People and Activities in Energy Efficient Buildings: Comparative Study of User, Owner and Facilities Management Perspectives in Schools

Roberto Valle Kinloch,
Norwegian University of Science and Technology
Roberto.valle@ntnu.no
Antje Junghans
Norwegian University of Science and Technology
Antje.junghans@ntnu.no
Ida Nilstad Pettersen
Norwegian University of Science and Technology
Ida.nilstad.pettersen@ntnu.no
Elli Verhulst
Norwegian University of Science and Technology
Elli.verhulst@ntnu.no

ABSTRACT

Tightening the link between the design and operation phase of buildings is widely regarded as a solid approach towards improving their energy performance. Energy management strategies delivered exclusively from an asset management perspective may often neglect the impact from the people who use, operate and manage the assets. This paper presents the findings from two case studies that aim to deepen our understanding regarding how energy management practice is carried out within "high energy efficient" school buildings in Norway. The methodology includes individual semi-structured interviews with at least one representative from each of the following user groups: building occupants, facilities managers (operational, tactical or strategic) and building owners. Energy data routines have been gathered through interviews and strategic documents. Findings suggest a strong disconnection between the expressed energy ambitions of the buildings (i.e. energy standard to which to which the buildings are designed) and the actual delivery of energy management as a practice. Building occupants relate to the use and management of energy in the context of activities relevant to the building´s core function. Energy data routines as implemented by building operators reflect disassociation from the activities that end-users deem as strategic. Results from this study have strong implications regarding the role that professional bodies, organizations and educators need to play in ensuring that high energy ambition buildings are met with energy aware users. The knowledge developed can support further development of facilities management qualifications. Through an activity-centred approach, we are able to develop key insight that supports in identifying key areas for collaboration between building occupants and facilities managers and building owners.

Energy Management, End-user Perspective, Facilities Management, Interdisciplinary, Collaboration

1. INTRODUCTION

Contribution from the built-environment to achieve energy efficiency (EE) goals is well established. Efforts to improve the energy performance of non-residential buildings can take the form of initiatives that: a) support the decision-making process at the design phase of a building. This is, to align principles of sustainable architecture with the adequate procurement of energy-efficient plant and equipment, in support of the sustainable operation of the building (Junghans, 2012, Ure and Camyab, 2016); b) support the development of energy measures that can be adapted or retrofitted into existing buildings. Beyond technology-based approaches, this includes solutions that can positively impact the way buildings are used and operated. Increasing evidence shows that buildings often perform worse than their design intentions. This issue is commonly regarded as the Energy Performance Gap (EPG). As suggested by Bordass et al. (2004), the EPG can escalate to affect market perception over the effectiveness of industry proven EE technologies for low-energy buildings. Causes for the EPG are many and stem from different phases in the life of a building (De Wilde, 2014, Valle & Junghans, 2014). Lack of knowledge at the design phase regarding how buildings are (to be) used and operated is often highlighted as one of the main causes for the EPG. Tightening the link between the design and operation phase of the building is widely regarded as a solid approach towards bridging the performance gap (Bordass et al., 2004) Technology-based solutions are the dominant approach towards improving the energy performance of buildings. However, energy management strategies which are delivered exclusively from an asset management perspective may often neglect the impact from the people who use, operate and manage the assets. Occupant engagement is widely acknowledged by both industry and academia as a critical factor towards achieving good energy performance (Janda, 2011, Menassa, 2014, TRUST, 2011, ENERGY STAR, 2013). This paper presents the findings from a selection of two case studies that aim to deepen our understanding regarding how energy management is carried out within “high energy efficient” rated school buildings in Norway. Central to this approach is the development of an activity-centred framework which facilitates identifying potential areas for collaboration between the different user groups that use, operate and manage the building. Findings from this study are complementary to current academic and industry efforts seeking to maximize energy efficiency gains through building occupant engagement.

1.1. Impact of building occupants on the energy performance of facilities: the need for end-user (occupant) engagement.

A report issued by the International Energy Agency (IEA, 2013) identified six key factors influencing building energy consumption, 50% of which can be linked to human interaction, including: a) building operation and maintenance; b) occupant activities and behaviour and; c) indoor environmental quality. Main areas of interaction between users and buildings include lighting, appliance electrical loads, ventilation, space heating, space cooling and domestic hot water (IEA, 2013, Demanuele et al., 2010, Hong et al., 2013). Nicol (2001) concludes that the use of controls in the building is linked: to climate conditions, particularly outdoor temperature, and to physical conditions related to user comfort, such as the need to improve indoor air quality. Haldi et al. (2008) present an overview of studies which led to further development of Nicol´s behaviour prediction model. Knowledge on occupant behaviour can lead to better energy prediction models, avoidance or at least minimization of interactions between building occupants and energy consuming systems. Occupancy patterns have been shown to have an impact on the energy consumption of buildings. Many studies have indicated that often buildings use a significant amount of energy after regular working hours (Bordass et al., 2001, Hoes et al., 2009, Menezes et al., 2012, Korjenic et al., 2012). The effect is felt most in buildings with large plain open spaces, as many of the energy consuming systems (e.g. HVAC, lighting) have to be kept on running on full system capacity just to provide basic working conditions for few people. Different analytical approaches can be used to evaluate impact of building occupants on energy use, including building simulation, site survey and a mixture of both of these approaches. Menezes et al. (2011) make use of Post Occupancy Evaluations (POE) to gather detailed data on the performance of a multi-tenanted (four tenants) office building in the UK. The data gathered is fed to an energy prediction model. Findings highlight that the differences in energy use between the tenants are linked to their particular organizational management styles and context relevant activities. It is reasonable to argue that buildings equipped with the state of the art of EE technologies, provide conditions that can minimize and even annul the impact of the building occupants on energy consumption. However, as pointed out by Stevens (2001), such a system would need to prove effective in keeping up with fast changing user demands for comfort. In addition, many studies on occupant satisfaction have shown that end-users become increasingly dissatisfied as their ability to manipulate their working environment is restricted (Galasiu et al., 2006, Hoes et al., 2009), and will often find ways to intervene the systems (Aune et al., 2009, Menezes, 2009, Morant, 2012). Aune et al. (2009) states: *"… even if user-interfaces are automated with intelligent systems, unexpected user actions, such as creative adaptation or even outright sabotage of systems, are frequent."* In this paper we support that end-users are to play a role in supporting the delivery of energy management practice. End-user engagement approaches are to be part of energy management practice. The benefits from end-user engagement must be perceived beyond the boundaries of energy performance, to include: better educated users, fewer interventions from users on building system and improved collaboration dynamics between end-users and facilities managers.

1.2. FM´s contribution to the delivery of high energy performance in non-residential buildings.

The FM industry deals with a great set of strategic management competences, including: Real estate management, financial management, organizational management, innovation and change management and human resources management (Atkin & Brooks, 2015). The European Standard for Facilities Management (EN15221-1, 2006) defines FM as the *"integration of processes within an organization to maintain and develop the agreed services which support and improve the effectiveness of its primary activities"*. Expansion of the FM industry is primarily driven by the need of organisations to remain competitive in an increasingly regulated business environment. In the built environment, the practices of sustainable production and service delivery are becoming progressively more legislated. Comparative energy performance measurements for buildings over specified floor area have been mandated (Atkin & Brooks, 2015). The strategic position of FM in driving the sustainability agenda at the building level has been acknowledged (Elmualim et al., 2012). The delivery of energy management practice is a service that the FM profession can provide (Junghans, 2013). Novakovic et al. (2012) adopt the energy management definition provided in the report "Energiledelse- Veileder for etablering og drift" (Energy Management – Guide to establishment and operation): *"Energy management is that part of a company´s leadership responsibility that ensures that the energy is used efficiently".* This definition falls short in failing to address the aspect of on-site energy production. Novakovic et al. (2012) also describe the roles of building owner, property managers and building users from a building and property management perspective. The strategic, tactical and operative levels at which the facilities managers interact with the organization have been theorized (Atkin & Brooks, 2015, Junghans, 2015, Novakovic et al., 2012). It remains unclear whether FM service providers embrace these theoretical models in the delivery of energy management service. The case studies in this project have been collected as part of a larger inter-disciplinary project called MINDER (Methodologies for Improvement of Non-residential buildings Day-to-day Energy efficiency Reliability). MINDER brings together the disciplines of Social Science, Design and Facilities Management, in the delivery of methods that can contribute to narrowing the EPG. The case study framework builds on the findings from a survey delivered in August 2014 which targeted representatives from 49 member organizations from a well-established Norwegian network for Real Estate and Facilities Management (See Valle & Junghans, 2015). Among other issues, the survey highlighted split opinion amongst FM practitioners regarding the impact of building occupants on energy consumption. Most facilities managers at the strategic level perceived that end-users do not have an impact on energy consumption.

2. METHODOLOGY

The aim of the case studies is to provide in-depth knowledge on the actual process of energy use and management in non-residential buildings in Norway. Semi-structured interviews are at the core of the process of data collection. Interviewees include representatives from building occupants, facilities managers (operational, tactical or strategic), and building owners. The case study framework is based on the deconstruction of the methods considered to be best-practice in the management of energy in non-residential buildings. This approach was developed during the design of the survey that precedes this study. The process is guided by the understanding that a method can be described as the sum of the actors, processes, tools, competences and outcomes required to meet an objective (See figure 1):

Figure 1. Model for the deconstruction of any given energy management method

- A= Actors. Refers to the key stakeholders involved during the lifecycle of a given method.
- PT= Processes & Tools. Series of actions and functions put in place to bring about a result.
- C= Competences. Range of skills, knowledge and abilities required to implement an action.
- O=Outcomes. Specific objectives of the method, either at a particular stage or as a whole.

From this perspective, it is possible to gain in-depth knowledge about particular actors, processes, tools and competences, to an extent where the risk of adoption or rejection of these individual elements within a particular context can be appraised. The strengths and weaknesses for each of the parts can be studied, and the threads which describe the relationship between the parts can be enquired. Based on the previous, a structure for the case study framework was produced and aims to gather: a) knowledge of the interviewee on the level of energy ambitions of the building; b) perception of the interviewee regarding the people who she/he perceives to have the most impact on the energy consumption and management in the building; c) Perception of the interviewee regarding the activities that she/he perceives to have the most impact on the energy consumption and management in the building; d) Perception of the interviewee regarding the people, processes, tools, competences and desired outcomes influencing delivery of energy relevant activities, and; e) knowledge of the interviewee on energy data routines, including how energy data is collected, stored, analyzed, communicated and used for improving the energy performance of the building. The latter aspect is only addressed with the person responsible for the day-to-day operation and monitoring of the building. For this study, only interview data relating to the activities that each of the interviewees considers relevant to the management and use of energy in the building was extracted. Identifying activity-based context is enabled by the data collection approach, which specifically asks from interviewees to discuss their understanding of energy management and energy use, within the context of the activities relevant to their day-to-day use of the building.

2.1. Case study selection

The criteria behind the selection of the case study buildings are: a) high energy performance buildings: The probability of learning about comprehensive energy management strategies and energy data routines is assumed to be highest among buildings with expressed high energy performance buildings. In addition, one is able to learn about end-user and FM perceptions in the context of highly automated buildings. Buildings complying with passive house standard (Passive House Standard NS3700/3701) were selected; b) significant energy saving potential: The sample is to be contained within the group of buildings considered to have the largest energy saving potential in Norway. The objective is to create solutions that have the potential to significantly reduce energy use from the perspective of the Norwegian building stock. The top three non-residential building types meeting this criterion in Norway are retail, office and school buildings, and; c) private and public buildings: The sample must facilitate comparability between energy management approaches from the public and private sector, as well as between similar building types. In this sense, eight buildings were selected, belonging to either office or school facilities (four from each group). This paper discusses the findings from two "passive-house" certified school buildings in Norway. The buildings are owned by different municipalities ("A" and "B"). The building owners sit at the level of the municipality, from where the energy management process is directed. Municipalities define their own energy management strategies according to their needs, knowledge and understanding of the energy management process. Municipality "A" assigns approximately one caretaker for every three of the 60 buildings in their portfolio (23 caretakers). On the other hand, municipality "B" looks over 41 buildings between kindergartens and other educational facilities. Within municipality "B", five building operators are trained on energy management aspects and oversee small clusters of buildings within the municipality´s portfolio. Rotation amongst operators is dependent on the knowledge and skills required to care for a particular building. Both passive-house projects were developed as annexes to existing building structures.

2.2. Analysis

This paper develops around the study of the activities that each of the interviewed user groups consider to be most relevant to the use and management of energy in the buildings they occupy, operate or manage. These images are used to identify missed opportunities for stakeholder integration in the context of the energy management process. This is an exploratory study, and findings are limited to the context of the buildings under study. Information on energy data routines is used to assess the extent to which energy data is used to support the high energy ambitions of the buildings.

3. Findings

First, the perspectives from all user-groups belonging to School Building “1” (SB1) and School Building “2” (SB2) are presented. Then, a brief description of the energy data routines as implemented by each of the municipalities is provided.

3.1. School Building “1” from Municipality “A”

The teacher and the director | representing the building occupants: Dancing and working with pupils are two of the main activities that the teacher perceives as relevant regarding the management and use of energy in the building. The first activity (i.e. dancing) was connected to energy consumption through the understanding that ventilation systems have to work harder in order to improve the quality of air: *“when we use this area outside here and we are dancing we can feel the air is with sweat and then the ventilation has to go faster to clean the air, so that's an impact”.* Working in rooms with small groups of pupils was directly connected to the need for additional heating. The teacher informs that when rooms are used below their normal occupancy level, it takes much longer for the temperature to stabilize at the desired set-point. From the teacher´s perspective, it is likely that this lag (i.e. the time in between the room is taken in use and the moment it feels warm enough) is consequence of a faulty or unbalanced heating system. Staff meetings were also indicated as activities with the potential to influence energy use in the building, as crowded meetings often result in poor air quality. As a result, participants turn to opening the windows as means to improve both the quality and temperature of air in the room. The director finds it difficult to connect her day-to-day work routines with energy relevant activities in the building. In turn, she narrates how teaching and “health & safety” meetings can have an impact on both how energy is used and managed in the building. With regards to teaching, the director argues that perceptions from both teachers and pupils regarding room temperature can be described as signals that lead to the adjustments of the building systems (e.g. heating and ventilation systems). Staff meetings were indicated by the director as the activity with most impact on how energy is managed in the building. Unlike the teacher, the *director* does not refer to the quality and temperature of air in the meeting rooms; rather, she comments on the opportunity to communicate about pressing matters regarding building use and staff concerns. Meetings are attended by staff representatives from different areas, including teachers, building operators, cleaners and union representative. The director comments on opportunities for integrating knowledge about the building´s unique energy features into day-to-day school curriculum; however, in practice, discussions about energy use and management are limited to complaints about indoor temperature, and rarely about initiatives aiming to improve the energy performance of the building.

The caretaker | representing the facilities manager at operational level: The caretaker comes from a background in general maintenance. Maintenance routines and building monitoring through the building management system (in norwegian: Sentral Driftskontroll or SD) are the two main activities indicated by the caretaker as relevant to the management and use of energy in the building. From his perspective, the first activity (i.e. maintenance routines) is considered to have the most impact on energy consumption in the facility. Reactive maintenance represents a significant component of the caretaker´s daily work. The caretaker indicates that the automated systems in the building were designed and commissioned to maintain an adequate balance of the building energy systems. In this sense, the caretaker fully relies on how the building systems were programmed by the contractors during the handover phase of the building. Accordingly, his role is primarily focused in providing timely response to the alarms generated by the building management system :*"I have some alarms on my SD that tell me if something is wrong… so I do this thing, that's mainly my job".*

The "Cost-focused" Energy Manager (CBO) | representing the building owner and strategic facilities manager: The role of the CBO is that of overseeing the technical aspects of the portfolio of buildings owned by the municipality "A". The CBO accredits most of the energy used in the building to activities which do not take place within the new passive-house portion of the school, but rather on adjacent community-shared spaces (e.g. use of pool and sports centre). The CBO speaks of the facilities and installed energy systems as finished products, meaning that they have been designed, implemented and currently work as intended. In this context, the CBO indicates that the energy efficiency of the building can only be raised by improving the work routines of the caretaker and increasing the energy literacy of all individuals who occupy the building. Energy use in the building is monitored through the monthly assessment of energy bills. In this sense, the municipality only initiates an action for a particular building when the electricity bill for a given period is perceived to be significantly higher than its historical value.

3.2. School Building "2" from Municipality "B"

The educator and the staff representative | representing the building occupants: The *educator* has been working in the passive-house building since it was handed over by the municipality "B" to the school staff. In addition to teaching, he is also part of a managing team that helps to steer school affairs. When asked about activities that impact on how energy is used and managed in the building, he refers to the use of computers by the pupils as well as to the automatic blinds. In the context of computers, the educator comments that equipment with long-battery life is preferred so as to reduce the amount of time used by students in charging their computers: *"...when you have a class you don't want them to be using the charger in the classroom, you want them to take the computer and use it without interrupting*." In this sense, he clarifies that the school's procurement strategy for computers does not aim to reduce energy consumption, but to minimize disruption of classroom activities. In terms of automatic blinds, the educator indicates that the system is meant to reduce energy use in the building; however, he perceives that the functioning of the system is not aligned with that of a school building, with the blinds often interrupting classroom activities. School staffs have demanded that control over the blinds is shifted from the municipality back to the building level. The *staff representative* fulfils a leading role mandated by national health & safety regulations, and acts as key mediator between school staff and the municipality. Ventilation is recognized as the activity with the highest impact on how energy is used in the building. She discusses ventilation in the context of community oriented activities that the school is mandated to accommodate for. The staff representative indicates that many of these services must be provided for free to community members. In this sense, ventilation is perceived as an increasingly requested and energy intensive service which impacts on the energy use and financial bottom-line of the school. The use of windows by building occupants is perceived to be the second most energy intensive activity in the building. The staff representative comments that she is not aware of the impact that opening the windows can have on the overall energy consumption in the building; however, she perceives that freedom to manipulate the windows is necessary as the building is not able to provide a consistent level of air quality.

The building operator | representing the facilities manager at tactical level: There are two aspects which dominate the conversation regarding how energy is managed and used in the building: First, the implementation of adequate automation and building management systems (BMS), and; second, the development of a solid energy metering strategy. The building operator perceives that organizations lacking well trained and knowledgeable staff regarding both of these aspects (i.e. BMS and energy data strategies) are at great disadvantage. Keeping up to date with the advances of technology is perceived as one of the most important aspects in supporting a highly energy efficient environment. In this sense, he argues that in line with current advances of technology, there is nothing else at the time that the municipality can do to improve energy use in the building.

The "System-focused" Energy Manager (SBO) | representing the building owner and strategic facilities manager: The SBO indicates that the most important activity regarding the management of energy in the building is the use of the BMS to monitor the operation of the building's energy systems. In turn, the focus is not to optimize the performance of specific energy systems, but to provide rapid response to the alarms generated by the BMS. Standardization of management systems across the building portfolio is perceived as essential: *"we are the only municipality in Norway with one system for all of our buildings… the absolutely most important (is) you have a system (all) people can use".* The frequency and extent to which the building is used by building occupants is considered to have a strong impact on energy consumption. The SBO indicates there is a gap between the occupancy levels defined in the national building standards for school buildings and the actual use of the school facilities. However, the SBO does not perceive this to be a problem since the building was designed to be used.

3.3. On energy data routines

Municipality "A" | Cost-Focused Energy Management: The building owner (CBO) from SB1 is unaware whether specific energy consumption goals are set for the building. Energy data are registered both by the caretaker by taking readings from the main utility meter, and automatically through a set of sub-meters which measure the energy used by the ventilation, heat pump and domestic hot water systems. Data generated from sub-meters are neither stored nor used. From the data that is collected (either manually or automatically), it is not possible to differentiate between the energy used by the existing building versus the new "passive house" facility. Further breakdown of energy use between different spaces (or uses) is not something the caretaker considers to be an advantage. On a yearly basis, the caretaker reports on the energy consumption of the building. Two actors demand this report: a) the municipality, with the purpose of validating the energy bills as issued by the utility company, and; b) a state owned agency that provided significant funding for the delivery of the passive-house portion of the building. Issues relevant to poor heat pump specification and the difficulty to separate energy use between existing and new facility are often included in reports to justify the building´s underperformance with regards to design intentions. On behalf of the caretaker, the difficulties experienced with the energy systems have led him to lose trust regarding how these systems are supposed to perform.

Municipality "B" | System -Focused Energy Management: The metering strategy implemented by the building owner (SBO) of SB2 follows the recommendations from the Norwegian Standard NS:3031 "Calculation of energy performance of buildings - Method and data". Energy data are collected from the main utility meter and a set of sub-meters, which register the energy consumed by specific systems, including: hot water, ventilation, lighting and technical equipment. The latter includes electricity sockets and computers used by the staff and pupils in the school. This approach facilitates identifying how much energy is used from extra-curricular activities, particularly during the summer when energy consumption from school-relevant equipment should be at minimum. Too much metering within a particular building is perceived to hinder the ability to take good decisions in support of the performance of the building portfolio. Seasonal energy profiles are used to benchmark energy performance data against previous years. Benchmarks are used to identify the building or group of buildings in the portfolio requiring primary attention. Alarms are raised when the performance of a particular building differs from its own performance on previous years. At that time, the SBO drops to the building level and evaluates what can be done to correct a particular issue. Comparing the energy performance between different school buildings in the system is possible; however, it is not a practice considered relevant within the municipality´s energy management approach.

4. Discussion

4.1. Perspectives from same user groups in different buildings

Perception from building occupants (as represented): both the teacher (from SB1) and educator (from SB2) relate to the management and use of energy in their buildings in the context of issues circumventing their daily work with pupils. Their focus is stronger on activities which impact on the consumption rather than the management side of energy in their buildings. Arguably, automated blinds are the only technical aspect discussed as a central activity; however, emphasis is placed on the disruptive impact that the lack of control over the blinds has over the educational activities that take place in the classrooms. As the level of responsibility increases, roles such as that of the staff representative and director embrace responsibilities relevant to stakeholder mediation and strategic thinking. Value is placed in seizing the opportunities created by the building´s unique energy efficiency qualities to further support the educational program. Awareness about impact from activities which fall outside of the building´s core function (i.e. community oriented services) is held at leadership or staff management levels. Broadly, building occupants perceive the use and management of energy in the building as a necessary expense for meeting a desired comfort level and achieving the school´s organizational objectives.

Perception from operational and tactical facilities managers (as represented): The differences in background and work experience between the caretaker (from SB1) and building operator (from SB2) seem to influence their understanding of and approach to energy management. With regards to the first, lack of sufficient knowledge regarding how the building energy systems are meant to operate may limit his ability, and arguably his willingness, to extend his role beyond providing reactive maintenance to the systems in place. In turn, the caretaker builds upon his current strengths (i.e. maintenance background) and focuses his attention on securing that the building systems operate as design intentions. Conversely, the building operator comes from a building automation background. He discusses the use and management of energy in the building from an integrative perspective; this is, through acknowledging the value of technologies (e.g. automation systems), supporting strategies (e.g. energy metering) and the training and knowledge required to seize energy saving opportunities. It can be said that both representatives (i.e. caretaker and building operator) understand the use and management of energy as a product of the technologies in place and the routines required to keep them functioning at optimal capacity.

Perception from building owners and strategic facilities managers (as represented): Both representatives (i.e. CBO and SBO) are responsible for the performance of a cluster of public buildings; in this sense, both relate to the use and management of energy in terms of scalable strategies that can be implemented across their building portfolio. The CBO and SBO hold contrasting views regarding the areas considered critical towards further improving energy use in their facilities. For example, the CBO focuses on activities aimed at developing the knowledge and skills of those who use and operate the building. Arguably, this view is enforced by CBO's perception that the building currently performs as intended; however, from the data gathered on energy metering routines, it can be said that the energy performance of the building has not been properly assessed. On the other hand, the SBO discuss the use and management of energy strictly from a technical perspective. The SBO acknowledges the impact of building occupant activities on the energy consumption in the building; however, the SBO rejects responsibility over the implementation of strategies aimed at managing the interactions between users and the buildings they occupy.

4.2. Perspectives from different user groups within the same building

Different user groups relate to the management and use of energy in the context of the roles, and consequently the activities, that each group embraces. One important aspect to discuss is the focus or objective that brings together the bundle of activities mentioned by each user group. In order to simply this task, this study asks: Is the focus of the activities related to the building´s core function or is it related to the building´s energy performance?

Figure 2 maps for each school building, the relationship between and focus of different user groups in the context of the activities that they consider relevant to the use and management of energy in the buildings they occupy or manage. The "Y" axis represents how much of the focus of the activities discussed is related to the building´s strategic function, and the "X" axis reflects how much of the focus is related to the actual energy performance of the building. As illustrated, building occupants relate strongly to activities aligned with the core function of the building i.e. support the effective delivery of educational and recreational activities. Their perspectives are disassociated from that of the people responsible for the operation and overall management of the building, whose primary aim is to support the continuous operation of the building. Within SB1, the activities carried out by both the caretaker and CBO can be perceived to have slightly more focus on energy performance than that of building occupants.

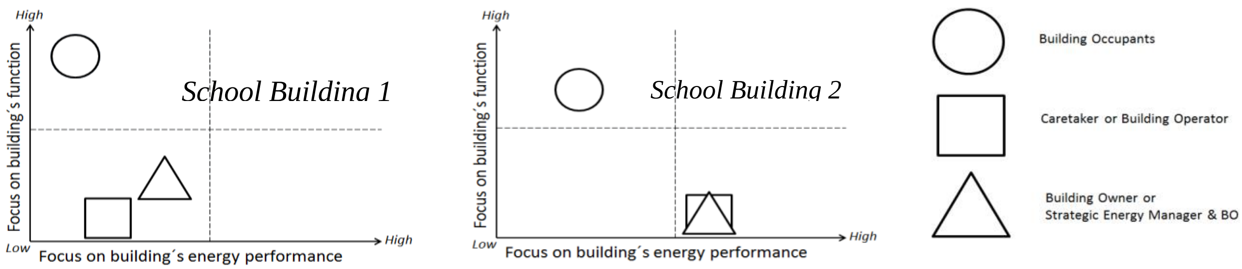

Figure 2. Images which mapping the relationship between and focus of user group perspectives on energy management practice from an activity-centred perspective.

However, energy data routines suggest that the lack of strategic guidance translates into operational routines that seek to minimize day-to-day disruption rather than support the building´s high energy ambitions. In SB2, energy management service is delivered with a solid technical foundation and larger focus on the building´s energy performance (when compared against SB1). With an energy strategy based on national standards, the SBO ensures that the knowledge and experiences gained through the management of one building are more readily applicable to the rest of buildings in the municipality´s portfolio. However, it can be argued that energy strategies that are designed uniquely from a portfolio perspective may fail to support individual buildings in achieving their particular high energy ambitions.

5. Conclusion

This paper described how representatives from different user groups (i.e. building occupants, facilities managers and building owners) relate to the use and management of energy within the passive-house school buildings that they occupy, operate or manage. Although contrasting views regarding energy management strategies were identified within the two buildings under study, strong similarities were identified with regards to how building occupants relate to energy issues on a day-to-day basis. Building occupants have a strong focus on supporting the building´s core function. This creates an opportunity for setting areas for collaboration between facilities managers and building occupants; in particular, collaboration is encouraged around the activities which building occupants consider as most relevant to the use and management of energy within the specific building they occupy. Further research will expand the set of case studies to include office buildings and investigate, among other issues, the attitudes from building occupants, operators and building owners to collaborate on EE aspects within highly automated buildings.

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