitors if they have remembered to turn off the lights. The lights switch off automatically, but this is seen as happening too slowly. Other examples also show how employees take the initiative to solve conflicts between the automated system and their own comfort standards, such as testing the differences in temperature between offices with environmental research equipment, just for the fun of it.

4.3 Relationship between energy-relevant practices, standards and building ambitions

In both cases, the high environmental ambitions of the building are aligned with the owner organisation's goals and strategies and with the expertise and professional standards of its employees, but in very different ways. Both reach for the passive house standard, but represent different shades of 'green' and ways of implementing environmental aspects in the building, its management and use. This is reflected in their designs, and is communicated already at their entrances. In building A, visitors are met by a display communicating the time to the investments made to achieve the passive house standard have been paid off, the monetary savings that have been made compared to buildings with energy label C, and the CO_2 reductions that have been achieved. At the entrance of building B, there is no such display of data, instead occupants and visitors are greeted by a vertical garden.

For case A, the building is a showcase enabling the building owner to demonstrate what it is capable of through the implementation of off the shelf technologies. It is in itself a project for the firm to maintain and keep it as a continuously updated, relevant example of its work. As provider of building services, the firm has also developed an integrated approach that has become its own standard and is offered to clients. The emphasis on keeping the firm's own building up to date does however also lead to tensions, as in having to balance work for clients up against maintaining the firm's 'sales window'.

For case B, the environmental properties and performance of the building reflect the vision and symbolic image of the organisation, which addresses environmental performance in a broader sense, beyond efficient technologies and energy use. This reflects and is reproduced in the research that the employees do, and in their broad environmental interest. The latter has for example manifested itself in how employees self-organise to foster pro-environmental practice changes related to waste management, taking the stairs rather than the elevator and walking or biking to work. The changes in mobility practices may however also relate to the more central and accessible location of the new building compared to the old one.

Despite these differences, both buildings pose similar challenges to their managers. ICT competence is described by the informants as gaining importance, and comes on top of building-related expertise. This has consequences for what the facility managers need to master, and their need to keep up with the technical development. Again, however, the challenge is answered very differently in the two buildings. While energy-efficient buildings are the bread and butter and the core competence of the case A building owner organisation, the energy managers in case B take courses provided by the system supplier to stay up to date, and participate in meetings in which they can exchange experiences and learn from representatives from other buildings.

There are also differences between the buildings in terms of the scope of work of the facility management team members, and in the resources they have available for it. In case B, two individuals have to cover everything from strategic to operational work as well as energy management follow-up, and place little emphasis on strategic work. In case A however, this work is divided between several individuals, each with their own expertise, including the strategic facility manager, the EMS and TTS managers, and technical experts at the operational level that work in different areas and get involved when needed. The emphasis on strategic work is stronger in that case, as is the focus on the commercial value of what is done, and the importance of demonstrating how well it works to existing and potential clients.

Further, the two buildings are home to different organisations and many different professionals and practices. Building energy performance may be at the forefront of some practices, and only indirectly relevant to others. For example, for the building user representative in case A working on economics and project budgeting, building energy performance is not a concern, unless the installed measures compromise his ideas about comfort. In case B, occupants share the interest in environmental issues, but not necessarily ambitions regarding building energy use.

Examples from the interviews show how professional standards connected to the occupants' practices create specific kinds of energy demand. In case A, interviewees mention tenant organisations installing professional equipment that potentially draws a lot of extra energy without clarifying it with the building owner, and requesting to install additional heaters without getting permission to do so. The characteristics of the research practices taking place in the case B building place requirements on spaces and installations that in turn influence the resulting energy use levels in the building, as is the case for the ventilation system connected to the research labs. Thus, the characteristics of the primary activities of the organisations do influence energy use levels, and to some extent such issues may make it harder for the buildings to realise their ambitions.

4.4 Relationships between energy management and use practices

When it comes to the relationship between energy management and use practices, we observe examples of issues that help and hinder the realisation of building ambitions and standards, as well as similarities and differences between the cases.

With regards to the relationship between energy management and other professional practices, the communication between facility managers and occupants does in both cases mainly concern practical issues and complaints. Tensions do primarily occur when the technical systems do not align with the standards and expectations of practitioners. Many of the issues are general to professional office-workers in both cases, e.g. lights that go off, blinds that go down in winter when any daylight would have been welcome, or variation in temperature conditions. When building occupants pass on complaints to the facility managers, they come and do measurements and make adjustments, showing that they do take them seriously. In some cases however, building occupants are asked to put on more clothing, or the 'necessary' adjustments are simply about placebo adjustments of 0.1 degrees (case A), which in turn shows that some standards are malleable and that some facility managers are aware of that.

5. Discussion

The automated technical installations constitute an important interface between energy managers and users. In the language of practice theory they are a shared element of a variety of practices, the practice of energy management, the practice of analysing research experiments, the practice of using a PC, etc. To great extents automated systems run unnoticed in the background of what people do at work. In line with practice theoretical assumptions, we have observed that the perspectives on technical automation vary between individuals. The high degree of delegation of practical competence to technology (in the cases referred to as a 'demand driven' approach) leads to a reactive (problem-fixing) approach from both facility managers and building occupants. The automated systems further influence the understanding of building systems among the occupants who are not themselves building experts, in both case A and B. When in case B the systems come equipped with some opportunities for individual adjustments, the poor quality of the user interfaces for temperature regulation and the impression that the system reacts slowly to changes made to it prevents occupants from making use of it. When the new built environment does not provide support for practice change or for the development of new practices, occupants cope by means of old skills, for example by opening windows to make temperature adjustments, even though that is not desirable from an energy management perspective.

In that regard, occupants are by no means passive, no matter how little agency they get allocated by the automated systems. They learn and adapt by experimenting and improvising, developing new practical skills, or making use of their professional skills and strategies to address practical problems they face within the building. In case A, the high in-house competence on building energy performance and the commercial value of attending to it has certainly led to the development of a number of strategies, own standards and practices to exploit it, and to draw the general attention of building occupants and visitors to the topic. Occupants in case B used post-it notes to block light sensors. They also made use of their research skills and curiosity in an initiative to find out whether all offices really had the same indoor temperature, as they started monitoring it themselves and found temperature variations. As pointed out by others (e.g. Strengers, 2014), with automation strategies and associated ideas about 'users' being uninterested or too busy to engage in energy management, what people actually do as they perform the many practices that make up their everyday life, including how material tools such as automated technologies go into that, disappears out of sight.

In order to reduce the gap between technically specified ambitions and the actual building use, understanding the characteristics of the practices that take place in the building and the rationale by which professionals work is a productive starting point for the development of practical interventions and approaches. This resonates with ongoing social science explorations of the opportunities for understanding and creating change that open up when social practices are taken as sites of intervention, rather than technologies or individuals' behaviour (Strengers and Maller, 2015). Here, coupling facility management standards with insights and approaches from social practice theory and design is highly relevant (Verhulst and Pettersen, 2015). Our case buildings show that routines and standards used in their management and operation are highly context specific. In case A, this was part of a standardised package that was developed as a service sold by the occupying firm. In case B we did not register any clearly defined standardisation. Practices that share the building as their material aspect, most importantly practices that are carried out to monitor, analyse and control energy consumption and practices related to the work done in the building (e.g. laboratory experiments) should be coordinated to support each other. In looking for synergies and opportunities for stimulating the formation of new or changing existing practices, issues such as prestige and experienced internal rewards (cf. Warde, 2005) deserve attention.

Upon entering a new built environment, practitioners - both occupants and building managers - bring with them old skills and ideas about what form appropriate conditions for what they want to achieve, and about how to interact with what they see around them. In order to influence them, it may not be enough to provide them with information and new technical tools and interfaces. While the design of interfaces that stimulate the formation of energy-saving practices is an area of study in itself, it is in the end practitioners who have to integrate the different practice elements and develop bodily routines that work for them (Pantzar and Shove, 2010). Further, practices are in continuous flux, and practitioners adapt and improvise according to the situations they are in (Warde, 2005).

Further complicating issues include how buildings are not always owner-occupied. In addition, they are often occupied by more than one organisation, and constellations change over time. As noted in case A, tenants were less interested in energy efficiency issues than employees of the owner organisation. Forming and maintaining shared understandings and practices is a challenge that goes beyond organisational borders. Enabling the different actors working with and within non-residential buildings to understand each other and each other's goals, ambitions and professional standards will help them develop strategies for reducing the performance gap. An overview of practices and their energy-relevant qualities forms the starting point for exploring what helps and hinders change, and what could form intervention points for fostering it (Pettersen, 2015). This would include looking for opportunities to influence obsolete or problematic standards, practices or elements and the links between them, as well as looking for inspiration in how things are done in other contexts. Joint practical explorations may aid this process, and the development of shared understandings and systems of practices that work in the building in question. As input for such work, an additional topic to explore in research as well as in practice is how to measure energy consumption per function or practice.

6. Conclusion

Buildings are considerable energy users, and they do indeed have a large technical energy saving potential, but current building standards do not take actual use into account. The discrepancies between intended and actual building management and use are considered to be among the reasons why an energy performance gap frequently can be observed.

In this article, we have taken the energy performance gap as the starting point for exploring what actually goes on as buildings are managed and used. Taking the social practices performed in non-residential buildings as units of analysis, we have explored how the professional practices and standards of energy managers and building occupants explain significant differences in buildings' energy performance. We have done that by presenting and discussing empirical data on the social practices performed in two Norwegian office buildings. The data demonstrates that studies of the practices of energy managers and occupants – the rationale by which they act, and the practical competence and tools they have access to for doing so, may be a relevant starting point for identifying problematic issues, as well as for finding opportunities for fostering change and reducing the performance gap.

Our exploration of the relationship between building standards, energy management practices and the other professional practices that take place in the buildings may in turn help advance knowledge in the field of facilities management. There, focusing on such issues has potential to become a new field of specialisation. For the future development of improved or new practical approaches to closing the energy performance gap, topics for further research include how to adapt to differences in building size, resource availability and organisation of energy management, the needs of the public and the private sector, and to differences in the composition of building occupants and practices. As energy data is currently commonly collected at the building level, a related topic is how to measure and get access to data on the actual energy use at the level of practice or function.

This interdisciplinary study has revealed a large number of specific differences between the two case buildings, how the practices of their occupants and managers differ, how they are intertwined and how they may influence the buildings' energy performance. The interdisciplinary collaboration that has enabled the writing of this paper - with experts from engineering, architecture, design and social science participating in the analysis - will not easily be available to daily building operation and use. However, there is in principle no reason why elements of the study, above all its integrated view on use, management and technology, could not be implemented in regular building management to inform decisions that account for the whole building's energy consumption.

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