The role of office users in the sustainability of office buildings – an empirical investigation and implications for FM

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Abstract

Energy consumption in office buildings depends on energy efficient construction and technology, but is also significantly affected by occupant behavior and facilities management practices. It is not clear, however, which reasons account for occupant energy consumption and what measures can be taken to realize latent energy saving potentials.

The aim of this study consists in the analysis of causes of energy-inefficient occupant behavior and thus to provide background information for organizational measures targeted at the reduction of energy-consumption. In the present study we investigated these questions by asking office occupants about (a) their energy related behavior, (b) reasons for suboptimal energy related consumption and (c) their knowledge of energy efficient behavior in office buildings.

1174 occupants working in 12 office buildings participated in an online survey. The results show that up to 20 per cent of occupants report bringing personal electronic devices to the workplace. Around 10 per cent of the occupants have manipulated ventilation ducts in their work area in order to optimize their comfort. The study shows that the main reasons for not acting energy efficiently are not attitudes or goals. They relate to a lack of information, lack of incentives, and habits. This finding is further supported by the survey participants' statements about the three most effective actions occupants can take to reduce energy consumption in the building. The most cited action taken by respondents to reduce energy consumption was to switch off lights when they were not required. There were a number of more effective energy efficiency measures that were not cited frequently (such as reducing heating), indicating a lack of awareness.

It is recommended that organizations implement awareness and feedback systems tailored to organizational practices in order to change occupant's habits. FM departments should take the responsibility of analyzing energy-related occupant behavior and of leading projects to increase energy-efficiency and sustainability in organizations.

Introduction

Buildings in use can be considered as systems composed of technology, design, and users. In the current discussion on sustainable building, there's a strong emphasis on energy efficient construction and technology. The role of end-users' behavior has largely been overlooked [1, 2]. Facility activities cause more than 50 per cent of the overall environmental impact in service organizations [3]. These activities are targeted at end-users of the buildings or influenced by them. Occupant behavior and facility management practices therefore play a crucial role in promoting energy efficiency and reducing the carbon footprint of workplaces. This perspective is substantiated by the fact that the actual energy

consumption of office buildings is often much higher than initially planned and predicted [4]. According to previous studies it can be assumed that 20 per cent of energy consumption in office buildings can be saved without any loss in occupant comfort [5]. It is not clear, however, what accounts for this apparent disparity and what measures can be taken to realize these latent energy saving potentials. Furthermore, much energy-related behavior may be associated with comfort, and therefore conflicts between occupant requirements for comfort and energy consumption may arise.

The focus of this study is the comfort of workplace occupants, and their energy related behavior. The aims of the paper are fourfold: (a) aspects of occupant behavior relevant to workplace energy consumption is analyzed; (b) reasons for energy-inefficient behavior explored; (c) occupant knowledge of energy efficient behavior in office buildings examined; (d) these analyses are related to individual-level theoretical models of energy-conscious behavior, and theoretical and practical suggestions are discussed.

Theoretical background

Research on energy-saving or sustainable behavior has focused on individual motivations rather than contextual factors [6]. An influential theoretical framework guiding much of this research is the Theory of Planned Behavior [7]. This theoretical framework is based on the assumption that human action generally is based on reasoned choices among behavioral alternatives in order to attain the highest benefits and lowest costs. These behavioral intentions themselves are influenced by both, one's attitude toward certain types of behavior, and a subjective value-based assessment of social and moral norms, i.e. the perceived social pressure to perform a behavior. In addition to the two components referring to attitudes and values, the degree of perceived behavioral control affects the intention to perform certain types of behavior. Perceived behavioral control refers to the perceived ease or difficulty of performing the behavior, i.e. contextual factors that facilitate or constrain intended actions. While the Theory of Planned Behavior has been successful in explaining various types of environmental behavior [6], it is still a subject of debate; especially the basic assumption of a strong attitude-behavior relation is discussed from an empirical-methodological point of view (e.g. [8]) as well as from a theoretical perspective (e.g. [9]). At the core of these discussions is the observation that general attitudes do not predict specific behaviors. Lindenberg and Steg [9] acknowledge that behavior results from different and multiple motivations that may be more or less in the focus of an individual in different situations. It is, however, not clear which characteristics of a situation will trigger a certain motivation, or set of motivations. Furthermore, different motives may conflict with each other. For example, an office user's primary goal will normally not be to save energy. Saving energy constitutes only one objective among a set of others (such as increasing one's comfort, for example). The study of energy-relevant behavior in office buildings and the context of business practice therefore requires the extension of a theoretical framework such as the Theory of Planned Behavior. In addition to attitudes related to energy-conservation, the following factors influence efficient or inefficient environmental user behavior in office buildings: habits [6]; self-efficacy for energy-saving behaviors (i.e. the evaluation of a person of whether he/she has the necessary resources, knowledge, and/or skills to reach a specific goal [2]); information about energy-saving options in the building [10]; incentives [11]; and goal conflicts [9].

Furthermore, building and organization specific factors (i.e. contextual aspects) may facilitate or constrain office building users' energy-related behaviors. Organizational and building related determinants of environmental behavior can be analyzed through the comparative study of buildings and organizations [2].

Methods

The data presented in this article has been collected from a current Swiss research project called "Quality of sustainable buildings – The impact of sustainable buildings on comfort, well-being and productivity". The project combines surveys of office users, interviews with facilities managers, and physical and chemical analyses of indoor environment quality. Data was collected in winter 2011/12 and summer 2012. The data presented here has been collected during winter 2011/12, and includes 12 office buildings of five organizations (financial and energy industry; construction and engineering consultancy). The sample of buildings is based on the voluntary participation of organizations, and as

such can be described as an ad hoc sample. However, the buildings that are studied have been chosen by organizations and the research team together in order to ensure that typical office building rather than extreme ones are analyzed. The study is therefore limited to private sector office buildings with at least 100 workstations per building. Buildings with major renovations in the past two years were excluded from the study. Two of the twelve buildings have a Minergie energy-efficiency certificate (a Swiss quality label for low-energy-consumption buildings).

A total of 1174 office users (40 per cent female, 60 per cent male; median age 37) participated in the survey out of 3693 invited making up a response rate of 32 per cent.

Participants also represent an ad hoc sample and the employees that were invited to participate have been selected by organizations and the research team in order to invite typical office users. The office user survey was conducted in an electronic on-line format and participants were informed and invited to participate by e-mail.

The questionnaire contains about 170 questions. The items relevant for this article concern reasons for energy-inefficient behavior, aspects of occupant behavior relevant for energy consumption, and users' knowledge on energy efficient behavior in office buildings. These items were developed for this research. The questionnaire includes 12 questions regarding the six aspects of energy-inefficient occupant behavior:

- Attitudes towards saving energy include 2 items (e.g. "I don't consider energy conservation to be that desirable").
- Energy-consumption habits were assessed by the users on 1 item: "Sometimes one just doesn't think of the own energy consumption and therefore wastes energy unintentionally".
- Self-Efficacy regarding energy saving behavior was assessed on 3 items (e.g. "Saving energy is useless because the other building occupants are not committed to energy conservation").
- Information was assessed on 1 item: "I'm insufficiently informed about my opportunities to save energy in our building".
- Incentives regarding energy conservations include 2 items (e.g. "Our company insufficiently rewards energy conservation").
- Goal-Conflicts were assessed on 3 items (e.g. "Saving Energy is not compatible with good work-efficiency").

The internal consistency of multi-item scales was assessed using Cronbach's alpha. The values range from .67 to .74 and are satisfactory [12].

The questions related to aspects of occupant behavior relevant for energy consumption refer to the use of personal electronic devices brought to the workplace by users (e.g. heaters or fans) and to modifications of the work environment (e.g. cover / block / seal / divert ventilation ducts).

Information concerning respondent awareness of effective actions to reduce energy consumption in workplaces was collected with a set of open questions, where survey participants were asked to name the most effective, second most effective, and third most effective action they knew.

Results

The results of the study are presented in three sections. First, the overall results from the occupant survey are presented. Second, these results are compared between buildings. Third, they are compared between participating organizations.

Energy-relevant behavior

Occupants were asked whether they used personal electronic devices and other equipment and if they had ever manipulated the building in order to increase their level of comfort. A total of 577 survey participants (53%) responded that they had used at least one) of the appliances proposed in the

survey and/or had manipulated a feature of the work environment. Figure 1 shows the results for the electric devices brought into the offices and used by the building occupants.

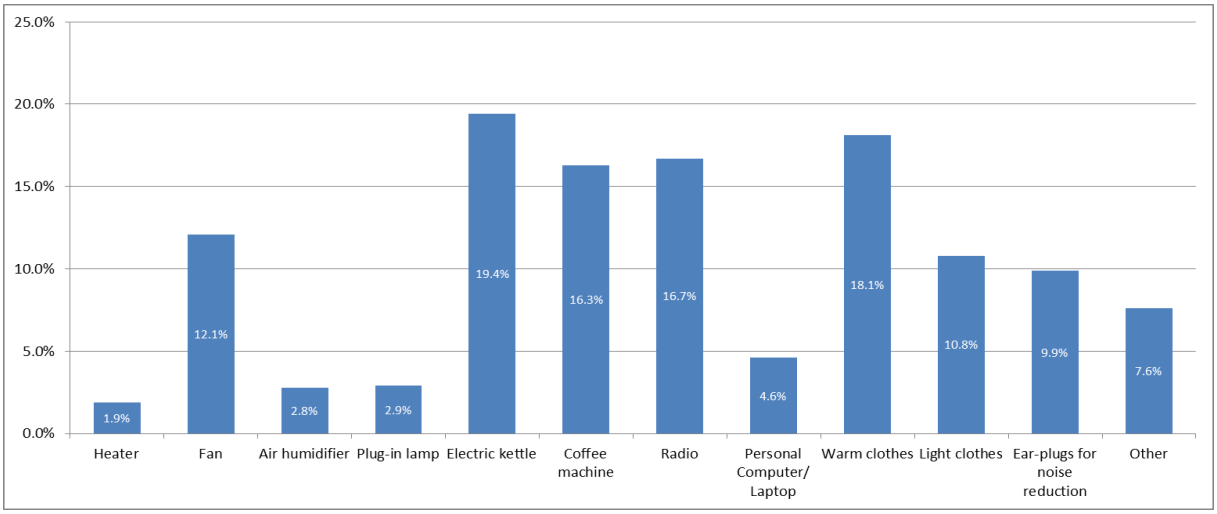

Figure 1: Percentage of occupants using personal electric devices/ special equipment in order to increase their comfort at work

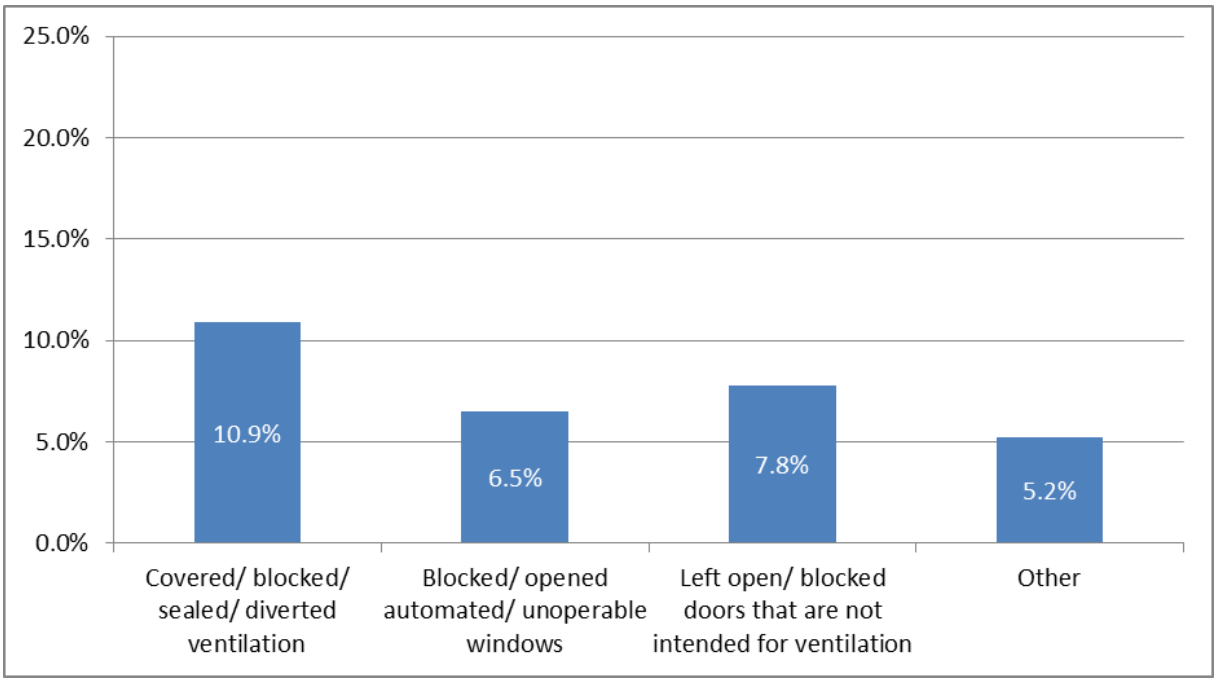

Figure 2: Percentage of occupants who have ever carried out different building manipulations in order to increase their comfort

The most common devices brought to workplaces by occupants were: kettles; warm clothes; radios; and coffee machines. Building-related manipulations in the work environment are presented in figure 2. 237 out of 1025 (23 per cent) participants who had answered this question indicated that they had altered some feature of their environment. More than 10 per cent said that they had covered, blocked, sealed, or diverted ventilation ducts. 6.5% and 7.8% respectively stated that they had blocked or unblocked windows or doors. Furthermore, 5.2% indicated that they had carried out other manipulations such as removing electric bulbs or moving to a different workstation.

Reasons for energy-inefficient behavior

Occupants were also asked for reasons why their behavior may be energy-inefficient or suboptimal. The results are displayed in Figure 3. Building users indicate that conflicting habits, lack of information, and lack of incentives are the most important reasons for suboptimal behavior. Attitudes, self-efficacy, and conflicting goals were found to be less important. A univariate analysis of variance (ANOVA) shows that the differences in the reasons are statistically significant ($F(11, 12934) = 140.18$, $p = .000$).

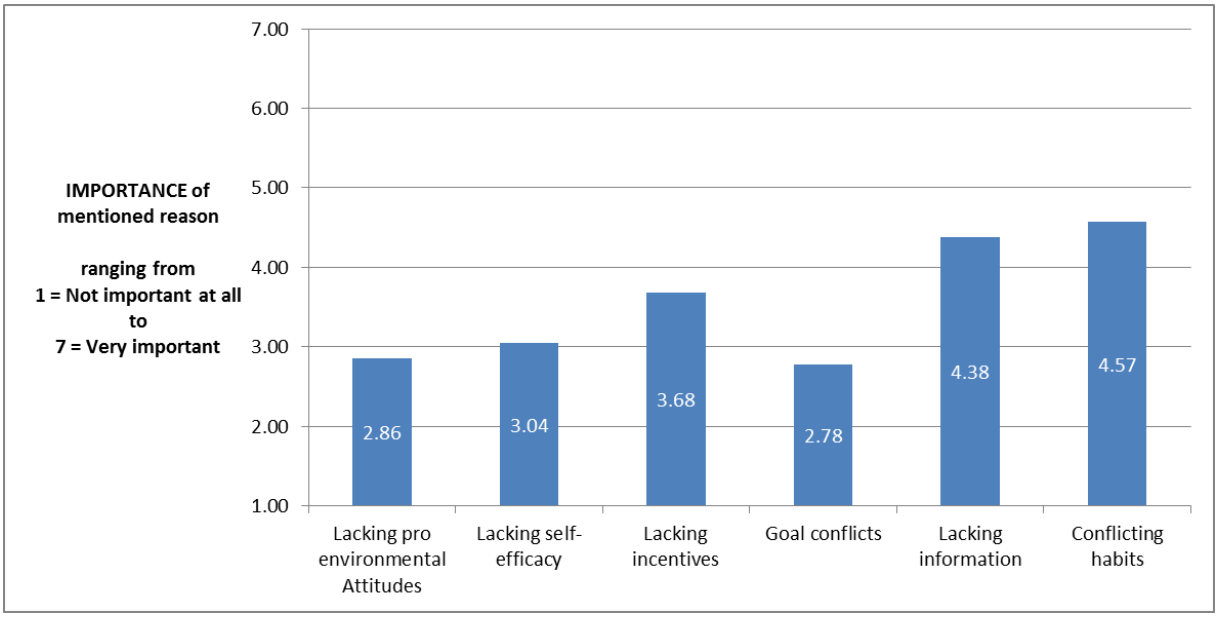

Figure 3: Perceived importance of reasons for energetically suboptimal behavior

Occupant knowledge on energy-efficient behavior

Occupant knowledge on energy-efficient behavior was measured with three open ended questions asking participants for the three most effective actions that users can take in order to reduce energy consumption in the building. Thematic clustering of all answers resulted in 12 categories with at least 20 entries (shown in figure 4). With regard to the response rate there were many participants who skipped one or two or even all of the three questions (response rate was 70%, 62%, 48%, respectively). At the same time there were also several participants who mentioned more than one action per question. This explains why the number of actions coded doesn't match the number of possible data entries.

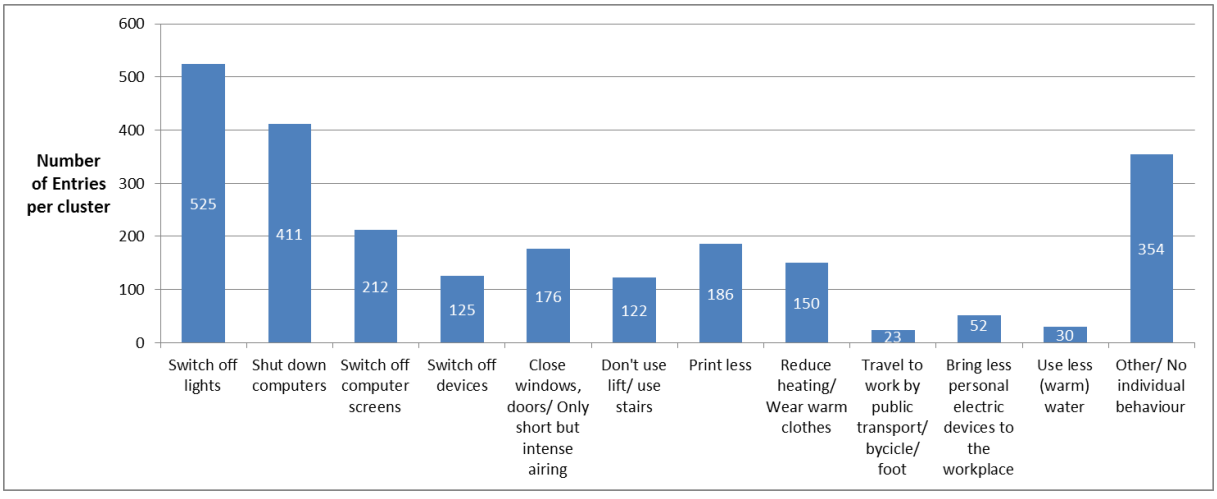

Figure 4: Occupant knowledge on energy-efficient behavior

The actions that were mentioned most frequently were switching off lights when leaving a room (525 entries) and shutting down computers in the evening (411). Switching off computer screens specifically (212) and devices in general (125) were also quite frequently mentioned and so was the idea to bring less personal electric devices to the workplace (52). In addition there were also entries that were not related to the direct but rather to the indirect use of energy such as: building related actions (close windows and doors/ short but intense airing: 176; reduce heating/ wear warm clothes: 150); transport related actions (don't use lift/ use stairs: 122; travel to work by public transport/bicycle/ foot: 23); and resource related actions (print less: 186; use less (warm) water: 30).

Comparison of energy-relevant behavior across buildings and organizations

The comparison of energy-relevant behavior, as well as of the reasons for suboptimal behavior, across buildings and organizations reveals that there are significant differences. Figure 5 and 6 illustrate these differences between buildings and organizations for the use of (personal) fans and manipulating ventilation ducts respectively.

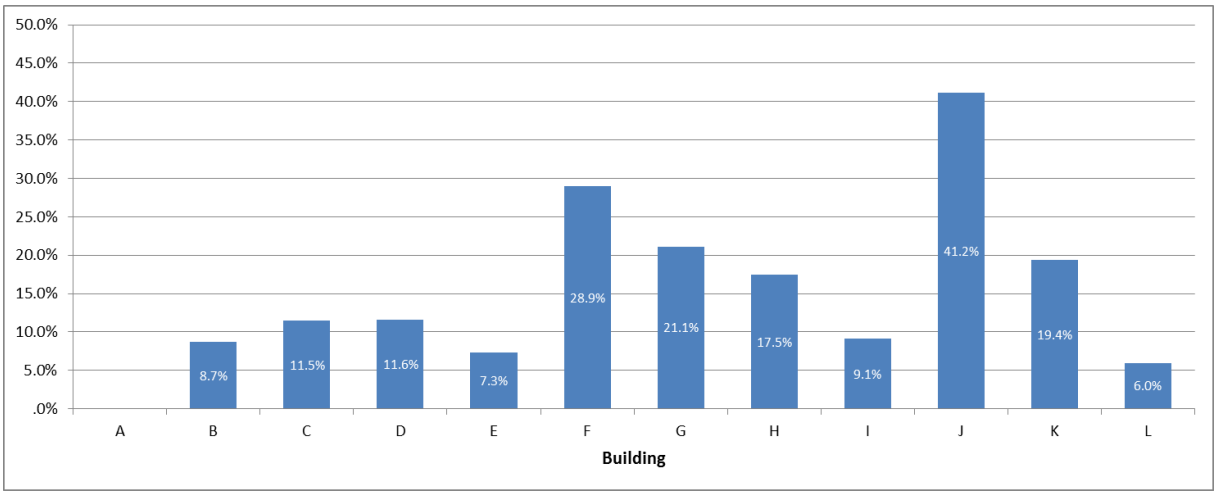

Figure 5: Percentage of occupants using a personal fan per buildings

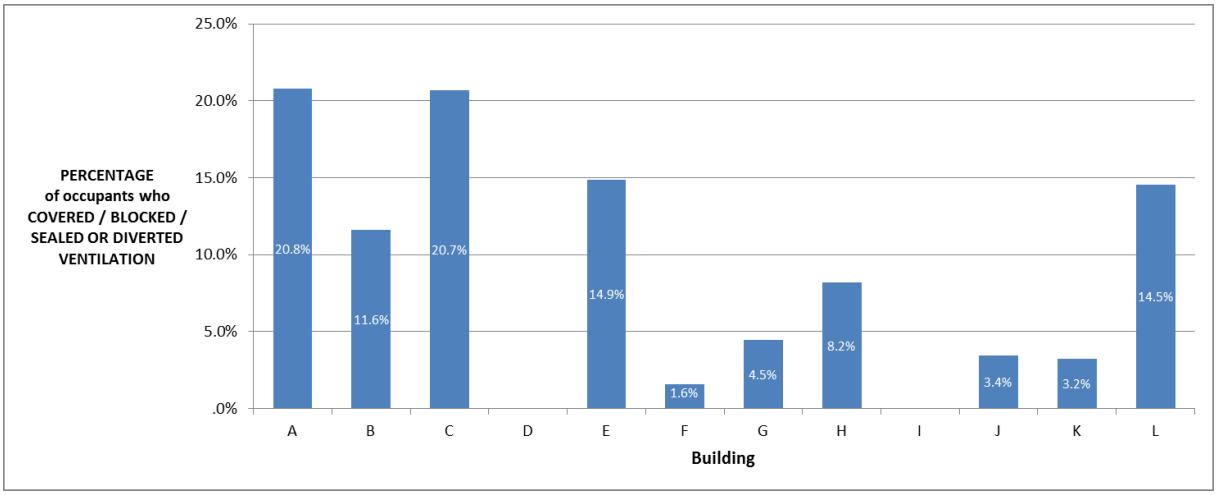

Figure 6: percentage of occupants who manipulated ventilation ducts per building

In contrast to energy-relevant behavior, the reasons are more similar across buildings: There are significant differences in attitudes, self-efficacy, and information. For habits, incentives, and conflicting goals there are no significant differences between the buildings studied. The differences follow a clear

pattern: in buildings where users think their attitudes are strongly pro-environmental, they also report higher self-efficacy and higher levels of information about energy saving opportunities in their buildings. Similar to differences between buildings, there are significant differences between organizations (figure 7 and 8). These results indicate that there are strong influences by organizational policies and practices.

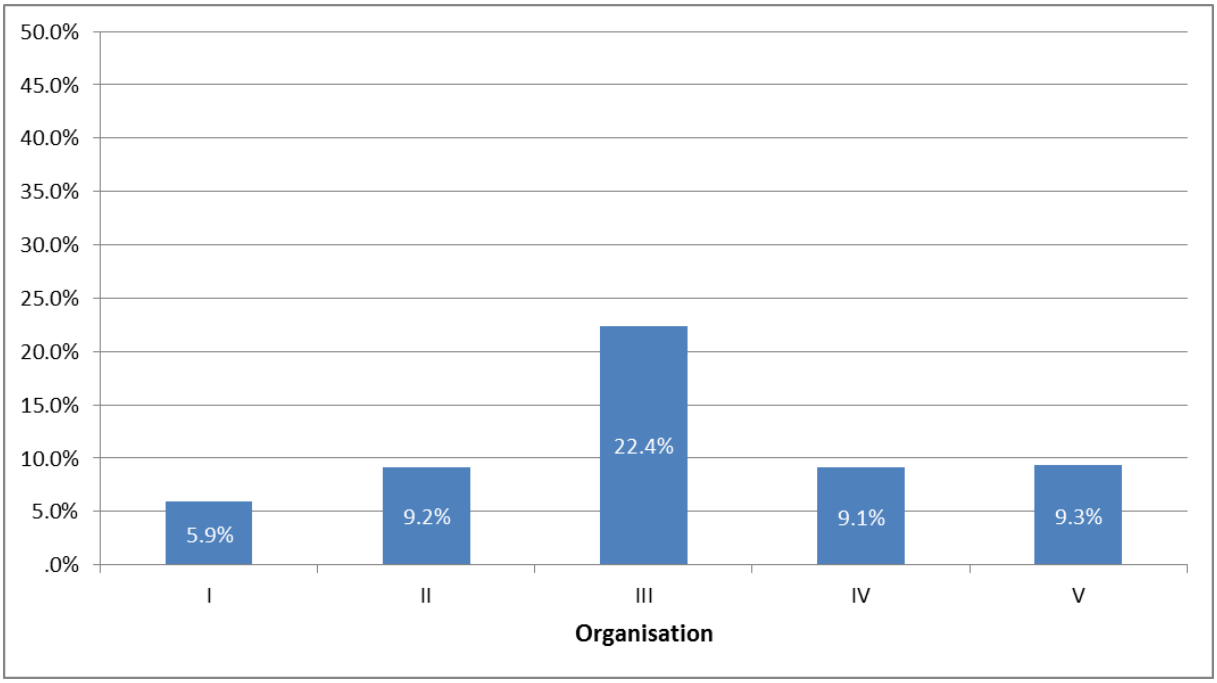

Figure 7 Percentage of occupants using a personal fan per organization

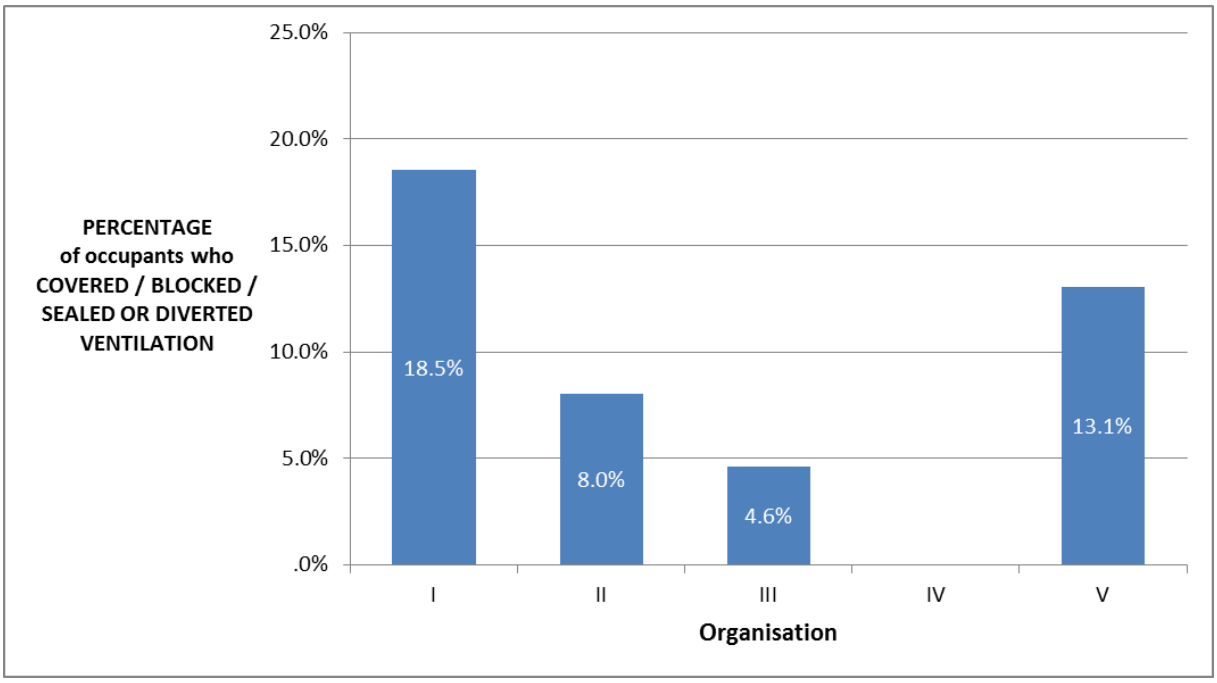

Figure 8: Percentage of occupants who manipulated ventilation ducts per organization

Discussion

The results show that employees control their comfort at work by bringing private electric devices and other equipment. These objects are not equally relevant for energy-consumption. However, coffee machines and fans may consume considerable amounts of energy.

A second indicator of energy-relevant behavior is the percentage of occupants who have carried out manipulations of the building or building technology in their work environment. The results show that more than 10 per cent tried to control their comfort by altering ventilation ducts. Additionally, 7 and 8 per cent blocked or opened windows or doors, respectively. Thus, a considerable number of employees thwart building-related energy or sustainability concepts.

With the multiple motivations approach to energy-consumption behavior at the workplace different reasons for energy inefficient behavior were assessed in their perceived importance by the employees. The results show that pro-environmental attitudes, self-efficacy for energy-saving behavior, and goal conflicts between energy-conservation and other domains are less important reasons than conflicting habits, lack of information, and lack of incentives. Thus, employees generally seem to care for environmental issues but are not aware of the possibilities to align their behavior with their attitudes.

Analyses of user knowledge confirm this finding. Survey participants most frequently mention switching off devices or shutting down computers as amongst the most effective actions office users could take in order to reduce energy consumption. These actions are obvious in the sense that they are associated with a direct feedback for the user. While these actions certainly contribute to energy-saving they may not be the most efficient measures for sustainable usage of office buildings (e.g. reducing heating / cooling will have a bigger impact). Because more and more electrical devices have power-saving functions, the effect of these actions may decline in the future. Thus, mechanisms of providing feedback to the users with regard to actions that do not have directly perceivable consequences will become more important for energy-saving behavior.

At least four limitations of the study must be mentioned: first, the operationalization of energy-relevant behavior is incomplete. While bringing own devices and manipulating the own work environment may be considered as a good indicator, other forms of behavior relevant for office building sustainability should be considered in further studies, e.g. use of electric installations, transport and travelling, or heating and cooling (where under control of employees). Second, the use of an ad hoc sample limits generalizability of the results. Differences between office buildings indicate that considerable variability can be found. Furthermore, the characteristics of the buildings, organizations, and facilities management practices and policies should be taken into account. Third, intercorrelations between the reasons for energy-inefficient occupant behavior are not considered in this article. Further research should aim at identifying causal relationships between behavior and attitudes, habits, self-efficacy, information, incentives, and goal conflicts by using longitudinal research designs. In order to identify such relationships, intercorrelations between the factors must be taken into account. Fourth, self-reported behavior measures may not be very reliable and information from user surveys may be biased due to social desirability [13]. Therefore surveying users should be complemented with more objective measures such as walkthroughs, sensor-based measures, or measures of energy consumption.

The results have important implications both, for theory and practice. From a theoretical point of view the multiple motivations approach proved fruitful. The results indicate that information, incentives, and conflicting habits are more important reasons for energy-inefficient behavior than attitudes, self-efficacy, or goal conflicts. Furthermore, there are significant differences between buildings and organizations indicating that building characteristics and organizational policies and practices may strongly influence employees' behavior in the context of sustainability of office buildings. Therefore interventions to change and improve users' behavior should be tailored to the specific situation. A goal-setting and feedback-intervention approach promises to be more effective than more general media-based persuasion strategies [see also 14, 15]. Furthermore, FM policies regarding personal devices and equipment as well as building-related manipulations should be formulated and communicated. Finally, information for users must be provided in order to enable them to understand the way the office building works and which actions are effective in relation to sustainability goals. Information and timely feedback on occupants' interventions have been shown to be a critical factor for their understanding of the way the office building works [10].

However, further research regarding such interventions is needed. Especially the interplay between individual motives, building characteristics, and organizational guidelines deserves more attention. Further studies comparing buildings and organizations are needed for a deeper understanding of sustainable office buildings in use.

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