Activity-based offices: synergies and trade-offs between energy efficiency and employees' work environment

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Abstract

Energy use in office buildings is significant. At the same time, more than half of the Swedish office buildings were erected before 1970, which means that extensive refurbishments and new establishments are expected. Requirements on efficiency in terms of costs, space and energy use are then usually high. To achieve both energy efficient buildings and stimulating workplaces, there is a trend towards the implementation of activity-based offices.

The activity-based workplace is structured to fit the employees' work tasks and may give an impression of stimulating employees' creativity. However, studies show that the work environment does not suit everyone. Instead, mainly managers and employees who frequently interact with others are supported by activity-based working. Practical examples indicate that the efficiency of buildings may affect the employees´ well-being and work environment negatively – i.e. aspects linked to social sustainability. Nevertheless, knowledge on synergies and trade-offs between environmental and social sustainability goals is limited regarding the workplace in energy efficient buildings. It has for instance been shown previously that studies on green buildings mainly focus on environmental sustainability aspects, while the social dimension is basically lacking. This includes aspects of physical and psychological well-being. Still, understanding the interaction between different sustainability dimensions is crucial for implementing sustainability work in practice.

The study presented in this paper is part of an ongoing Swedish research project exploring the consequences of energy efficient office buildings on the employees' work environment based on case studies and literature. This paper presents a literature review of scientific papers on the topic and describes the outline of the case studies to be executed during spring 2019. It is concluded that scientific literature focusing on both energy efficiency and work environment at the activity-based workplace is scarce. Still, to ensure that environmental benefits are not realized at the expense of the employees' well-being, it is highly important to further explore potential synergies and trade-offs between social and environmental sustainability factors.

Introduction

Energy use in the residential and service sector constitutes 40 percent of the total final energy use in Sweden (Swedish Energy Agency 2018). In office premises, the purchased energy per square meter and year amounts just over 200 kWh (Energimyndigheten 2007). As the total office space area amounts nearly 35 million square meters in Sweden (SCB & Energimyndigheten 2005), the total energy use in office premises is significant. Furthermore, more than half of all office buildings were erected before 1970 (Energimyndigheten 2007), which means that further extensive renovations and new establishments of modern office environments are to be expected within the next few decades. Thus, there is a considerable potential for energy savings in office premises.

Combining energy efficiency in buildings with comfort and well-being has challenged researchers for decades (Shaikh, P.H. et al., 2014). In fact, comfort and well-being both refer to the

social dimension of sustainability – social sustainability[1]. As there is a trend towards energy efficient office buildings, special attention must be paid to the work environment for the organizations located in the buildings. Office spaces designed in line with energy savings and environmental considerations do not necessarily mean that the social work environments are promoted. The deterioration of the work environment can lead to poor health for employees and in the long run also to lower productivity for the organization. This has been pointed out in Martinac (2017), who states that much more attention should be paid to how the indoor environment affects a prosperous, healthy and productive workplace.

The demands on cost, space and energy efficiency are usually high when establishing new office buildings. Furthermore, the Swedish national energy targets state that energy consumption should be reduced by 20 percent by 2020 and by 50 percent by 2050 (Martinac 2017). Therefore, there is a trend to adapt office premises to smaller areas in order to use the premises more efficiently in terms of resources, equipment and space. As a consequence, costs will also be reduced. At the same time, the work environments should be stimulating, creative and attractive to the employees. Activity-based office workplaces are assumed to be such environments, for example by offering conditions for meetings between people. They are further assumed to meet both efficiency requirements for office buildings and contribute to increased creativity and innovation at the workplace. Practical examples, however, have shown that the efficiency of the building may be achieved at the expense of the employees' well-being and work environment, for example by employees choosing to work from home due to difficulties in working undisturbed in the office. Still, research on how these social factors and factors linked to energy and space efficiency interact and counteract each other is limited.

Unlike the individual office space and the open-plan office, the activity-based workplace is an office workplace that is designed based on the tasks that employees perform. The employee moves to different locations in the building that suits the current tasks. Apart from open-plan offices, the activity-based workplace also comprises separate areas for concentrated work and phone calls as well as various types of meeting rooms. The activity-based workplaces can give a modern and creativity-enhancing impression, but recent studies show that not everyone enjoys working in this type of work environment. This is, for instance, pointed out by Toivanen (2015), who also points to the importance of the involvement of the management and the employees' influence in order for a conversion or relocation to activity-based workplaces to be successful. One concrete problem in activity-based office environments is that it may be difficult to find colleagues at the office, which in one case was solved by introducing a system where employees could see the location of each other's phones in the office (Martinac, 2017). Other more difficult problems are that the work environment does not suit all types of employees or working tasks. For example, Pettersson-Strömbäck et al. (2018) show that managers and employees with tasks that require communication and interaction with others appreciate this type of work environments the most. They found it easier to collaborate between different units, while employees with tasks requiring concentration did not enjoy the work environment as much. Speech and other types of sounds were perceived as disturbing by many employees. Previous research has also shown that sounds, such as speech and telephone signals, create significant disturbance. Sudden noise or to hear people talk, breaks the concentration more easily than the frequent sounds from for example a fan system (Jahncke et al. 2011). Other studies on activity-based workplaces show that offices that are supposed to be designed for activity-based working do not always follow the principles of the concept. This may result in loss of productivity, illness and dissatisfaction (Appel-Meulenbroek et al. 2011).

A previous literature review found that existing studies on so-called green buildings mainly focus on environmental sustainability aspects, while studies of other sustainability dimensions, including the social dimension, are basically lacking (Zuo and Zhao 2013). Aspects related to social sustainability, such as physical and psychological well-being, are in principle not considered for green buildings. At the same time, recent research shows that understanding the interaction between the different dimensions of sustainability becomes important when implementing sustainability work in practice (Ekener and Katzeff, 2018; Weitz et al., 2017). Practical examples indicate that the efficiency of buildings may affect the employees' well-being and work environment negatively – i.e. aspects linked to social sustainability. Nevertheless, knowledge on synergies and trade-offs between environmental and social sustainability goals is limited regarding the workplace in energy efficient buildings.

According to existing research, it is thus clear that social well-being at work does not necessarily accompany an energy and space-efficient design of the activity-based workplace. This points to the need to study how to combine energy targets with the social sustainability dimensions in the activity-based office environment.

AIM AND OVERALL RESEARCH QUESTIONS

The aim of this paper is to summarize the current state of knowledge regarding the interaction between environmental and social sustainability factors at the activity-based workplace, based on scientific literature.

The literature review presented in this paper is part of an ongoing Swedish research projects addressing the interaction between environmental and social sustainability factors in activity-based offices. Upcoming project activities in terms of case studies that will be carried out during spring 2019 are described in the end of the paper. The overall research question upon which the project is built is:

> How do factors concerning the social aspects of the work environment and factors related to energy efficiency interact and counteract at the activity-based office workplace?

Method

A systematic literature review was performed, based on the recommendations for systematic literature reviews from the Centre for Reviews and Dissemination, University of York (CRD 2009). The review presented in this paper is limited to scientific, peer-

1. By social sustainability we denote goals from Agenda 2030 especially focusing on the social dimension of sustainability: 1) No poverty, 2) Zero hunger, 3) Good health and well-being, 4) Quality education 5) Gender equality, and 10) Reduced inequalities. For this research project, goal 3 is particularly relevant.

reviewed full-papers. Searches were mainly performed in the electronic database Scopus. The searches were performed during the period 9–11 January 2019. The search was preceded by thorough preparatory work in order to identify keywords and formulate the search string. The process was guided by a librarian.

The intended focus of the review was studies of how organizations that relocate to activity-based office environments are affected regarding work environment as well as environmental factors, in particular energy efficiency. The aim was to identify synergies and trade-offs between factors related to work environment and energy efficiency.

Search terms included terms for activity-based offices and possible terms associated with environmental sustainability and energy efficiency. Since the aim was to identify studies where energy or environmental aspects play a significant role, all terms must be found in the title, keywords or abstract of the articles to be considered relevant for this review. Relevant synonyms to activity-based offices were included to captures studies performed before the formal introduction of the concept "activity-based". To capture as many relevant scientifically published studies as possible the following search string was finally used:

> TITLE-ABS-KEY (("activity-based" OR flexible OR "non-territorial") PRE/5 (office OR workplace OR "work environment" OR "work space") AND (energy* OR electricity* OR climate* OR sustainab* OR environmental*))

All papers identified in the database search were screened by both title and abstract. The screening was done in a joint process by two researchers. The final set of papers were read in full-text and compiled. From the total search result only three papers were found relevant to read in full-text. One of the three papers was then excluded due to its focus on building flexibility rather than flexible working methods. In order to identify additional scientific publications on the topic so-called forward snowballing was applied, i.e. papers citing the two identified studies were screened and assessed. However, it did not generate any more relevant references to the literature review.

Due to the low number of papers additional scientific publications were searched via OpenAIRE. In this case *activity-based workplace* was used as the main search string, resulting in 32 publications. Publications in other languages than English as well as bachelor or master theses were excluded. The search resulted in another two relevant publications. This means that a total of four scientific publications were finally found relevant, i.e. including both social and environmental aspects of activity-based offices.

The literature review of scientifically reported studies presented in this paper will be followed by further reviews of national and international reports to identify relevant non-scientific studies.

Results

The search in Scopus yielded a total of 53 hits, publication period ranging from 1974 until 2019. All papers were assessed for eligibility by screening titles, abstracts and keywords. Out of these, only two papers were assessed as relevant to meet the scope of the literature search. The main reason for excluding the remaining papers were lack of focus on both energy/environmental factors and employees' well-being. Instead, the majority focused on either energy/thermal comfort or behaviors/well-being at the activity-based workplace. The papers addressing energy use in activity-based offices were focused on thermal comfort or managing installation systems to provide a good indoor climate, while satisfaction and social aspects of the activity-based approach were left unexplored.

The two relevant papers from the Scopus search as well as the two publications from the search in OpenAIRE were further examined by their full-texts. Summaries of the findings are found below.

Göçer et al. (2018) present a post-occupancy study executed at a flexible office situated in a highly energy efficient building (Gold LEED certified) in Istanbul. The authors mention a previous conflict between energy efficiency and the comfort of individuals, but claim that the design of contemporary energy efficient buildings make strong efforts to also cater comfort and well-being. However, from the case study, the paper concludes that the majority of the employees prefer to work at a certain work space every day. The main reasons mentioned were being close to ones' colleagues, to get more daylight and to avoid noise and thereby being able to concentrate on work tasks. Another problem addressed was the loss of individuality, due to the inability to personalize the work space. No correlations between energy efficiency and the identified social factors were made.

Kojo and Nenonen (2017) present a review of academic literature on the evolution of co-working and collaborative workplaces. Economic efficiency and sustainability are identified as two of the main drivers for the development. However, sustainability issues highlighted in the paper are of economic nature rather than environmental. Still, the possibility to reduce material and energy consumption is mentioned as a possible positive consequence of the co-working approach. The new way of working, in terms of participatory activities, social interaction and knowledge sharing, is highlighted as another main driver towards collaborative workplaces. However, no correlations between social and environmental sustainability aspects are discussed.

Brunia et al. (2016) explore success factors and obstacles for employees' satisfaction at the flexible workplace by analysis of four case studies within the same organization, two successful and two less successful cases. Critical success factors are concluded to relate to the workplace ability to meet both physical and psychological demands from employees, as well as clear behavioral rules to achieve a well-functioning workplace. Moreover, environmental sustainability is raised both in terms of well-functioning indoor climate in buildings and in terms of the modern employee striving to contribute to sustainability. The two case studies with lower satisfaction among the employees both show lack in indoor climate quality, such as dissatisfaction with indoor temperatures and discomfort related to high airflows. One of the case studies was also shown not to meet the high ambitions and thereby high expectations regarding the sustainability of the building, which resulted in low satisfaction with the indoor climate. However, possible correlations between the social and environmental aspects are not identified or discussed.

Dooley (2017), on the other hand, presents a somewhat different approach, starting from the energy performance of a

building and activity-based working as an organizational innovation. The study is based on the hypothesis that activity-based working is rejected by organizations since it disrupts the routines and requires behavioral change of the employees. The influence of activity-based working on the energy performance of an office building was analyzed in a case study, tracking the occupancy pattern and routines of the employees in the building. The paper refers to social aspects mentioned in the literature, but do not investigate the social factors related to the case study.

To conclude, hardly any scientific literature that combines social and environmental factors at the activity-based office workplace was found. Still, recent research shows that understanding the interaction between the different dimensions of sustainability becomes important to implement sustainability work in practice (Ekener and Katzeff, 2018; Weitz et al., 2017). This implies that there could be a significant knowledge gap that needs to be handled in order to promote holistic and practical sustainability work in activity-based offices.

Discussion and conclusions

To ensure that the environmental benefits from modern energy efficient office buildings are not realized at the expense of the employees' well-being, it is crucial that both environmental and social sustainability factors are taken into account, and their mutual interaction understood. Environmental sustainability of recently built energy efficient office buildings seems to go hand in hand with providing conditions for efficient use of office space often entailing activity-based workplaces. In using energy and office space efficiently, environmental goals, such as mitigating climate change and reducing environmental impact of cities, are addressed (Nam, 2015). Still, the review presented in this paper shows that scientific literature covering both environmental and social sustainability aspects of the activity-based office workplace is scarce. It is therefore concluded that potential trade-offs and synergies need to be further explored.

Scientific studies seem to focus on either of the two aspects, i.e. either energy efficiency or well-being. The reason for this is unclear, but one explanation might be a lack of interdisciplinary approach to the energy efficient office building in research, and, in practice, that there are two distinctly different categories of staff working with those issues at office workplaces. The human resource unit handles issues related to the work environment, while the environmental or building unit handles issues related to energy efficiency, design and construction of the building. The energy efficiency targets are probably clearly stated at an early stage, while impact assessments focusing on the work environment, as well as strategies to achieve socially sustainable workplaces, may appear later in the process. Collaboration at an early stage might therefore contribute to workplaces that meet both resource efficiency and employee satisfaction in practice. It should, however, be noted that it may well be other examples of such collaborations in practice, which have not so far been reported. For instance, one of the case studies within this research project showed proactive work with these issues during the design and construction phase of a new energy efficient activity-based office building. Thus, even though we did not find any scientific literature on the topic, there might be more practical examples addressing both environmental and social sustainability.

Clearly, we received few hits from the literature search focusing on energy efficiency combined with well-being in relation to activity-based workplaces. However, a quick supplementary literature search reveals that studies exist with a more general focus, i.e. not addressing activity-based workplaces, but organizations in green buildings in general. These studies point to some interesting aspects, which may be well worth to follow up concerning activity-based workplaces. For instance, in a review paper Heerwagen (2000) explores the question of how the physical attributes of green buildings[2] may affect the physiological, psychological, and social functioning of building occupants at the individual level. She concludes that green buildings are relevant to business interests, including enhanced quality of individual workspaces. Comparing employees' physical and psychological well-being in a green building with that of employees' in an ordinary building, showed no significant differences (Thatcher and Milner, 2012). In a more recent study, the researchers raise the problem that employee performance is not addressed in any green building rating tools (Thatcher and Milner, 2016). Because of the relevance of the above-mentioned studies to our search question, an extended literature review could reveal more studies with bearing upon the interaction of energy efficiency and well-being in the activity-based workplace.

The practical implications of this work will target both individual office workplaces and policy makers. A possible mismatch in communication at individual workplaces was pointed out above. At the society level, this might as well be the case for policy-makers. For instance, in Sweden, the National Board of Housing, Building and Planning provides a regulatory framework for the design of buildings and requirements for thermal comfort, energy efficiency etc., while the Swedish Work Environment Authority provides regulations to prevent ill health and create good work environments. As for the individual workplace, and in line with the findings in Ekener and Katzeff (2018), improved collaboration between authorities focusing on environmental and social dimensions, respectively, might be necessary to avoid conflicting goals and regulations. If considerable trade-offs between environmental and social sustainability factors will be identified, it implies that policy-makers must make further efforts to take the social dimensions into account when designing energy regulatory frameworks in order to support the design of the future office workplace.

Future outlook

Apart from the literature review presented in this paper, focusing on peer-reviewed scientific papers, grey literature in terms of doctoral theses, authority reports, European project reports etc., will also be reviewed to explore non-scientific studies addressing the combination or interaction between

2. The concept of green building is generally understood as "a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment" (World Green Building Council).

environmental and social factors at the activity-based office workplace.

Moreover, during spring 2019, two case studies will be carried out in order to explore environmental and social factors at activity-based workplaces in practice. The case studies are built on the findings in the literature review and aim to contribute to filling the limited knowledge on the interaction between social and environmental factors at the activity-based workplace. The purpose of the case studies is to explore how technical data on building performance, combined with interview data, can enhance the understanding of potential trade-offs and synergies between environmental and social aspects and sustainability targets at the activity-based workplace.

Two different types of workplaces have been recruited for the case studies. Selection criteria included 1) office workplace, 2) activity-based approach, and 3) environmental and/or energy strategy for the building.

- Workplace A is a property company that operates throughout Sweden and is focused on offices and buildings for scientific research. The company has a focus on sustainability and innovation. The case study will be carried out in a new-built office building, where the building and its premises are designed to form a creative and innovative environment. The building, which will be finalized in summer 2019 will host both the company itself and tenants in the form of innovation companies. The workplaces will be activity-based, and meeting methods and co-working areas are created to promote knowledge exchange and collaboration between employees from the different companies. A considerable amount of building data will be collected, which will be made available to other stakeholders within product development and innovation.
- Workplace B is the head office of a Swedish bank. The 2,500 employees moved to the new activity-based office in 2014, reducing the floor area by about 30 percent, and 80 percent of the employees had no longer dedicated work spaces. Due to complaints from the employees, significant modifications of the design and furnishing of the workplace have been made since then, for instance by introducing permanent work spaces for more employees than originally intended.

The mapping of environmental and social factors and their interaction at the case studies will mainly consist of two parts:

- Qualitative semi-structured research interviews (Kvale, 2009) conducted with employees at the two case studies, representing different generations and staff categories. The purpose is to map how the energy-efficient activity-based office building is received in practice by the employees with regard to environmental (energy, climate, resources) and social (work environment, well-being) factors, as well as identifying potential conflicts of interest. These interviews are supplemented with so-called walking interviews, which combine interviews and the informant pointing out specific places, objects etcetera that are important for the topic. The method was used in Pettersson-Strömbäck et al. (2018) based on a method developed by de Laval (2014) to study an environment "on site" and note one's experiences.
- A large amount of measured data is collected for the two office buildings, both linked to operation and use of the building, for instance presence, temperature, airflow, humidity and air quality. The building data collection will be mapped in order to identify which information is relevant to make available to employees and the management team to enhance the understanding of trade-offs and synergies between environmental targets and work environment.

The results from the case studies are expected to contribute with new knowledge about the interaction between environmental and social factors at activity-based office workplaces. This knowledge can support the design of office environments that are not only energy and space efficient, but also promote a good work environment and well-being among the employees.

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