

Judith Thomsen, Åshild Lappegard Hauge and Åsne Lund Godbolt

Interventions on energy behaviour in non-residential buildings – a literature review



The Research Centre on
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Foreword

This literature review was commissioned by work package 4 (“Use, operation and implementation”) within the Research Centre on Zero Emission Buildings. The centre’s ambitious work programme covers the built environment in all its manifold manifestations, both residential and non-residential and both existing and new buildings. Within the literature on energy and emissions reduction in the built environment, certain combinations of research approaches and type of building are more prevalent than others. For instance, in the centre’s previous work as well as elsewhere there exists a bias towards technological and administrative approaches to reduce energy in non-residential settings, while behavioural aspects are more likely to be studied in people’s homes. This bias results in a research gap that is addressed in the present literature review: occupant focussed energy efficiency interventions in non-residential buildings.

Abstract

The aim of this review is to gain an overview of how interventions or experiments as a method are used to detect how to influence employees to use less energy. Most of the interventions on energy behaviour have focused on the residential sector. This literature review focuses on experiments conducted in non-residential buildings, but also refers to some relevant studies done in the residential sector.

Employees do not have economic motives for saving energy, nor do they usually have the possibility to follow the energy consumption of the building. What type of interventions can motivate them to save energy? What are implications for further research on user behaviour for energy efficiency in non-residential buildings?

The findings from this review show that possibilities for strategic interventions to influence energy consumption in non-residential buildings are more limited than in households. Interventions should be based on feedback, knowledge, beliefs and norms since the economic dimension available in housing is inaccessible in non-residential buildings.

The organizational context has shown to be important in influencing energy related behaviour at a workplace. In order to create a new energy culture and motivation for energy reduction, it is important that the management participates, and that the pro-environmental attitudes pervade the organization.

Giving the employees access to information about the general energy consumption of the building can also motivate changes in energy use.

Further research on energy behaviour in non-residential buildings should adopt an interdisciplinary focus in order to deal with the complexity of energy behaviour. Multiple interventions to test different motivational factors and long-term documentation of effects can be recommended on the basis of the existing studies. The role of attitudes of the management and the organization should also be investigated and documented more thoroughly.

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1. Introduction

Energy efficiency is recognized as one of the most effective ways to reduce the impacts of climate change (IEA, 2009; IPCC, 2007). Despite the fact that occupant behaviour is a major determinant of energy use in buildings, energy saving potential due to behaviour is often neglected or considered unimportant compared to the outcome of technological solutions. However, energy behaviour represent a significant untapped potential for the increase of end-use energy efficiency in buildings. Changing user behaviour is often presented as a cost-effective way to achieve energy efficiency. There is a clear economic incentive for organizations to address energy behaviour change at the workplace (Carrico & Remier, 2011). The saving potential due to feedback interventions on energy behaviour is estimated to be from 0 to 15% (Abrahamse, et al., 2005).

Lopes, Antunes & Martins (2012) say that most of the interventions/experiments on energy behaviour have focused on the residential sector. Energy behaviour studies in the residential sector are predominantly *field experiments* testing interventions (incentives, feedback, information etc.) to promote more efficient energy behaviour. They also point to the fact that there is a *noteworthy unexplored line of research associated with energy behaviour in services buildings*, as well as comparing energy behaviour in both types of buildings.

There is a great potential for energy saving when it comes to user behaviour in the non-residential area (Carrico & Riemer, 2011). But there are very few studies that cover user behaviour for energy efficiency in these types of buildings. The challenges with the focus on energy efficiency among employees will be discussed.

1.1 Aim

The aim of this literature review is to give an overview of how experiments and interventions are used to detect how to influence user behaviour in a more energy efficient direction in non-residential buildings. Since most of the experiments on this topic are done in residential environments, some of the results from these studies will be taken into consideration as well.

The main questions are:

- What motivates employees to save electricity at work?
- What types of interventions are used in studies on energy conservation?
- What special challenges and advantages can be identified for energy behaviour in non-residential buildings?
- What results from studies in household energy behaviour support findings from studies on energy behaviour in non-residential buildings?
- What are relevant issues for future research?

1.2 Method

The review is based on literature search of studies newer than from year 2000 in the following databases: Scopus, ISI, Science Direct, Engineering Village, Taylor and Francis, and Google Scholar. The following search terms were used in different combinations: user behaviour, energy efficiency or energy efficient, buildings, experiment, quasi-experiment, intervention, office building or non-residential building. Further literature was found by examining the references on the relevant papers.

The literature found in this search supports the statement by Lopes, et al. (2012), Coleman, et al. (2013) and Murtagh, et al (2013) that most of the interventions on energy behaviour are done in the residential sector.

1.3 Definitions and limitations

To find ways of changing energy behaviour, interventions or field experiments of different types are often used. A *field experiment* or *field trial* experimentally examines an intervention in the real world/ naturally occurring environments, rather than in the laboratory. In a traditional experiment, randomized groups of respondents are used, but in field experiments the use of a real world setting is seen as more important. Interventions are done for one group, and another group is used as a control group. There will be less control over variables, but the meaning of context will be analysed (Denscombe, 2003).

A few studies on interventions in housing are included in order to compare and strengthen findings from studies on non-residential buildings.

Feedback on energy use of different types is included and defined as an intervention. Feedback is a broad field in housing studies, but has not been used to the same extent in non-residential buildings.

2. A short review of conceptualizing frameworks on energy behaviour

Energy use is in many ways framed by dominant conceptions of comfort, cleanliness and convenience, which become embedded in the built environment (Shove 2003a,b, Aune and Sørensen, 2007).

Stephenson et al. (2010) present the "Energy Cultures" framework whose aim is to assist in understanding the factors that influence energy consumption behaviour, and to help identify opportunities for behaviour change. The Energy Cultures framework suggests that consumer energy behaviour can be understood at its most fundamental level by examining the interactions between cognitive norms (e.g. beliefs, understandings), material culture (e.g. technologies, building form) and energy practices (e.g. activities, processes). These three core concepts are highly interactive, and are also linked to an outer ring of wider systematic influences of behaviour (also referred to as the "contextual soup"). The framework is change-oriented rather than deterministic; "wider social, environmental and economic forces *structure* but do not *determine* people's cognitive norms, practices and material cultures" (p. 6127). Furthermore, this interdisciplinary framework is designed to identify clusters of "energy cultures" – similar patterns of norms, practices and/or material culture – as a tool for understanding the potentials and possibilities for sites of action to achieve behavioural change.

According to a literature review by **Lopes et al. (2012)** on energy behaviour, the majority of research on energy behaviour comes from environmental psychology. The focus has been on identifying motivational factors, contextual factors and habitual factors. However, being traditionally focused on the individual perspective, environmental psychology often fails to examine the contextual influence on energy behaviour. While environmental psychology addresses mainly behavioural factors, economics assumes individuals as fully rational actors who make rational decisions and actions. Therefore, economic strategies consist of correcting market failures by providing information, securing capital for investments etc. On the other side, whereas psychology and economics focus on individual behaviour, sociology proposes that energy demand is not only originated by the individual, but it is also a result of social factors. Energy behaviour strategies must therefore consider this perspective to be effective (e.g. social learning, collective actions etc). They explore the most relevant social theories that determine individual decision making when it comes to energy use:

- Utility-based decision and behavioural economics: Microeconomic theory of utility maximization given certain preferences. Consumers are assumed to behave economically rational as long as they receive the right information.
- Technology adoption and attitude-based models: Aim to explain how and why innovations, such as energy efficient technologies, occur and are disseminated. These models assume that there is a decision process with several phases that guide a change from knowledge to change in behaviour (also, how cognition leads to action).
- Decision theories in social and environmental psychology: Social psychology research has focused on the existence of socioeconomic and psychological correlations in residential energy use. Also, the value-belief-norm (VBN) theory proposes a causality relation between the personality, specific beliefs about the consequences and responsibilities of particular actions, attitudes and personal and social norms. In order to fully explain decision making, context was subsequently incorporated in the attitude-behaviour-external conditions model (ABC).
- Sociological theories that cover the influence of social context in decision making: In contrast to the previous models, sociology approaches generally argue that energy use is not a consequence from individual choices, but a result of different social contexts. "*Needs, attitudes and expectations are not individual in nature but are part of a complex relationship between social norms and relations, technologies, infrastructures and institutions*" (Lopes et al. 2012, p. 4100). This perspective highlights the ubiquity of energy use in domestic routines, since habitual home activities such as cleaning and cooking consume energy, and analyses the household level (rather than the individual), capturing normative and routine behaviour and recognizing domestic rules.

Energy behaviour is often divided into informational and structural strategies. Information strategies try to influence people's motivations to act pro-environmental, while structural strategies will change the context people make their choices in (for example economic incentives or regulations). Most user behaviour studies on energy efficiency are based on interventions in informational strategies (Lopes, et al. 2012).

A literature review by **Abrahamse, et al. (2005)** on household energy savings concludes that interventions in different empirical studies were successful to varying degrees. Antecedent interventions like information campaigns were found little effective if applied alone. Tailored information for households on energy savings was more successful. Rewards were also effective. The provision of different kinds of feedback, especially frequent feedback, was found to be an effective strategy for household energy reduction. They also state that the underlying factors for energy-related behaviours are hardly examined. Several of the studies reviewed have found that a combination of strategies is more effective than single strategies.

Lockton, et al. (2008) review different approaches to changing user behaviour in a more energy efficient direction. Their concept "Design with Intent" addresses the potential of product design and engineering in persuading or guiding users to operate products in a more sustainable manner. The first type of approaches described is affordances and constraints of products and interfaces, meaning functions that are available and whose limits can be altered in a way that leads the user into a more efficient direction. Default settings, for instance, will have an impact on the choices users make. Behaviour-shaping constraints are also described as a method for correcting user choices. A constraint can be rationing of resources available, e.g. printer paper or hot water.

Affordances- and constraint strategies are techniques to push user behaviour in a desired direction. A second type of strategy is described as a persuasion. Persuasive techniques are more "friendly" than affordance and constraints and aim at cognitive norms. Persuasive principles are for instance feedback approaches that can indicate to users how efficient their behaviour is. Different types of feedback (e.g. descriptive or comparative) can affect user behaviour to different degrees. Feedback in the form of increasing understanding of how systems around users actually work is also described as a persuasive technique. A computer game developed to increase teenagers' understanding about energy behaviour at home through simulating households and effects of household appliances is an example for that (ref. Bång et al 2006). The types of strategies described can be combined in different design products.

Brekke, et al. (2007) remind us that one of the most effective ways to achieve behavioural change is to observe what other people do. If a "significant other", a person we look up to and want to be liked by, does something positive for the environment, we would want to do it ourselves. The power of examples is strong, and good role models therefore seem to have a stronger effect than information campaigns. Why? People do not like to differ too much from others. It means a lot to be liked and accepted. People therefore mainly behave in ways that give social acceptance, and in many ways environmental friendly behaviour has become a way to achieve social acceptance. The opposite, the consequences of breaking a social norm, to be exposed to social sanctions or negative attention from others, may in some cases be a strong prevention to act against social norms (Brekke, et al., 2007). The study conducted by Brekke, et al. (2007) shows that the more people think others recycle their garbage, the better they are at recycling themselves. Moral responsibility is learned through observation of others behaviour. **Nolan, et al. (2008)** say that recent research has shown that direct observation of others is not required for normative social influence to have its effect. Communicating a descriptive norm oral or written about how most people behave in a given situation, can induce conformity to the communicated behaviour.

3. Empirical studies on energy efficient behaviour in non-residential settings

The review of the studies is organised according to the type of intervention used.

3.1 Individual and comparative feedback

Murtagh, et al. (2013) conducted a field trial on the effect of individual feedback on energy use in an office setting. There is little knowledge on employees' energy use in offices. The field trial monitored energy use for four weeks first and after that started to provide individual feedback to 83 university employees over 18 weeks. The trial comprised a survey before and after the intervention, plus two focus groups.

Findings show that there was a statistically significant energy reduction, but not over the whole measurement period. An immediate reduction of energy use after setting up individual feedback could not be found. Energy use was reduced in months three and four, a phenomenon that the authors find difficult to explain.

Other findings show that self-reported pro-environmental behaviour could not be related to actual energy use, engagement with feedback or energy savings. There was a relationship between attitudes to reducing energy use and actual energy consumption. The qualitative data from the focus groups reveal that people have a multitude of reasons for not acting pro-environmentally and that there is a lack of goals and motivation to drive energy saving behaviour.

The authors conclude that feedback may help to reduce energy consumption to a certain level. A challenge is to keep employees interested over time and to reach more than a limited number of employees. The authors point out that social norms and group norms of an organisational culture were not considered in their study, and these may be relevant motivational factors.

Colemann, et al. (2013) have conducted a study on promoting more energy efficient behaviour through wireless personal feedback in offices. The objective behind the study was to use wireless technologies to provide feedback of actual energy use to individuals within the workplace. The intervention is evaluated through 19 qualitative interviews. Quantitative and qualitative data supported both social and technical insights and show that individualised feedback can help to identify reduction opportunities. The authors also point out privacy and surveillance issues as a concern of individualized feedback, unlike building-level feedback.

Siero, et al. (1996) conducted a study with the aim of changing organizational energy consumption behaviour through comparative feedback. They provided two different forms of feedback in two units of a metallurgy company. One unit had to set goals for reduction and received feedback on their own conversation. The second unit got the same task, but received also information on the performance of the other unit. The second unit, which compared their own savings to the savings of the other unit, saved more energy, also half a year later. Another finding the authors point out is that behaviour changed but without hardly any changes in attitudes or intentions.

Brown, et al. (2009) explores how feedback is provided in the design and delivery of two green Canadian office buildings and how this shapes the knowledge and adaptive behaviour of occupants. A central theme is whether occupants are treated as passive or active in establishing the comfort conditions of their immediate environment. Results suggest that occupants can only truly be active participants if they receive effective feedback on their adaptive behaviour (engaging with building controls and complaints). Lack of effective feedback can render occupants passive participants. Their behaviour will be adaptive rather than improving their understanding of how the building works and how

overall comfort levels can have the opposite effect. Findings underscore the many challenges in interpreting occupants' subjective statements about knowledge, comfort and engagement with a building.

3.2 Peer-education and feedback

Carrico and Riemer (2011) did a study on energy use among university staff in different buildings at the campus. The average building had 88 occupants. Invitation to participate in a survey after the planned energy intervention was sent out to 2056 people. The baseline survey had a response rate by 29 %. Two different methods to obtain reduction in energy use were tried out: Peer education and feedback techniques. The study had a factorial design within a cluster-randomized field experiment. All study groups were exposed to the same basic information campaign in which they were educated about energy use and how to conserve energy (e.g., turning off lights, adjusting thermostats). One-fourth of the buildings received only this public information campaign and was considered a control group. One-fourth of the buildings also received a peer education intervention, a third set received a feedback intervention, and the final one-fourth of the buildings received all three interventions. All interventions were run simultaneously over a four month period of time.

The interventions were evaluated using a combination of electricity data and surveys. Occupants participating in the feedback intervention received emails monthly where the energy use of the building was compared to the energy use of the previous month, visually presented through graphs and with encouraging text. Another group had volunteers answering questions on energy use, and sending out information on energy use in the specific buildings. At the end of the study, survey participants were asked to report how frequently during the previous work week they had turned off computers, monitors, printers, lights, and office equipment. Very few had access to control the heating, and this aspect was therefore excluded. The results showed that in the control group, the energy use increased with 4%, in the peer education group the energy use decreased with 2 %, in the feedback group the energy use decreased by 7 %, and in the combined group it decreased with 8 %. The survey data do not explain or replicate the findings in reduced energy use. The study demonstrates that feedback on energy use may be a good enough incentive to change energy behaviour. Energy behaviour change is not dependent on economic incentives (Carrico & Riemer, 2011).

3.3 Norms and antecedent beliefs

Goldstein, et al. (2008) exemplify the significance of social norms on pro-environmental behaviour in a field experiment. They examined the effectiveness of signs requesting hotel guests' reuse of towels during their hotel stay which may reduce energy consumption indirectly in the case of these towels being cleaned in-house. They suggested that information on how most people behave in a situation (descriptive norm) is likely to influence other people's behaviour in a similar situation. The field experiment investigated whether using an appeal that conveys the descriptive norm (e.g. the majority of people reuse their towels at least once during their stay) would be more effective at encouraging towel reuse than standard appeals which focus on the importance of environmental protection. The results showed that the descriptive norm appeal yielded a significantly higher towel reuse rate (44.1%) than the standard appeal (35.1%). They also tested whether associating one-self with a group results in greater motivation to act more pro-environmentally. Guests that were told that 75% of former guest of the same hotel reused their towels were more likely to reuse their own towel. They suggest that people act more pro-environmental to conform to societal norms.

Scherbaum, et al. (2008) explored individual level factors related to employee energy-conservation behaviours at work. They use the "value-belief-norm theory" (Stern 2000). The authors examined individual level factors related to energy saving behaviour among employees of a large university. They

found that environmental personal norms predicted self-reported energy conservation behaviour, as well as behavioural intentions. They discuss the question of which factors the organizations can use to encourage employees to save energy. Appeal to employees' sense of personal responsibility, persuasion to changing personal norms, and external rewards may be motivations. They also point out the need for further studies on the same issues to validate results.

Zhang, et al. (2013) have studied antecedents of employee electricity saving behaviour in organizations, applying norm activation model (NAM). NAM is often used to study individual pro-environmental behaviour (ref. de Groot and Steg, 2009). Pro-environmental behaviour is anticipated to be positively influenced by personal norm. Their findings show that personal norms positively influence employees' saving behaviour. Awareness of consequences, feeling of responsibility, and the organizational electricity saving climate/intentions positively influences personal norms.

A study by **Greaves, et al. (2013)** presents results from a questionnaire distributed among employees that explored environmental behavioural intentions, based on the theory of planned behaviour. Theory on planned behaviour (TPB) (Ajzen, 1991) that shows how we rationally weigh our actions based on what positive and negative consequences we believe our behaviour may lead to. The theory explains the motivation we have to act environmentally friendly based on weighing costs and benefits, assuming that an individual makes well-reasoned choices and chooses the alternatives with the greatest benefits and the smallest disadvantages. This theory has proven to predict pro-environmental behaviour for both recycling and travel mode choice (Stig & Vlek, 2009). Employees' antecedent beliefs and environmental behavioural intentions for 3 scenarios were tested: 1. Switch off PC; 2. Video-conference instead of travelling; 3. recycling as much as possible. In a second phase, face-to-face interviews, ten on each topic, were conducted.

Findings showed that all the three different constructs mediate the relationship between beliefs and intentions. From a practical perspective it is useful to explore antecedent beliefs as they provide information on interventions that can be implemented. The example of switching off PC's showed that long PC-start-up time was a significant factor for whether employees switch off computers. Reducing start-up time can lead to greater numbers of people switching off PC's while not at their work place. Normative beliefs such as "doing something good for the environment" were also key issues that influenced the TPB constructs. This knowledge is useful for campaigns within the organization, ensuring that the information is found relevant by the target population. Addressing more specific behaviour than general appeals to conserve energy also showed a greater relevance for employees' behavioural intentions.

The study shows the relevance of including the target population at an early stage. Antecedent beliefs can explain why employees engage or not.

Christina, et al. (2014) explore how organizational behaviour and attitudes can impact building energy use. They have qualitatively studied staff's energy behaviour and individual attitudes in a leading UK store chain. 51 employees participated in 10 focus groups. They adapted VBN (Value-beliefs-norm, Stern 2000) theoretical framework to their study. Their aim was to identify key drivers for environmental behaviour at work. Findings illustrate the importance of the organizational context in understanding energy-related task performance at work. Energy management should consider individual attitudes and behaviour alongside with organizational policies, building design and technology. A key finding is that energy behaviour is not a primary goal but is vulnerable to multiple-goal conflicts. They emphasize the meaning of organizational drivers such as managerial vision, commitment, and strategy and performance management as the most effective drivers for an improved energy management in large organizations.

3.4 Manipulation

Brown, et al. (2013) describe a randomized controlled experiment in which the default settings on office thermostats in an office building were manipulated with 1°C and with 2°C during the winter heating season. In addition, employees' chosen thermostat settings were observed. The experiment was conducted over a 6-week period.

Brown, et al. (2013) found that small decreases in the default temperature (1°C) led to a greater reduction in the individually chosen thermostat settings than large decreases (2°C), and thus can contribute to saving energy. Larger decreases in default temperature settings led to greater adjustments and in the end to an increase of temperature and energy consumption. Office occupants who were more used to adjust their thermostats prior to the intervention were also less susceptible to changes in the default temperature. Brown et al (2013) conclude that this kind of intervention, if it is done in a moderate way, may increase energy efficiency.

Roussac, et al. (2011) present findings from an attempt to improve occupant comfort and reduce energy use in mechanically ventilated office buildings by adjusting internal air temperature set points. Two approaches were adopted: a *static* control strategy (i.e. raising temperatures 1°C higher than normal over summer); and a *dynamic* approach (i.e. adjusting temperatures in direct response to variations in ambient conditions). It was found that occupant comfort was adversely affected in both trials. Meanwhile, the 1°C static set point increase was associated with a 6% reduction in daily heating, ventilation and air-conditioning energy use. This was slightly less than the 6.3% reduction when the dynamic approach was adopted.

Zeiler, et al. (2014) state that efforts to reduce energy consumption in work places have mainly focused on information. They argue for a greater focus on how the building occupants behave and which comfort needs they have. Optimizing energy performance without focusing on one of the goals of energy consumption – human comfort - is not sufficient. They presents findings from a field experiment including the human body (hand, feet and head) as sensor for temperature controlled individual heating in office buildings. The upper-extremity skin temperature is used as feedback control signal. The goal is to provide a comfortable temperature to the individual employee and at the same time, to save energy. The experiment focuses on the human-perspective on comfort and the availability of new technology. They propose personalized radiant heaters, such as infrared lamps.

4. Discussion and conclusions

4.1 Challenges with energy efficient behaviour in non-residential buildings

Do employees have sufficient motivational factors to reduce energy use? The focus groups conducted by **Murtagh, et al. (2013)** revealed that employees come up with a multitude of reasons for not acting pro-environmentally, and that there is a lack of goals and motivation to drive energy saving behaviour.

In households, residents' decrease in energy consumption is in many cases rewarded economically. Possibilities for strategic interventions to influence energy consumption in non-residential buildings are more limited than in households. ***Energy behaviour in non-residential buildings has to be based on feedback, knowledge, beliefs and norms, not economic incentives.***

Based on focus-groups interviews, **Throne-Holst, et al. (2007)** consider the relevance and strengths of various barriers for changing energy consumer behaviour. They identify six barriers for energy change: physical and structural barriers, political barriers, cultural-normative barriers, economic barriers, information barriers and individual-psychological barriers. Out of these six barriers, the three with the highest explanatory value are: cultural (visions of good life: large and flexible homes, degree of freedom etc), economic (economic barriers to investment in new energy technologies, payback time, increased wealth etc), and information (What to do? How do we save energy?). With the economic dimension being inaccessible, *culture and information* (**Throne-Holst, et al., 2007**) have to be in focus when trying to reduce energy consumption among employees in non-residential buildings. And even in residential settings, economic savings are not the only motivation for occupants to save energy. **Ek & Söderholm (2010)** analyze Swedish households' willingness to increase their daily efforts to save electricity through new behavioural patterns. Their empirical results, based on a postal survey, indicate that costs, environmental attitudes and social interactions are *all important determinants* of electricity saving activities. According to Ek and Söderholm, both economic and environmental motives play a role in households' decision-making processes, and the latter matter just as much as the former, or even more. Also **Allcott & Mullainathan (2010)** state that a recently-growing body of research in psychology and behavioural economics suggests that *nonprice* interventions can be just as powerful as prices in changing consumer choices.

Most users of non-residential buildings have limited influence over the energy efficiency of their buildings, with responsibility often being assumed by designated managers and influenced by building characteristics and systems. The lack of motivational factors for energy saving may be related to the lack of pro-environmental attitudes in the management of the firm or organization. This topic is not treated in any of the publications we have reviewed, except the study by **Christina, et al., (2014)**, but it is a highly relevant contextual factor in non-residential settings. What can be expected from the employees if the management **does not improve the energy efficiency of the building they work in?** If the management is interested in energy efficient behaviour, they are probably interested in energy efficient buildings too, and not only in the economic benefits from energy savings. In attempts to change energy behaviour among employees, it might be important to focus on idealism, saving energy for the sake of the climate, not the economic savings for the organization. ***To create a new energy culture and motivation for energy reduction, it is important that the management participates and that the pro-environmental attitudes pervade the organization.*** Christina et al. (2014) say that organizational context is important in understanding energy related behaviour at a workplace.

Another challenge for creating motivation for change in energy use is that employees seldom have access to information about the general energy consumption of the building. As the study of Carrico and Riemer (2011) shows, feedback on a building's energy use is a strong motivation for energy behaviour change in non-residential buildings. This is also documented in research on household energy use. Ehrhardt-Martinez, et al. (2010) and Fischer (2008) report that electricity savings of

between 4–12% and 5–12%, respectively, can be realized through the effective provision of feedback on energy use in homes. With a little effort, the management can arrange and distribute the energy use of the building regularly by email. Coleman et al. (2013) shows an example of how to do so. This will inspire the employees to save energy, especially if the feedback is compared to another unit (Siero et al., 1996).

4.2 Advantages with energy efficient behaviour in non-residential buildings

When the economic motives to save energy are irrelevant, one has to focus on changing the social and personal norms through different interventions.

An important strand within the studies of energy behaviour in office buildings is based on the role of personal and social norms, organisational culture, and antecedent beliefs. Findings indicate that focusing on norms and beliefs especially in combination with feedback can have an effect on energy consumption in non-residential buildings. (Long-term effects are not documented in any of the studies we found and are therefore important in further research.) Nonetheless, studies on similar topics in housing may strengthen these findings, as for instance **Peschiera, et al. (2012)** and **Jain, et al's (2013)** work on student housing. Both studies explored the effect of norms and relevance of peer-group behaviour on saving energy. Student housing is a type of communal housing where group dynamics are strong. These findings on the influence of social norms within peer-groups are assumed to be highly relevant for groups of occupants in non-residential buildings. We suggest that ***in non-residential buildings it is an advantage to have a collective focus***. The shift in energy culture is a collective project, not mainly an individual project as in households. This is also recognized by Carrico & Riemer (2011); the workplace may be an environment conducive to behaviour change, because the workforce can form a captive audience and there is potential for influence by peers.

Heiskanen, et al. (2009) discuss that individual decisions to save energy are framed by social dilemmas which are that individual efforts are useless unless others participate. Also, energy-related behaviour is shaped by conventions and socio-technical infrastructures that are largely beyond individual control (Shove 2003, Guy 2006). These problems, together with the invisibility of the consequences of each individual's actions, lead to a sense of disempowerment that is a major obstacle to more energy efficient lifestyles. In terms of saving energy in buildings, these findings can be assumed to be especially relevant for (single family) housing. In non-residential buildings it can be an advantage that there is a large group of employees to focus on making people realize that "others participate". A sense of community may be more easily developed in non-residential buildings.

Heiskanen, et al. (2009) propose low-carbon communities as a partial solution to changing energy end-user behaviour because they offer a new context where individuals can take the role of citizens rather than consumers. Low-carbon communities are defined as "forms of co-operation and collaboration that aim to reduce the carbon intensity of their members' lifestyles by providing amenable contexts and mechanisms that encourage behaviour change" (Heiskanen, et.al. 2009: 7586).

Adopting these thoughts to non-residential buildings, low-energy working communities could be discussed as an approach for organizations as well.

The advantages of employees being part of a larger group has to be taken into consideration. Attempts to change attitudes, beliefs, or norms through information campaigns should focus on co-operation and collaboration. As the study of Carrico & Riemer (2011) shows; peer-education probably strengthens the changes in energy culture. The personal gains are a greener and more idealistic life, rather than the economic savings the energy reduction in households gives.

Energy related behaviour is also more visible in a large environment in a non-residential building. The social control will therefore be stronger. Energy behaviour in households is more hidden. No one will know if you turn off your computer at home, except maybe your close family. At the work place, depending on material structures, colleagues will know if you leave your computer on. If the management succeeds in creating a strong pro-environmental culture, the desire to be included in the "community" will keep up the good behaviour. But people are not necessarily aware of the power of these social processes. **Nolan, et al. (2008)** investigated the persuasive impact and detectability of normative social influence. They carried out two different studies, and the first study surveyed 810 Californians about energy conservation. It showed that descriptive normative beliefs were more predictive of behaviour than were other relevant beliefs, even though the respondents rated such norms as least important in their conservation decisions. The second study, a field experiment, showed that normative social influence produced the greatest change in behaviour compared to information highlighting other reasons to conserve, even though the respondents rated the normative information as least motivating. Results show that normative messages can be a powerful lever of persuasion but that their influence is often hidden. Normative social influence was even significantly more effective in introducing energy conservation behaviour than economic or social benefits, or environmental protection.

4.3 Further research

There are five aspects we find important for further research, based on the discussion of the existing literature and its research gaps:

Interdisciplinary approaches

Lopes, et al. (2012) point at "energy behaviour modelling" which integrates quantitative and qualitative approaches to predicting behaviours and establishing user profiles. Their literature review exposed two studies of this type, which the authors found interesting and important, although they also stress that energy behaviour modelling is a very time consuming approach. However, despite the fact that interdisciplinary energy behaviour research is resource intensive, Lopes et al. claim that energy behaviour studies require an increased integration of disciplines in order to deal with the complexity of energy behaviour. In particular, they want to bring engineering and social sciences together to capture the important energy behaviour components. Also, they emphasize the need to combine quantitative and qualitative methods when studying energy behaviour and the energy savings potential – these two approaches must work together to make energy behaviour relevant for energy efficiency policy.

We want to add that an interdisciplinary focus requires that the technical barriers and social norms are seen together, along with the definition of energy cultures – cognitive norms, material culture, and energy practices (Stephenson et al., 2010).

Long-term effects

Implications for further research on the effectiveness of interventions that Abrahamse, et al. (2005) recommend, is also relevant for planning interventions in non-residential studies. They summarize that previous reviews had pointed out several issues in order to improve intervention studies in the future, such as the inclusion of long-term measurements. Long-term effects are not included in the studies reviewed here. There is a need to investigate how to keep up the good energy behaviour over time in non-residential buildings.

A mix of interventions

Abrahamse, et al. (2005) ask for the use of clear study designs, precluding a confounding of effects when using multiple interventions. They add that they found that single antecedent interventions are not very effective alone, but antecedent interventions' effectiveness (e.g. goal setting) combined with consequence strategies (e.g. feedback) resulted in energy savings.

As a first step in designing and implementing interventions they recommend a thorough problem diagnosis (ref to Geller, 2002). This should be done by identifying behaviour that significantly contribute to environmental problems, and by examining factors that make sustainable behaviour patterns (un)attractive, such as motivational factors (e.g. attitudes), opportunities, and perceived abilities.

They also recommend an interdisciplinary focus. Intervention studies are typically conducted from a psychology perspective. Finally, they state that evaluations of an intervention's effectiveness should focus on two perspectives: 1. changes in behavioural determinants, as well as, 2. changes in energy-related behaviour. Most studies reveal only to what extent interventions have been successful, without providing insight into the reasons why.

The attitudes of the management

What is the meaning of the contextual factors related to the organizational culture and the environmental attitudes of the management? This is only considered in the latest publication by Christina et al (2014) reviewed for this paper. To create a new energy culture and motivation for energy reduction, it is found important that the management participates and that the pro-environmental attitudes pervade the organization. These contextual factors have to be taken into consideration in further research and should be investigated in different types of workplaces.

A common project

As described in the discussion, one important advantage of changing energy culture in non-residential buildings is the number of people. Depending on the degree of openness in the working environment, the employees' behaviour may be more visible than in their homes. There is an audience. The "community" has their own organizational culture. This provides opportunities to create social norms that are followed because people look to each other to see what to do. Even if the energy behaviour is not visible, Nolan et al. (2008) refer to recent research that demonstrates that written or oral messages about what other people do may have the same effect. Fear of the consequences of breaking a social norm, to be exposed to social sanctions or negative attention from others, may in some cases be a strong prevention to act against social norms (Brekke, et al., 2007). This advantage of changing energy culture in non-residential buildings has to be taken into consideration.

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