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User satisfaction and well-being in energy efficient office buildings: Evidence from cutting-edge projects in Austria

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ABSTRACT

This paper aims to improve our knowledge of energy use and well-being in energy efficient office buildings. It explores the interrelations between forms and patterns of energy use on the one hand and user satisfaction, comfort, and well-being on the other hand. Findings are derived from qualitative and quantitative data collected in a recently finished research project in Austria. Fieldwork consisted of two qualitative case studies as well as an online-based survey amongst users of energy efficient office buildings. In addition, secondary data from energy-monitoring research was used to underpin the analysis. The results show that extremely low levels of energy use in office buildings can be aligned with high levels of well-being. Based on empirical findings the paper argues that both well-being and energy performance in office buildings are the result of a complex, on-going and intertwined process that involves various material and social elements.

1. Introduction

Energy efficiency is one of the main objectives of green buildings. Whilst ultra-low energy standards became quite common in the residential sector in Austria in the last 15 years, developers of commercial office buildings only recently adopted energy-efficient construction principles. Compared to residential settings energy use in office buildings definitely involves a different set of behavioural patterns, informal rules, legal requirements, and usually a wider range of building technologies. Green office buildings, however, not only have to meet targets in relation to energy efficiency as well as even zero energy targets in the near future [1], they also have to provide a healthy, comfortable and productive indoor environment quality. For this reason, highly ambitious efficiency aims in such buildings could easily contradict the demand for appropriate working conditions.

Only recently, Ucci and Yu [2] pointed out that our knowledge of the effects the latest advances in low-carbon building designs and technologies towards energy efficiency have on users' health and well-being are quite limited. Indeed, empirical research in this field shows a rather fragmented picture. Post occupancy evaluation research suggests that user satisfaction in green office buildings is not necessarily higher than in conventional buildings. Using a quantitative survey design Gou et al. [3] found that users of two recently retrofitted office buildings in Hong Kong (certified as LEED Commercial Interiors Gold) did not report higher levels of indoor environmental satisfaction when compared with users of conventional buildings. In a similar study, Paul and Taylor [4] found no evidence that the perceived indoor quality in a newly-constructed green university building had better ratings than in two conventional university buildings in Australia.

In a parallel vein, energy-efficient buildings often need considerably more energy in use than originally predicted. Previous evaluation research has revealed what is generally called the energy performance gap [5]. Across a sample of 16 energy-efficient buildings in the UK, Bordass et al. [6] found a deviation of a factor of 6 in carbon dioxide emissions per unit floor area, and even higher differences per occupant. Dealing with the energy performance gap in a recently published paper, Menezes et al. [7] argue that, in most cases, higher energy consumption can be explained by the use of unrealistic input parameters regarding occupancy behaviour and facility management performance in energy models. Moreover, a

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study by Steemers and Manchanda [8] drawing on detailed monitoring and survey data of 12 energy-efficient office buildings in the UK and India shows that more energy use in buildings does not improve well-being when it is associated with increased mechanisation and reduced occupant control.

More recent results of a large demonstration programme with 22 monitored energy-efficient office buildings in Germany show that the primary energy use in newly-constructed buildings can be reduced to about one-third of the average building stock without substantially affecting the comfort of the users [9]. Detailed monitoring and simulation studies on newly-constructed nearly zero-energy office buildings in Switzerland [10] and Spain [11] point in the same direction.

With this paper we aim to contribute to this field of research by presenting empirical findings from a recently finished study in Austria. Referring to Wagner et al. [12] who call for a broader approach to occupant satisfaction in buildings that is able to better cover the overall building performance, the paper adopts a 'sociomaterial' perspective [13]. In its simplest understanding the term sociomaterial claims that the phenomena in question are simultaneously social and material. As a result, well-being as well as energy use in buildings are both constantly produced in practises of sociomaterial nature. Although this paper does not apply a distinct social practice approach [14], the pioneering work of Gram-Hanssen [15,16] on the development of residential heat comfort practises as well the work of Wilhite [17] on energy efficient technologies have to be mentioned as important inspiration. Both authors have shown that new insights can be gained when energy demand and comfort are treated as elements and outcomes of sociomaterial practises involving technologies, embodied habits, knowledge, and social meanings.

Using a mixed-methods research approach, the paper combines in-depth case study material with quantitative survey data. However, the main focus of our analysis is on two case-study buildings featuring the latest energy technologies available in Europe. More importantly, neither case shows problems with regard to realising projected operational energy demands. The paper explores to which extent low levels of energy use can be aligned with high levels of comfort and well-being in real life. In particular, the paper discusses how energy-efficient technologies, facility managers and users of such buildings interact with each other in pursuing to align these various goals. The main questions explored are around whether it is possible to achieve synergies or does it result in trade-offs? And how can we explain outcomes achieved? Before addressing these and similar issues, the following section will briefly develop a working definition of well-being in buildings for the purpose of this paper.

2. *Well-being and user satisfaction in office buildings*

Form a normative point of view it is widely accepted that buildings can and should contribute to well-being and satisfaction in a positive way. But what is meant when talking about well-being in buildings and how can it be measured?

Generally speaking, the term well-being can be used to describe the condition of a group or an individual in a comprehensive way. In the context of sustainable buildings, Storey and Pedersen [18] argue that well-being is to be understood as "a holistic concept comprising both physiological and psychological elements that can be sub-categorised into physical, intellectual and emotional well-being corresponding to body, mind and spirit" [5]. The authors furthermore argue that architecture is related to all of these different aspects of well-being in various ways. Classical indoor environmental quality (IEQ) criteria, i.e. for example thermal and humidity comfort, air quality, light quality, noise, or workplace pollution, correspond mostly to physical well-being; whilst others, such as the interior and exterior design of a building, its symbolic meanings, or opportunities for personal control and engagement with nature, are usually connected to intellectual and emotional aspects of well-being.

The notion of indoor comfort overlaps to a degree with the concept of subjective well-being, although tends to be a more focused concept of satisfaction with physical conditions. Even scholars advise that comfort is a complex phenomenon. An example is the recent work of Sarbu and Sebarchievici [19] who stress that subjective comfort of persons in a room not only depends on indoor environmental factors such as thermal comfort, air quality, acoustic and visual comfort, but also on a wider variety of factors including humidity and air circulation, smell and respiration, touch and touching, sight and colours, and even building vibrations and unpredictable risks.

As with comfort, well-being in buildings, is neither a mere reaction to external conditions nor stable over time. Kahneman et al. [20] point out that subjective well-being "involves a component of judgement and comparisons with ideals, aspirations, other people, and one's own past" (x). In other words, well-being is not only a psychological, but also a sociological phenomenon. In line with this argument, Bluyssen et al. [21] have argued more recently that well-being in office buildings should be studied as the result of a complex process including external factors such as air quality, personal characteristics such as age or education, and user behaviour and learning effects.

Indeed, empirical studies on energy-efficient buildings have shown that users actively shape their working environment as a response to discomfort [22]. More recent studies have revealed a strong correlation between user satisfaction and the possibility to personally control the indoor climate and directly perceive associated effects [23,12]. Based on a broad sample of occupant surveys in the UK involving green and conventional buildings, Leaman and Bordass [24] identified a number of factors that likely cause dissatisfied users. Amongst a long list of rather expectable factors such as inappropriate indoor temperature, dry air or glare on computer screens, the authors found that slow response times are possibly the most important factor of all. Users are satisfied when their workplace-related needs are met quickly and with as little trouble and effort as possible. This result, however, directly points to the often-neglected role of building managers and related staff. Technology and architecture are important, but indoor conditions in office buildings inevitably depend on the ongoing maintenance by facility managers [25]. When users report on well-being and indoor environmental satisfaction they implicitly talk about a seamless web of architectural, material, technological, social and organisational elements responsible for both the subjectively reported well-being and the measurable energy demand.

In the underlying study for this paper well-being in energy efficient office buildings has been approached in two ways. [1] In the written survey, well-being has been operationalised and measured as self-reported user satisfaction only. [2] Detailed qualitative case-study research allowed us to draw a more comprehensive and process-oriented picture of occupant well-being. In both parts of the study we aimed at addressing the role of the facility management in influencing user satisfaction and well-being. The next section briefly addresses the methodology of the underlying study.

3. Methodology

The paper is based on quantitative and qualitative data collected in a recently finished research project. Fieldwork consisted of a quantitative survey amongst broad users of sustainable office buildings across Austria as well as two focussed qualitative case studies in Vienna and Graz.