Discussion of Facilities Management as lead user and innovation driver towards improvement of energy efficiency and user comfort of buildings

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Abstract

The target of this paper is to discuss user-driven innovation as a new approach towards the improvement of energy efficiency and user comfort of buildings. This approach contributes to the general need for the improvement of building energy performance in buildings. Reducing energy consumption, greenhouse gas emissions and increasing the share of renewable energy is not only a technical challenge, but also of high national and international importance. Facilities Management (FM) is addressed as having the lead user role referring to approaches of the social science and management discipline. Users can contribute to the advancement of knowledge on building energy performance. These approaches are based on the state of the art innovation theory. The focus is set on Eric von Hippel's user innovation methodology. It was conceptually applied on FM as lead user in the building context. In addition, literature research revealed other examples of user driven innovation referring to research and practice in the field of energy efficiency improvement. These are presented as a contribution to the discussion and highlight different perspectives.

Facilities Management has so far not been considered as lead user of energy-efficient and comfortable buildings. Moreover, the complex interaction between the building itself and its' management and usage overburden the existing lead user theory. Thus, further research is mandatory to transfer lead user theory from product innovation towards service innovation, especially for sectors with high levels of complexity.

Keywords: Facilities Management, user-driven innovation, energy efficiency, lead user, building energy performance.

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1 Introduction

It is widely acknowledged that “buildings account for 40% of total energy consumption” (DIRECTIVE 2002/91/EC, p13). As a consequence of this, the EU is targeting reduction of energy consumption as well as promoting the use of energy from renewable sources in the building sector. The European approach is to prioritise the improvement of the energy performance of buildings, with a focus on technical innovation, “taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness” (DIRECTIVE 2002/91/EC, p17). The objective of this paper is to discuss how far improvements of energy efficiency and user comfort can be considered as more than a technical challenge. The consideration of outdoor climatic factors, local conditions, and indoor climate requirements are essential for the design of a building’s construction and its’ technical services. The motivation for this paper is the assumption that an understanding of how a building is used might be more important for efficient energy management in a day-by-day and long-term perspective. Literature research on the state of the art on user-driven innovation towards energy efficiency improvement has been conducted. Referring to methodologies from social science and management theory the question comes up as to how far FM can be considered as an innovation driver towards the improvement of energy efficiency and user comfort. The purpose is to extend the scope of building energy performance. A better understanding of the behaviour of building users and FM decision-making on a strategic, tactical and operational level is needed.

Referring to common FM terminology a building can amongst other things be considered as a “Facility” and the person who is responsible for the management of the building therefore as a “Facility Manager”. However the FM discipline refers to a much broader field of work. FM includes all kinds of support facilities and services which develop and improve the organisation’s primary activities from a day-by-day and lifecycle perspective. Energy management is only one of the service processes which supports the user’s primary activities. FM services are referring to owned or rented space and infrastructure. FM interacts with the client organisation on a strategic, tactical and operational level (Atkin and Brooks 2009, Cotts et al. 2010, Barret & Baldry 2003, Junghans 2012a, EN 15221-1). Could FM therefore be considered as a lead user for energy-efficient building management and energy-efficient building design and construction?

Research from the social sciences has shown that the way a building is taken into use is important for the fulfilment of its’ technical possibilities (Aune & Bye 2005). Findings from real estate management related research similarly point out that, from an environmental perspective, the management and maintenance of buildings have an impact on building performance (Kyrö et al. 2010). Atkin and Brooks (2009) consider energy efficiency as long having been recognised and practiced from a FM perspective. They highlight recent changes towards a “wider environmental concern” and the adoption of a “whole-life perspective of buildings and other facilities” (p120). Borgers et al. conducted a systematic review of literature on user innovation (2010). They discussed state of the art user-driven innovation with a focus on the role that users play during innovation. Referring to the pioneers of innovation theory, they point out that users have been considered in the context of innovation since the 18th century. “The role that these users play during innovation of the products that they ordinarily buy from producers has been the subject of research since at least Adam Smith" (p857) Borgers et al. recognised that the literature on the role of users during innovation has significantly grown. They studied 106 references in total. Among those were 52 references with publication dates since the year 2000. A major focus was the work of Eric von Hippel. This was studied with 16 references published between 1976 and 2007. (Borgers et al. 2010, pp872-875) The diffusion of innovation theory by Rogers can be considered as theoretical basic knowledge and was first published in 1962. "He [Everett Rogers] argued that diffusion was a general process, not bound by the type of innovation studied, by who the adopters were, or by place or culture." (Rogers et al. 2007, p2)

The following section gives a brief description of user-driven innovation theory, highlighting the management approach by Eric von Hippel (1988) in which user innovation projects have been primarily targeted to enhance the development of innovative products. User-driven innovation from the aforementioned social science perspective emphasises the needs of end-users and underlines the importance of developing an understanding for the social construct aside the technical innovation itself.

2 Methodology of user-driven innovation theory

Eric von Hippel (1988) introduced the term 'lead user'. He defines a lead user of a new or enhanced product, process, or service according to two characteristics: 1) "Lead users face needs that will be general in a marketplace, but they face them months or years before the bulk of that marketplace encounters them, and 2) Lead users are positioned to benefit significantly by obtaining a solution to those needs." (von Hippel 1988, p107)

Churchill, von Hippel and Sonnack (2009) developed the lead user approach further and applied it as a research method for the conducting of lead user projects with four main research phases:

"1. Selection of the Project Focus and Scope: This is the preparatory phase of a lead user project. A management group first decides the new product or service area that will be the focus of the innovation initiative and selects the core team that will implement the lead user study. This project team then does the practical work required before launching the actual lead user study in the next phase.

2. Identification of Trends and Needs: The core project team begins the lead user study by doing an in-depth investigation of trends and emerging market needs. By the conclusion of this phase, the team will have selected the specific need related trend(s) that will drive concept generation in the next phases.

3. Collection of Needs and Solution Information from Lead Users: This phase begins the concept generation phase of the project. The project team interviews lead users to gain deeper insight into emerging needs and to acquire new product and service ideas. By the end of phase three, the team will have generated preliminary concepts.

4. Concept Development with Lead Users: A select group of lead users and technical experts join the project team and other company personnel for a workshop to do intensive product or service concept development work, usually over a 2 or 3 day period. The outcome of this workshop is typically a new product or service concept – or sometimes, several of them. The project team then refines these concepts and develops a business "case" which is presented to management for its review." (Churchill et al. 2009, p10)

Targeting the discussion on FM driven innovation towards the improvement of a buildings energy performance, phase 3 "Collection of Needs and Solution Information from Lead Users" is considered as the most essential. Regarding this phase it is recommended to define and study three different types of lead users: 1) Lead users in the target application and market; 2) Lead users of similar applications in advanced /analogue markets; 3) Lead users in respect to important attributes of needs faced by users in the target market.

Churchill et al. (2009) demonstrate the application of the different types of lead users by using an example taken from the field of medical instrument development:

"Suppose that a manufacturer of medical X-ray systems decides to form a lead user project team to identify concepts for new products in that field. The team researches the target market and finds two important trends. One trend is towards images with higher resolution; another was towards better methods for recognizing subtle patterns in images that are medically important – for example, patterns that indicate possible early-stage tumours. In this example, the team might go on to identify and learn from the three types of lead users as follows: 1) Lead users in the target application and market – These might be medical radiologists working on applications in medical imaging that are very demanding with respect to images of high resolution and pattern recognition. 2) Lead users of similar applications in advanced 'analogue' markets – These could be users in more demanding but related markets such as engineers who create images of microscopic patterns developed on semiconductor chips. 3) Lead users with respect to important attribute of needs faced by users in the target application – These could include pattern recognition specialists in fields other than imaging such as pattern recognition in sound or mathematics." (Churchill et al. 2009, p9)

The example relates to product innovation and represents a continuation of earlier research by von Hippel (1988), in which he examined the role of users in product development in the fields of scientific instrument innovation and semiconductor and electronic assembly manufacturing equipment. This systematic approach was used before to identify relevant case studies on user innovation towards improvement of building energy performance and to structure case studies referring to four market development phases: lead users, early adopters, routine users, and laggards (Junghans 2012b).

3 Conceptual application of user-innovation theory considering Facilities Managers as lead users

The following conceptual application of von Hippel's lead user theory was developed to initiate a user-driven research project. It is a fictive consideration referring to the author's experience from earlier studies on energy efficiency improvement of buildings (2009). However, the exemplary application aims to study FM as having the lead user role, intending the improvement of energy efficiency and user-comfort of buildings. Regarding von Hippel's lead user approach, lead user projects are structured into four project phases. (Churchill et al. 2009, p10) The four project phases are applied as follows:

1) Preparing for the lead user project: The starting point is the preparation of the lead user project on behalf of the client and initiation of the project team ("client" in this example are owners of, or investors in public office buildings). FM can be regarded as both client and lead user. The driving need for innovation is to utilise FM's experience within the operation and use-phase of buildings to improve energy efficiency by better integration of energy-efficient buildings and energy-efficient management. To initiate the project team the main stakeholders in the operation and use of a building have to be considered.

2) Identifying trends and key customers' needs ("key customers" in this example are public departments): The main task of the project team is the identification of trends and key customer needs. The trends should have a strong connection both to the energy efficiency of a building as well as the way it is managed and used, and to needs for further improvement of energy efficiency. Regarding the state of the art in energy efficiency improvement of buildings and statistics about energy consumption, two preliminary trends were identified: 1) Reduce the steadily increasing demand for electricity for basic functions, such as heating, cooling and ventilation. 2) Increase the possibility to control energy consumption by changing user needs, for example user specific technical equipment.

3) Understanding the needs and solutions of lead users ("lead users" in this example is the FM supplier): The understanding of the needs and solutions of lead users supports the identification of appropriate innovation types.

3.1 Lead users in the target application and market – whose objective is to strengthen the demand perspective in the target application and market (e.g. reduce building demand for electricity and increase control of energy consumption). In-house FM of public office buildings are considered as lead users in the target application and market. The objective is to strengthen the demand perspective in the target application and market. The demand is determined by the need for energy-efficient improvements and the target application market is described by in-house FM services. In-house FM of a public office building is, therefore, considered as lead user in this category.

3.2 Lead users of similar applications in advanced analogue markets – who add higher demand perspectives similar to the target application, but in an advanced analogue market (e.g. reduce building demand for electricity and improve cost efficiency, increase control of energy consumption considering changing user demands). External FM service providers as lead users of similar applications (to target application and market) in advanced analogue markets. Advanced analogue markets add higher demand perspectives in similar applications and have higher standards for the measurement and control of costs and quality. External FM service providers consider FM a core activity and make it their business. This branch is referred to in the European standard definition (EN 15221). The definition describes the target of FM service integration, within an organisation as, to maintain and develop the agreed services which support and improve its core activities (EN 15221). In order to do this, FM should interact between end-users and clients on strategic, tactical, and operational levels. External FM service providers who might be involved or contracted in public-private-partnership (PPP) or private owned office buildings, are therefore considered as the focus group in this category.

3.3 By helping us understand specific areas of demand and need lead users can help us gain a deeper understanding of the problems faced by users in the target market. This knowledge can then be transferred into other areas of application. One aspect that could be examined is the energy management in hospitals which has high requirements for continuous availability and constant quality of power supplies. FM with high service intensity and supporting large and complex building and operational systems, for example hospitals, can be considered as lead users with respect to important attributes of problems. Studying FM in hospitals highlights important aspects of the demand perspective in respect to energy efficiency, with the highest requirements regarding energy supply of constant quality for 24 hours per day, 7 days per week, and 365 days per year. FM in hospitals is therefore considered as lead user in this category.

4) Improving approaches to problem solving by involving lead users and experts to maximise the likelihood of success

As a result approaches to problems solving will be improved with lead users from in-house and external FM and architects and engineers as well as client, key customer and end-user representatives.

4 Examples of user-driven innovation with focus on Facilities Management and energy efficiency improvement of buildings

4.1 Consideration of FM as lead users of buildings

FM can be considered as a building user amongst other users and has been discussed as having a kind of lead user role, without using the term ‘lead user’ specifically, by Olsson et al. (2010). The authors pointed out that, Facility managers are working in the building and that they are working with supporting facilities services. Facility managers use buildings and facilities and act on behalf of the users. They simultaneously link the ‘supply side’ and the ‘demand’. FM are the section of users who are characterised in the context of buildings as follows: “Owners; facilities management and service personnel (who operate buildings) [Facility Manager]; management of the organization(s) based in a building; service providers; service receivers and indirect service receivers.” (Olsson et al. 2010, p28)

The role of FM in general is defined by the European standard definition of facilities management (EN 15221-1). “Facility managers are responsible for the integration of processes within an organization. They act as a link between the demand and supply side on a strategic, tactical, and operational level.” (Junghans 2012a)

4.2 Norwegian study on energy-efficiency potential and barriers of buildings

On behalf of a large Norwegian Real Estate Property and Asset Management organisation engineers and consultants conducted a study addressing energy-efficiency potential and examining barriers for improvement in commercial buildings in Norway (Multiconsult and Analyse&Strategi 2011). The aim of the study was to quantify the potential for energy savings towards the year 2020 targeting all commercial buildings in Norway. The results were structured into theoretical, technical, financial and real potential. Referring to the calculation method used, based on square meters and technical standards for the key input factors, the technical potential was calculated as the portion of the theoretical potential that is technically feasible. Economic potential was calculated as the share of the technical potential that is economically feasible to implement. The real potential for energy efficiency was described as the proportion of the economic potential that naturally occurs, but is limited by various barriers.

A qualitative, survey-based evaluation was conducted to find out more about the various barriers and how to deal with them. Respondents of the survey were particularly concerned with the economic barriers, and least concerned with the technical barriers. Attitudes and knowledge barriers were also considered as very important. Another result was the respondents' lack of knowledge about the effects and benefits of energy efficiency. This was considered as a possible reason why negative attitudes persist, and myths about lack of profitability continue to exist. Many survey respondents believed this was due to lack of knowledge, which in turn can be the cause of other types of barriers, such as financial barriers.

Case studies, focus group interviews and workshops contributed to the analysis which demonstrates that part of the real potential is limited by these barriers, and the type of institutions in society that can reduce these barriers with the various measures. Main barriers for existing buildings were practical barriers, economic barriers and knowledge barriers. For new construction the barriers were financial and knowledge. The overall result of the study finds the greatest potential for improvements in energy efficiency in existing buildings, it is therefore important to concentrate measures here. (Multiconsult and Analyse&Strategi 2011, pp1-12)

The initiation of the focus groups led to discussion about who should be represented. The client preferred participants who showed why decision-makers choose particular measures. Decision-makers in the examined case study were building owners. The contractor was of the opinion that it would also be appropriate to include people with technical management responsibilities, because they were supported by more detailed information on barriers related to specific measures in the building, assuming that they had a more practical approach. (Multiconsult and Analyse&Strategi 2011)

The study also included an approach with reference to diffusion of innovation theory by Rogers. The authors considered it as important to refer to market development and to group decision-makers based on the theory of diffusion of innovation. Participants were therefore asked to answer a short questionnaire in which they categorised themselves by whether they perceived themselves as, respectively: 1. Innovators, 2. Early users, 3. Early majority, 4. Late majority, 5. Last few. The answers to this survey, as well as additional observation of the participants in the focus groups gave input to this part of the study. (Multiconsult and Analyse&Strategi 2011) However, the authors commented on the achieved results and mentioned potential weaknesses of the approach later in their report. “Participants perceive themselves as innovative and early users. Based on the discussions in the focus group, we (Multiconsult and Analyse&Strategi) believe, however, that participants may seem somewhat more conservative than they express themselves, because participants experience many economic barriers, which may indicate that they are not willing to take risks and thus are not innovative” (Multiconsult and Analyse&Strategi 2011)

4.3 Strength and weaknesses of interaction between energy users and energy efficiency practitioners

Heiskanen et al. (2012) explored the interaction between energy users and energy-efficiency improvement measures in the context of a European research project. They underlined the usefulness of the user-driven approach referring to user-driven projects.

User-driven projects (or pilot projects) are considered as “ideal in many ways” (p6). Strengths are that, “end-users know their needs and circumstances and can contribute to context tailored designs” and “end-users are motivated and engaged from the start and do part of the work.” (p5). Weaknesses were found in that, “End-users may not be fully aware of their behaviour and all the factors underlying it” and, “Up-scaling from small user-driven pilots to broader groups of end-users can be difficult.” (p5)

In addition, strength and weaknesses of three other approaches, i.e. surveys and interviews, prior research, and familiarity and informal interaction can be summarised as follows:

Surveys and interviews were regarded as, “obviously useful” and categorised as “formal, dedicated research” (p6). The strength of this method is, “the systematic approach to data collection” and “the possibility to poll representative samples” (p5). Weaknesses are that surveys and interviews, “do not always feed into program design” and, “Surveys may be designed to confirm existing preconceptions, may fail to bring up new insights” as well as, “Conducting good research is expensive and requires specialised skills” (p5).

Prior research, particular theoretical perspectives, were summarised as, “previous experience” and considered as, “obviously useful” and, “speeds up the learning phase” especially if previous experience with the same user-group was available (p6). The strength of using previous experience is that the, “theoretical base can guide observations and help to make sense of energy-related behaviour” (p5). Examples were explored referring to hands-on activities and experiments. Weaknesses of this method are the “commitment to prior findings or theories may lead to overlooking contextual particularities” (p5). In addition, an “overly theoretical background can lead to complex and confusing designs” (p5).

Familiarity and informal interaction with the target end-user group can be based on face-to-face contacts or membership in the user community (p6). “Informal interaction allows a rich exchange of information" and "Immersion in the user community helps to understand users' every day routines" as well as, "Familiarity creates trust" (p5) were considered as strengths. Weaknesses are that, "much time and commitment is needed to build up the necessary level of familiarity" and, "Contacts can be biased: some end-users are more familiar than others" (p5).

5 Discussion of FM as having lead user role

How far can FM be regarded as lead user and innovation driver towards improvement of buildings energy performance?

Discussion of FM driven innovation as the topic of this paper seems to be in line with the suggestion of Borgers et al. (2010) to transfer user innovation theory into other management fields. "We believe it is useful to provide a comprehensive review of the role of users in the innovation process and to link the notion of users as innovators to other literatures in the field of management." (Borgers et al. 2010, p858). As underlined by Borger et al. (2010), it was Eric von Hippel (1988) who introduced the notion of a user as a source of innovation in the 1980s. He described the user as one of the four sources of innovation, beside manufacturers, suppliers, and others. If the user is considered as a building's user, the following key questions, by von Hippel (1988, p3), relate to the categorisation of the different functions of a building and address the potential benefit of innovation, "Do they benefit from using it? They are users. Do they benefit from manufacturing it? They are manufacturers. Do they benefit from supplying components or materials necessary to build or use the innovation? They are suppliers." Based on lead user theory by von Hippel (1988) the main research approach is how whether FM as lead user fulfils the following criteria.

1) Does FM face needs months or years before the bulk of that marketplace encounters them, and

2) Is FM positioned to benefit significantly by obtaining a solution to those needs?

From a FM perspective, needs regarding the improvement of a building's energy performance are faced by integrating user demand and service delivery. FM gains benefit from achieving cost reduction and user satisfaction, as well as ensuring a healthy and safe environment. FM is involved in the whole life-cycle (Atkin and Brooks 2009) and interacts with the client organisation and service provision on strategic, tactical and operational levels (EN 15221-1). Thomzik et al. (2011) identified non-residential buildings in several categories as most relevant for the FM industry, such as: educational buildings, heath care buildings, light industry and workshops, retail and storage buildings, buildings for sports, culture, and recreation, housing for institutional owners, and other types of non-residential buildings. Building engineering services like heating, ventilation, air conditioning and cooling (HVAC), lighting, power, transportation, fire and security systems are consuming significant financial resources up to, "more than half of the capital cost" in the construction phase and require controlling during building operation and use. "Control over these installations is vital if the facility is to perform optimally and not exceed targets for energy consumption or reduce user comfort, amongst other concerns." (Atkin and Brooks 2009, p146).

While the general perception is focused on the improvement of building energy performance and technical innovation for buildings and technical infrastructure as stated in the EU definition, "energy performance of a building" means the calculated or measured amount of energy needed to meet the energy demand associated with a typical use of the building, which includes, inter alia, "energy used for heating, cooling, ventilation, hot water and lighting" (DIRECTIVE 2002/91/EC, p18). FM driven innovation can be considered as targeting improvement of building energy performance referring to the complexity of the building lifecycle and including the understanding of how a building is used and managed.

6. Conclusion

Lead-user theory was introduced in management discipline in the 1980s, however, examples of user innovation projects are still targeting the development of industrial or consumer products, like for example CAD software, pipe hanger hardware, outdoor consumer products, 'Extreme' sporting equipment. (von Hippel 2005, p36).

The social science perspective on user-driven innovation highlights the need to understand end-users and consider the social construct alongside technical innovation. Heiskanen et al. (2012) point out that "information about users' needs and manufacturers' capabilities is highly contextual, tacit and difficult to transfer from one site to another"(von Hippel 2005). They explain that this problem of common understanding hinders the uptake of innovative solutions. Referring to Rohracher (2001) they highlight "Energy efficient building solutions" as examples for innovative solutions that fail to address users' concerns and practices. Limited uptake and effectiveness are considered as consequence of this. (Heiskanen et al. 2012, p2)

Until now FM has not been considered as a lead user of energy efficient and comfortable buildings. However following the research on, "diffusion of innovation" (Rogers et al. 2007) and, "user-driven innovation", referring to Borgers (2010), Churchill et al. (2009) Heiskanen et al. (2012), Rohracher (2001), the understanding of the innovation user and the consideration of the social context aside, the technical innovation is of high importance for a successful innovation implementation.

Von Hippels lead user approach does not yet meet all the requirements of service innovation within such complex systems like building-management-use settings. This shows a need for further research to transfer lead user theory from product innovation towards service innovation.

Future research might further develop the "user-driven innovation approach" into an "innovation-driven user approach". This means implementing social science knowledge into management concepts to actively support the communication and diffusion of innovation. Future research questions could be: Is social context supporting the improvement of building energy efficiency and user comfort? Is the social perception of technical innovation measurable? And, if it is measurable, can it be managed by FM?

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