Improving energy efficiency in office buildings through behavioral change
a study of the influence of group feedback on office workers’ electricity consumption
in a flexible working environment

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Improving energy efficiency in office buildings through behavioral change:

A study of the influence of group feedback on office workers’ electricity consumption in a flexible working environment

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In partial fulfillment of the requirements for the degree of

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Summary

It is of interest to both organizations and society in general to realize more energy efficiency in office buildings. Next to technological improvements, improving building occupants’ behaviors could be a possible strategy to realize more energy efficiency in buildings. Persuasive technologies are often used to reduce people’s energy consumption. The term ‘persuasive technology’ refers to systems and environments that attempt to change people’s attitudes or behaviors (Fogg, 2003). An example of a persuasive technology is a group feedback intervention in which feedback about the total performance of a group is given to all members of the group. A recent study investigated the effectiveness of a group feedback intervention to influence energy conservation behavior of group members (Midden et al., 2011). Findings of that study suggested that group feedback is only in collective societies effective to stimulate energy conservation among groups (Midden et al., 2011). However, that study included artificial groups instead of real groups. Studies and theorizing suggested that real groups have various performance advantages over artificial groups (Karau & Williams, 1993; Mullen & Copper, 1994). Therefore, the feedback might also have an effect on energy conservation behaviors in individualistic societies, for example the Netherlands, when real groups are included. Furthermore, Midden et al.’s (2011) research was performed in a lab setting, so evidence is lacking that their findings also apply to real-life settings. Therefore, the current study investigated the effectiveness of a group feedback intervention to stimulate energy conservation behaviors of a real group within a real life setting in the Netherlands. The setting of this study was an office environment in which flex working practices (New Way of Working, NWoW) were implemented. In the current study it was investigated in what way feedback interventions can contribute to more efficient use of office environments with the NWoW.

Three studies were performed to explore the effectiveness of the group feedback intervention to stimulate conservation behaviors. We expected that the feedback should stimulate behaviors that are (a) not performed often but which are (b) evaluated positively. Therefore, we first performed a survey that indicated that efficient behaviors regarding the use of electric office equipment meet both these requirements. Second, we performed a field study to test whether group feedback could influence these behaviors. Behaviors regarding the electricity consumption for three equipment groups (lighting, collective equipment and desk equipment) were taken into account. The electricity consumption before and after the feedback intervention were compared to test the feedback’s effectiveness. Results provided evidence that group feedback influenced energy conservation for desk equipment only. Third, we organized a focus group to investigate employees’ experience with the feedback intervention and their behavioral and attitudinal changes as response to the feedback. Participants of the focus group indicated that they did not adjust their behaviors after the feedback presentation. Some participants mentioned it was not clear in what way they should behave to realize savings and they did not feel able to realize significant savings. However, participants also indicated that their energy awareness increased and that they communicated more about the topic with colleagues after the feedback presentation.

Further analyses of the electricity consumption data and information from the focus group, indicated that equipment and office space were not used efficiently. Collective equipment and several monitors were left on after work hours and these appliances therefore unnecessarily consumed
energy. The occupation of workplaces could also be improved, because people tended to spread over the entire space and did not use workplaces according to NWoW agreements.

The field study provided evidence that the presentation of group feedback indeed influenced energy conservation for desk equipment among Dutch people in a real life setting. These findings implicate that group feedback can in the future be used as a tool to realize more energy conservation behaviors. Results from the focus group further indicated that conservation behaviors probably occurred unconsciously. Insights from the focus group insinuated that more energy savings could be realized within the office when employees are more motivated by the feedback and when energy efficiency becomes better embedded in the organizational culture.
Preface

This report describes the master thesis research that I have been working on during the last period of my study in Innovation Sciences at the Eindhoven University of Technology. The research was performed in collaboration with BAM Techniek, a subsidiary of construction company Koninklijke BAM Group. During my study, I have always had a broad interest in sustainable buildings, with a special interest for the role and experience of users. I am glad that my interests for innovation, buildings as well as human-technology interaction were eventually combined in a single research.

The fulfillment of my research would not have been possible without the help of others. First of all, I would like to thank Jaap Ham, Peter Ruijten and Geert Verbong, my supervisors from the TU/e, for their support, supervision and useful insights during the entire project. I would also like to thank Linda Pennings, my supervisor at BAM Techniek, who provided me with lots of information and new ideas to approach this project and who also gave me the opportunity to get to know BAM Techniek and its activities. Furthermore, I would like to thank everyone at BAM Techniek for giving me a pleasant work environment and for their interest in and contribution to my research. I specifically want to thank Michiel and Johannes, who were of great help during the entire project.

Besides having a pleasant work experience at BAM Techniek, I also enjoyed working at the TU/e where I was fortunate to share an office with other graduate students. A special thanks to Kristine and Sophie for all the helpful brainstorm sessions and for making a day at the office something to look forward to. Last but not least, I want to thank my parents for all their support and for always giving me pleasant distraction during weekends.

I worked with great pleasure on this project, which I found interesting from the beginning to the end. I hope you will enjoy reading it!

Bregje Vos
Eindhoven, March 2013
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1 Introduction

Making sustainability part of the business strategy is becoming more important for organizations these days. This new trend is called Corporate Social Responsibility (CSR) (MVO Nederland, 2012), which means that an organization takes responsibility for the impact of its activities on people and the environment. Of all CSR activities, organizations currently give highest priority to energy savings (MVO Nederland, 2012). Energy savings are urgent, tangible and they save money. Furthermore, it is consistent with the expectations that society has of businesses (MVO Nederland, 2012). Improving the energy efficiency of an organization’s office building is one way to realize energy savings. More energy efficiency in office buildings is also profitable for society, because buildings are responsible for almost 40% of total energy consumption (Pérez-Lombard, Ortiz, & Pout, 2008). The current research investigates whether energy savings can be realized in an organization’s office space by stimulating building occupants to behave more efficiently. More specifically, the use of a group feedback intervention to stimulate behaviors is investigated.

For organizations, improving the energy efficiency in office buildings is a good manner to expose their CSR commitment to society and to reduce costs (Van Miert, Verburgt, & De Ruiter, 2012). Energy efficiency in office buildings is also relevant for society because office buildings are a large contributor to the total energy consumption in Europe (Pérez-Lombard, et al., 2008). In 2004, the energy consumption of buildings in the EU was 37% of total energy consumption (Perez-Lombard et al., 2008). Of the total energy consumption by buildings, 20% is accounted for by commercial buildings. Of the commercial buildings, 17% is accounted for by office buildings. Because of the large contribution of offices to the total energy consumption, it is worth investigating how energy savings can be realized.

Nowadays, common strategies to reduce the energy consumption in offices are based on technological innovations. Such technological measures to improve energy efficiency in existing buildings for example focus on the improvement of the insulation of the building envelope and improving the performance of installations via automation and control (Van Miert, Verburgt, & De Ruiter, 2012). However, to reach energy efficiency, also building occupants have to be taken into account. Building occupants are important because they influence the effectiveness of implemented technologies (Jazizadeh, 2012). They for instance can diminish the revenues of energy efficiency measures because they tend to consume more energy when the energy has become relatively cheap due to efficiency improvements. This phenomenon is called the rebound effect (Herring & Roy, 2007). Besides increasing energy consumption, users’ behaviors can also interfere with the operation of automated installations (Jazizadeh, 2012), for example when they open a window while the ventilation is active. These behavioral ‘flaws’ could be overcome by letting installations react to occupants’ behavior. But people’s behavior could also be stimulated in a desired direction. Persuasive technologies can be useful tools to stimulate behavioral changes (Fogg, 2003)

Previous research has provided evidence that energy conservation behavior by users can be stimulated with persuasive technologies, for example by presenting feedback to users (e.g. Midden & Ham, 2012). While previous feedback studies mainly targeted individuals in households, recent studies have also investigated the effectiveness of group feedback. One speaks of group feedback when feedback about the total performance of the group is given to all members of a group. The
findings of a recent study suggest that group feedback is effective to stimulate energy conservation among Japanese persons (Midden, Ham, Kleppe, Kimura, & Nakajima, 2011). Also a Dutch sample was investigated in Midden et al.’s (2011) study, but with the Dutch participants the group feedback was only effective when people received additional individual feedback to compare the individual performance to the group performance.

A limitation of the study by Midden and colleagues (2011) is that the groups in the experiments were not real groups. Ad hoc groups, as in the study by Midden et al. (2011), are expected to perform poorer than real groups because people have no experiences with the group (Mullen & Copper, 1994). Furthermore, the participants received feedback in an artificial setting instead of in a real life setting.

To our knowledge, there is no academic research evidence for the effectiveness of group feedback in a real life setting. There was however a campaign of ‘10:10 Netherlands’ in 2012 in which group feedback was presented in a field setting (10:10, 2012). The results of the 10:10 campaign suggest that the group feedback led to energy savings. However, empirical proof is lacking to support these findings. Furthermore, the realized savings in the 10:10 campaign were limited and likely influenced by weather conditions. Therefore, the outcomes have to be interpreted with caution.

So, there appears to be a lack of empirical research in which group feedback is tested in a field setting. Therefore, the current research investigates the effectiveness of a group feedback intervention within a real life setting, namely an office environment. Besides the lack of research in which the effectiveness of group feedback is tested in a field setting, other motives for this study are determined by the office environment in which this study is executed. An important characteristic of the office building, is the New Way of Working (NWoW) concept which has recently been introduced. The NWoW principles can both positively and negatively influence the energy efficiency in an office; it therefore is an important factor to take into account in this research.

This chapter further introduces the research objectives, questions, relevance and scope of this study. Also background information to the office setting is provided, to sketch the context in which this study is executed.

1.1 Research objectives and questions
The growing need for energy efficiency in office buildings calls for strategies to stimulate energy conservation by building occupants. The aim of this research is to analyze the effectiveness of a group feedback intervention that attempts to stimulate energy savings by office workers. This research has an explorative purpose to get more insight in the possible success of these kinds of interventions in the future to reach more energy efficiency.

As mentioned, in this study, a feedback intervention is applied within an office in which the NWoW has recently been introduced. The idea behind the NWoW is that people work more effective and efficient and also enjoy their job more when they are given more trust, freedom, responsibility and a sense of connection (Bijl, 2009). At the research setting, NWoW resulted in a new office layout and a new mindset for the employees. Employees no longer have to be present at the office all the time,
but can work outside the office and beyond the regular office hours. NWoW is a goal in itself, because it can lead to more productivity and more satisfied employees (Bijl, 2009). But it could also be a mean to realize energy savings, because when employees are no longer bonded to the office, less office space is needed and this can result in energy savings, for instance for climate control and lighting. This flexible working principle is not unique for this office, but is nowadays implemented by many organizations. Because the NWoW has a great influence on working routines and the use of office space, it is included in this study as a mediating factor.

Given the influence of this mediating factor, this study aims to explore the effectiveness of the group feedback intervention to (a) stimulate energy conservation, and (b) to optimize the occupation of the office space according to agreements of the NWoW. Together, both energy conservation and optimal occupation lead to efficient use of office space and thus energy efficiency.

The main research question formulated for this study is:

_In what way can group feedback interventions contribute to more efficient use of office environments with the New Way of Working?_

Two sub-questions are formulated to answer the main research question:

I. **What is the influence of group feedback on a group’s energy consumption within a field setting?**

II. **What managerial insights follow from the analysis of employees’ usage of office space and equipment?**

For both sub questions, information about the usage of office space and equipment by employees is gathered with electricity meters. To answer the first sub-question, a group feedback intervention is tested in a field setting. By comparing the usage patterns before and after the intervention, it can be concluded whether the intervention is able to change behaviors. Furthermore, insights from a focus group with employees indicate whether energy awareness of employees increased and in what way they behaved due to the feedback. Based on the information about the usage of the office space and insights from the focus group, conclusions can be drawn for the company’s management regarding energy consumption and the compliance with NWoW agreements. Management can also learn whether persuasive technologies can be used to limit energy waste.

1.2 **Research justification**

1.2.1 **Societal relevance**

As mentioned, energy savings in offices can contribute to a reduction in a country’s total energy consumption because office buildings cover a significant part of the entire building stock. Organizations can take voluntary action to become more energy efficient by including CSR principles into their business strategy. CSR measures can have several benefits: it can improve the efficiency of business operations, help develop client and supply chain relationships, attract and retain talent, drive innovation and build a reputation (MVO Nederland, 2012). To improve its reputation, an organization can communicate its environmental involvement through a CSR report and via business
activities. An organization’s housing is also a good way to expose CSR activities and improve its image, because clients, suppliers and employees see the building and form an opinion about it and reflect that on the company (Van Miert, Verburgt, & De Ruiter, 2012). When energy-related feedback is displayed somewhere in the building where it can be noticed by visitors, it will also contribute to the company’s reputation.

Besides building a reputation, cost savings can also be a beneficial outcome of this research. This research can result in cost savings in two ways. First, it provides insight whether a feedback intervention can stimulate energy conservation behavior by employees. Second, the information about usage of the office space provides insight in further possible savings. Aside from cost savings, this research also provides insight in possible cost increases due to influences from the office environment. Furthermore, qualitative analyses can provide insight in the influence of group feedback on other phenomena, such as organizational culture and productivity.

1.2.2 Scientific relevance
This research builds on previous research in which the effectiveness of group feedback was investigated. The first contribution of this research is that group feedback is tested in a field setting, while previous studies were conducted in a lab. A field study provides more insight in the effectiveness of feedback in a natural environment where people perform their daily tasks. Therefore, it provides a more realistic understanding of the effectiveness of feedback.

A second contribution is that a feedback intervention is tested in an office setting. Previous studies mainly tested the effect of feedback on household tasks. These tasks were either simulated in a lab setting (e.g. Ham, Midden, Maan, & Merkus, 2009) or sometimes performed in real residential buildings (e.g. Midden, Meter, Weenig, & Zieverink, 1983). Previous findings from feedback studies in households cannot simply be generalized to the office setting, because the two contexts differ in several ways. Firstly, in households, people are used to get feedback about their energy consumption in the form of energy bills. This type of feedback is not provided in offices so people are unaware of the consumption. Secondly, office workers lack financial incentives to save energy, because they do not have to pay the energy bill.

1.3 Research scope
In office buildings, users can only influence a certain part of the total energy consumption in a building. Graph 1-1 presents the distribution of energy consumption in offices by function.
The energy consumption in offices can be divided in three categories (Willems, 2010; Van Miert, Verburgt, & De Ruiter, 2012):

- Building-related energy consumption, which is all energy needed for conditioning and lighting of a building independent of usage, e.g. ventilation, heating, cooling and lighting.
- Building dependent user bound energy consumption; this includes energy consumption for elevators, ICT and emergency lighting.
- User equipment’s energy consumption, which includes energy consumption of computers, copiers and printers.

The current research investigates the possibility to influence users’ behaviors, and therefore mainly takes user equipment into account because users are in the position to control these appliances. In Graph 1-1, user equipment is represented by decentralized ICT, which consists of appliances at the workplace such as computers and printers. These appliances are responsible for over 7% of total energy consumption per m² in offices in the Netherlands (SenterNovem, 2012). Moreover, use of these appliances also increases the cooling demand, so the contribution of user equipment to the total energy consumption is actually higher than 7%. Users influence the energy consumption of these appliances because they can control the settings, e.g. turn the equipment on or off, and in this way users determine the appliance’s energy consumption. Figure 1-1 schematically represents the influence of users on user equipment.

**Figure 1-1: Control of user equipment by users.**
The setup of this study is adjusted to the specific office setting in which the analyses are performed. Therefore, parts of the outcome of this research are mainly of interest for that specific office environment. However, part of the results will be generalizable to other offices, because office buildings’ characteristics are quite uniform over the building stock (Pérez-Lombard et al., 2008).

For this study, three different methods are used. First, a survey is executed among employees to ascertain the current behavioral characteristics of employees. These characteristics are part of the context of this research. Second, a field study is performed in which the effect of a feedback intervention is tested. In this field study usage patterns are analyzed on the basis of power consumption data. These data are gathered before and during the feedback presentation to determine the effectiveness of the intervention. Third, a focus group is organized to gain additional qualitative information about the effect of the feedback intervention.

The context of this research provides limitations for the design of the three methods. Both the survey and the focus group had to be kept within certain boundaries to make sure employees were willing to participate. This led to a survey with a limited amount of questions so that the questionnaire could be filled in within an acceptable time frame. For the focus group the duration of the discussion was kept short, so that people were willing to participate during work hours. With regard to the field study, time and budget constraints might have had an effect on the success of the feedback intervention. To present the feedback to employees, available resources were used instead of purchasing new equipment. Furthermore, time constraints limited the duration of the field study, therefore long term effects are not within the scope of this research.

1.4 Introduction to the test setting

As mentioned, the test setting for this study is part of an office building of an organization in the Netherlands. In this section, background information is provided about the organization’s strategy to reduce the environmental impact of its activities. This information provides insight in the organization’s commitment to CSR. Also information about the company’s core business is provided because that might have an influence on the results of this research.

The office setting under investigation is part of an organization that strives to reduce its impact on climate change by improving its energy efficiency, reduce CO₂ emissions and work with clients to develop CO₂-neutral solutions. Offices of this company were responsible for a total of 15.9 kilotons CO₂ in 2011, which is 5.9% of the company’s total CO₂ emissions. The company’s target is to reduce total CO₂ emissions and office waste by 15% by 2015 compared to 2009. To achieve these goals, it has several ideas and strategies to become more sustainable. Strategies to reduce the CO₂ emissions of offices are: reducing the required office space, reduce thermal demand, use green power, efficient heating and cooling, efficient lighting and efficient energy use. In the context of the NWoW, the company also aims to reduce the environmental impact of business flights and car use. Currently, 83.9% of CO₂ emissions is caused by the vehicle fleet and 6.2% by air travel. The company strives to reduce the amount of travels and to use more environmental friendly alternatives. The company is clearly ambitious to reduce its impact on the environment. Therefore the company will be interested in solutions that can realize large CO₂ emission reduction within a few years.
The company’s business activities are concerned with technical installation in buildings. Most employees that participated in the current study even have jobs related to energy systems in buildings. It therefore has to be kept in mind that participants in this study have more knowledge of solutions to increase the energy efficiency in buildings than the average Dutch population.

1.5 Structure of thesis

After this introductory chapter, the second chapter discusses the theoretical background for this research. In that chapter, two questions are answered: (1) Why can group feedback be an effective method to stimulate energy conservation behaviors? and (2) Which behaviors should be stimulated with feedback and what factors influence these behaviors? At the end of this chapter, the reasons for the three different research methods are discussed. Chapter 3 discusses the survey, the field study is discussed in chapter 4 and the focus group in chapter 5. The final chapter includes the general discussion in which the research questions are answered, and theoretical and managerial implications are discussed.
2 Theoretical background and methodology

This chapter provides theoretical background information which forms the basis for the three analyses of this research. Two questions are discussed in this chapter: (1) Why can group feedback be an effective method to stimulate energy conservation behaviors? (2) Which behaviors should be stimulated with feedback and what factors influence these behaviors? In the field study, a group feedback intervention is tested which aims to stimulate pro-environmental behaviors. Insights from the first part of this chapter are used as guidance for the design of that feedback intervention. Information from the second part of this chapter is used to determine influential factors which should be taken into account and to indicate which behaviors should be stimulated with feedback.

2.1 The power of feedback interventions

Employees’ behaviors are an influential factor in realizing an organization’s sustainability goals. However, their behaviors cannot be changed easily. Persuasive technologies can therefore be used to let people adjust their behaviors. The term ‘persuasive technology’ refers to systems and environments that attempt to change people’s attitudes or behaviors (Fogg, 2003). Feedback is an important element for many persuasive approaches and it has proven to be a successful strategy to persuade individual people. Feedback is a persuasive method which provides people information about their performance, so that consequences of a certain behavior become clear (Abrahamse, Steg, Vlek, & Rothengatter, 2005).

Recent reviews of literature about the effectiveness of feedback showed that feedback can result in energy savings ranging from 0 to 15% (Darby, 2001; Fischer, 2008). Several reviews (Fischer, 2008; Abrahamse, Steg, Vlek & Rothengatter, 2005; Darby, 2001) also showed that the most effective feedback is:

- provided frequently;
- based on actual consumption;
- interactive;
- appliance-specific;
- provided over a longer period;
- appealing and easy to understand;
- combined with saving instructions;
- combined with a conservation goal (McCalley & Midden, 2002; Agentschap NL, 2010);

Feedback can also include historic or normative comparisons. Historic comparisons compare the current consumption to prior consumption while normative comparisons relate individual performance to the performance of others (Fischer, 2008). Research reviews have shown that normative feedback is not more effective than historic feedback in household settings (Abrahamse et al., 2005; Fischer, 2008). In contrast, research in organizations showed that groups which receive normative feedback save more energy than groups that only receive information about their own performance (Siero, Bakker, Dekker, & Van den Burg, 1996).
These previous studies mainly investigated the effectiveness of feedback to stimulate sustainable behaviors of individuals in household settings. The current research differs from those studies because a group receives feedback instead of individuals. Moreover, this research is executed in an office setting instead of a household setting. In households, people are used to receive feedback about their energy consumption in the form of energy bills or via energy displays which are more often installed in households these days. Because this type of feedback is normally not provided in offices, people are unaware of the consumption and also lack financial incentives to save energy. These differences suggest that findings in household settings cannot be generalized to the office setting. Instead of targeting individuals, the group level is important because energy conservation usually happens in social systems (Midden & Ham, 2012). Social dynamics within a group can influence the energy consumption. Especially in office settings the group level is important, because a large group of people makes use of the same environment and equipment. Therefore, the current study focuses on group feedback.

2.1.1 Group feedback
When feedback about the total performance of the group is given to all members of a group, it is called group feedback. Research suggested that individuals can be motivated when they receive feedback about the performance of their group (Karau & Williams, 1993) or even by the promise of group evaluation (Harkins & Szymanski, 1989, as cited in Midden & Ham, 2012). Handgraaf, Van Lidth de Jeude & Appelt (2013) suggest that social norms are a promising approach for stimulating energy conservation. The findings of their research suggested that public feedback is more effective than private feedback, and social rewards are more effective than monetary rewards. Their findings suggest that telling people what other people do or what is commonly approved or disapproved can have strong long-term effects on energy conservation behavior.

As mentioned, findings of a recent study by Midden and colleagues (2011) indicated that group feedback is able to influence energy conservation behavior in Japan. However, in the Netherlands, group feedback by itself was not sufficient to stimulate energy conservation, but only in combination with individual comparison feedback. Midden et al. (2011) concluded that group interventions can be an effective persuasive intervention, but cultural differences have to be taken into account. A limitation of the study by Midden and colleagues (2011) is that the groups in the experiments were not real groups. The performance of a real group is expected to be higher than the performance of artificial groups (Mullen & Copper, 1994). According to Kenrick, Neuberg and Cialdini (2007), real groups can be characterized by a stable structure and members of the group are interdependent and share a common identity. In Midden et al.’s (2011) experiment, an individual was assigned to a group with three other participants. This procedure suggests that group members did not know each other before the experiment. Or at least, they did not form a group in real life. Another limitation of the experiment was the separation of group members. During the experiment, each group member was individually seated in a small room, so they were not able to communicate directly.

To our knowledge, there is no academic research evidence for the effectiveness of group feedback in a real life setting. However, a non-academic research has provided some insights in the effect of group feedback on energy consumption of real groups in a field setting. Recently, ‘10:10 Netherlands’
set up the campaign ‘The Electricity Meter On Tour’ together with grid operator Liander, in which five participants attempted to save energy during one week (10:10, 2012). The participating parties included three municipalities and two organizations in the Netherlands, under which the University of Eindhoven. The consumption of the participants in the campaign week was made visual on displays on location and online. The displays showed the electricity consumption in comparison with a reference week and their performance of each day was evaluated with a positive (smiling face) or negative (sad face) smiley. Figure 2-1 presents the feedback as was provided on location in the 10:10 campaign. 10:10 stated that the campaign resulted in more awareness of simple actions that can be taken to realize savings. The five participants also realized actual energy savings, however limited, ranging from 0.3% to 1.4%. But the results of the campaign have to be interpreted with caution. 10:10 declared that the savings were limited due to the weather conditions; the temperature was much lower during the campaign week compared to the reference week. Another explanation for the limited energy savings might be the large group size: entire municipalities and organizations formed one group. The likely influence of the group sized is explained below.

The results of the 10:10 campaign and Midden et al’s (2011) study suggest that a group intervention can indeed enhance energy conservation behavior. However, the large group sizes in the 10:10 campaign and the lack of real groups in Midden et al’s (2011) study might have led to a lower group performance because the cohesiveness between group members was low. Cohesiveness is one of the characteristics that typifies the structure of a real group (Kenrick, Neuberg, & Cialdini, 2007). Cohesiveness refers to the strength of the bonds among group members. Groups can be cohesive when members enjoy being together or because everyone is committed to a group task (Kenrick et al., 2007). Several studies suggest that high group cohesiveness positively influences group performance (Karau & Williams, 1993; Mullen & Copper, 1994). Group performance appears to be higher when group identity is enhanced (Karau & Williams, 1993) and when the group size is limited (Mullen & Copper, 1994). Regarding group size, studies on social phenomena have indicated that individual effort decreases as group size increases (Mullen & Copper, 1994; Latané, Williams, & Harkins, 1979). Therefore, the large group sizes in the 10:10 campaign might have led to limited energy savings.

In comparison with the groups in Midden et al.’s study and the 10:10 campaign, groups in offices are expected to be more cohesive because people interact more often, e.g. when they collaborate in a project, and because the group size of a company’s department is mostly limited. This suggests that results of Midden et al.’s study might have been different when real groups were included in the experiments instead of artificial groups. Therefore, the current study investigates the effectiveness of group feedback to a cohesive group of colleagues.
2.2 Influential factors on energy consumption behavior
Before evaluating the effectiveness of the feedback intervention, it has to be determined which behaviors can and should be influenced to reach energy savings. These behaviors on the one hand depend on determinants of people's behaviors and on the other hand on influential factors from the environment. This section first describes psychosocial determinants of people's behavior and then discusses three other factors which can influence people's behavior: managerial determinants, technical determinants and work practices. For each factor, additional information is provided about the specific office situation in this study.

2.2.1 Behavioral determinants
Within organizations, several people can influence the energy consumption, including the management and employees with energy-related jobs, such as facility managers. All other employees also affect the energy use, directly through their daily activities and indirectly through the possibilities and constraints they pose on management and technologies (Lo et al., 2012). The current research is interested in the energy conservation behaviors of these ‘general’ employees. Therefore, this section describes important determinants of individual sustainable behaviors. Insights from Lo et al’s (2012) qualitative study are hereby used to present the relevance of each determinant within an office setting. In their study, they examined self-reported individual and organizational determinants on energy-related behavior in offices.

2.2.1.1 Attitudes
An attitude refers to the evaluation or appraisal of a behavior, which can be favorable or unfavorable (Ajzen, 1991). Such an evaluation can be based on reasoned considerations. In that case, people choose the alternative with the highest benefits against lowest costs. These benefits and costs can be in terms of money, effort or social approval (Steg & Vlek, 2009). Besides reasoned considerations, evaluations are also based on norms, beliefs and values (Ajzen, 1991). The Theory of Planned Behavior stated that behavioral intention is determined by people’s attitudes, subjective norms and perceived behavioral control (Ajzen, 1991). According to the Theory of Planned Behavior, positive attitudes are an important determinant to realize conservation behavior because positive attitudes towards a behavior increase the likelihood that a behavior is performed (Ajzen, 1991).

Lo et al. (2012) found that overall, attitudes of office workers towards energy conservation were positive. However, conserving energy was found less important when it is incompatible with optimal work quality and efficiency. Also an employee’s personal comfort, convenience and interest are found more valuable. Furthermore, compared to the household context, office workers have less favorable attitudes towards energy conservation in offices because they do not have any feedback or financial incentive to reduce their energy consumption (Lo et al., 2012).
2.2.1.2  Self-efficacy
Self-efficacy refers to a person’s evaluation of whether one has the necessary resources, knowledge, and skills to perform a behavior (Lo, et al., 2012; Ajzen, 1991). Ajzen (1991) uses the term ‘perceived behavioral control’, which refers to people’s perception of the ease or difficulty of performing a certain behavior.

Employees often associate control to the effort needed to perform a behavior (Lo et al., 2012), which makes it less likely that they perform more difficult behaviors. In the same study, office workers mentioned that a low perceived behavioral control is caused by technical installations, such as the automation of climate controls. The inability to control the temperature not only led to discomfort but also led to energy wasting behavior by employees such as opening windows when the heating or cooling was active (Lo et al, 2012). Some office workers mentioned that they are ill-informed about concrete benefits of certain behaviors and what behaviors they could perform themselves.

2.2.1.3 Subjective norms
An individual’s behavior can also be influenced by the perception of other persons’ evaluation of a behavior; this is called subjective norm (Lo, et al., 2012). A distinction can be made between injunctive norms, which refer to other people’s approval or disapproval, and descriptive norms, which concern the behavior of others.

Due to social influences, social loafing can occur. Social loafing is “a decrease in individual effort due to the social presence of others” (Latané et al., 1979). Research showed that individual effort decreases when group size increases (Latané et al, 1979). Kenrick et al. (2007) point out that the occurrence of social loafing is related to two other social dilemmas: free-rider dilemma and sucker-effect. The free-rider dilemma occurs when a group member reduces his own effort when he sees his contributions as unnecessary because other members’ contributions already lead to the group’s success (Kerr, 1983). A member can free ride on someone else’s contributions, but others may also free ride on his contributions. The person who carries free riders in this situation has the sucker role. The sucker-effect occurs when the sucker finds it aversive to carry other members and as a result reduces his own contributions to the group. In this study, the sucker effect could be measured by investigating whether people reduce their energy savings when they notice that other people are not reducing their energy consumption. This is however outside the scope of the current study, because individual electricity consumption in not investigated. Nevertheless, the qualitative analysis which is part of this study could provide more insight in this phenomenon.

These social dilemmas could constrain the goal to reduce energy consumption in the office when some or all employees reduce their effort to reach savings. However, office workers in Lo et al.’s (2012) study propose that social norms can be a useful strategy to stimulate sustainable behaviors. They indicated that for example middle and top management’s as well as colleagues’ behaviors can influence their behavior.
2.2.1.4 Habits

In practice, behavior is often habitual and is therefore performed automatically and unconsciously instead of via reasoning (Steg & Vlek, 2009; Lo et al., 2012). When behaviors are performed frequently, people create a mental association between a behavior and a certain goal. The more often that behavior is performed, the stronger the association will be, and the more difficult it will be to behave differently in the same situation (Steg & Vlek, 2009). In offices, employees have many routines to make their work easier to do. To have long-term benefits, new behavioral habits have to be ‘learned’ that have a lower impact on the environment.

Office workers acknowledge that their behavior is often irrational (Lo, et al., 2012), but they are not refusing to change their habits, as long as it does not lead to productivity losses. Lo et al. (2012) suggest that employees’ habits differ across contexts and that facilities, formal policies, and norms of colleagues partially account for these differences. Employees also mentioned that habits at home influence behaviors at the office, and vice versa (Lo et al., 2012). Previous research confirms the existence of spillover effects of environmental-friendly behaviors (Thogersen & Ölander, 2003). However, the same study noted that the transfer of behaviors is a slow process and it depends on personal norms and is more likely to occur for closely associated behaviors. So it is not assured that people who are very energy efficient at home, also behave efficiently at work.

2.2.2 Managerial determinants

Managerial determinants refer to decisions and behaviors towards sustainability of top and middle managements as well as employees with energy-related jobs, such as energy managers and facility managers (Lo et al., 2012). The energy management division makes energy management policies and regulations and they base this on technologies installed in the building. Tudor, Barr and Gilg (2008) presented a framework of factors influencing pro-environmental management behavior. They distinguish five relevant determinants: organizational focus, organizational structure, organizational type and size, departmental type and size, and organizational culture (Tudor, Barr, & Gilg, 2008).

The organizational focus influences pro-environmental management behavior because when environmental sustainability is set as a priority at the organizational level, the focus in the organization will be more directed to pro-environmental behavior (Lo, et al., 2012). An organization’s size also influences its environmental strategy. Larger companies for example have more resources to absorb the risks and unpredictability of voluntary environmental strategies. Moreover, large companies also have a higher visibility and reputational damage plays a larger role. The elements that are shared by all organizational members together form the organizational culture (Lo et al., 2012). Within an organizational culture, informal rules are shared by employees, and these rules indirectly influence the behaviors of employees. In Lo et al.'s study (2012) some people for example indicated that they leave their lights on as a signal that they are in the office. Also printing behavior depends on informal rules, many people for example receive large document from their colleagues. The same study indicated that the organizational structure also influences office workers’ behaviors in several ways. Facilities in an organization for example influence relevant pro-environmental behaviors and the likelihood of energy savings (e.g. default double-sided printer settings).
To reach sustainability goals of an organization, it is important that employees are well informed about the organizational priorities, because employees for a large part determine whether savings are realized. This is however often lacking, and as a result, employees have no knowledge about desired behaviors and their consequences and they also have a sense of uncontrollability to influence central organizational policy (Lo et al., 2012). However, to motivate employees to change their behaviors, organizations should be careful with expressing their interests in terms of energy savings or money, because organizational interests not always match employee’s personal interests.

2.2.3 Technical determinants

The automation of building services is an often adopted technical strategy to achieve more energy efficiency. Automation is a fundamental element of intelligent buildings. In an intelligent building, building structures, systems, services and management are integrated and optimized in order to create a productive, cost effective and environmentally approved environment for the building occupants (Wong, Li & Wang, 2005, p.2). Besides the heating, ventilation and air conditioning (HVAC) systems, also lighting, fire protection, elevator, security, and communication systems can be included in the integrated system of an intelligent building. Such an integrated system is also called a Building Management System (BMS). A BMS makes it possible to easily control and change the performance of all building services with the use of control systems. Examples of such control systems are: turning systems on and off automatically at desired times, letting certain systems only operate when occupants are present (e.g. lighting systems controlled by presence sensors), and automatically adjusting systems to internal conditions (e.g. temperature and daylight levels) (Carbon Trust, 2007).

These control systems can lead to sustainable outcomes, such as energy conservation, space utilization, flexibility, cost effectiveness, human comfort, working efficiency, and so on (Wong, Li, & Wang, 2005). When the controls are used correctly, energy costs could be reduced by 10% (SenterNovem, 2007). Realized savings however depend on the measures that are taken in a building. For example, implementing timers for the heating system can lead to maximum savings of 2-8% and presence-dependent controls for lighting can result in maximum savings of 5-20% (SenterNovem, 2007). However, as mentioned, realized savings are also influenced by occupants’ behaviors. Occupants can cause energy waste when they use installations incorrectly, e.g. by opening windows while the heating or cooling is on. This energy wasting behavior could be caused by a lack of information or as a reaction to low perceived behavioral control.

In the office setting of this research, presence-dependent lighting controls are installed in most spaces, so that lights automatically switch off when a room is unoccupied. A couple of spaces are not equipped with presence controls, such as restrooms and some meeting rooms.

2.2.4 Work practices

As mentioned, the NWoW has recently been implemented in the office space under investigation. NWoW, sometimes also called flexible working, is a new organizational form which differs from the traditional office where everyone has a personal desk and works on fixed working hours. The
organizational form impacts the energy consumption in a building because the office is used in a different way.

Bijl (2011) describes NWoW as “a vision for making work more effective, efficient, pleasurable and valuable for both the organization and the individual.” (Bijl, 2011, p. 29). This is achieved by giving employees more trust, freedom, responsibility and a sense of connection. ICT and the physical environment play an important role in NWoW. ICT facilitates time and place-independent working. Furthermore, many new applications have become available due to ICT developments, together called Web 2.0, which give a new dimension to collaboration, networking and sharing knowledge. The primary function of the physical environment, in most cases the office, is to support people in their work. This means that different types of workstations are offered, for both concentration activities and communication activities. As a result, people are no longer tied to a fixed workplace (Bijl, 2009).

NWoW can have the following benefits: more profits, lower costs, more satisfaction, reputation and sustainability. For the scope of this research, lower costs and sustainability are the most interesting. Cost savings can be realized because in an open office with flexible workplaces, 30 to 40 percent of office space could be saved compared to a classical office (Bijl, 2009). Place-independent working also leads to lower costs for commuting. The reduction in travel time and energy consumption in offices has a positive effect on the environment. Moreover, ICT can contribute to sustainability, for example by reducing the energy consumption of equipment. Transportation can also become more environmentally friendly, for instance by promoting public transportation and by allowing only energy efficient lease cars.

Besides these possible benefits of NWoW, flexible working practices can also have negative consequences for the individual, the organization and the society. For the individual, disadvantages can be: impaired feeling of belonging, feeling of isolation, no separation between spheres of work and home, lack of professional support, difficulty to develop career and being approached for work outside accepted work hours (Harpez, 2002). Furthermore, for NWoW to be successful the individual has to have self-discipline and other personal characteristics should fit the NWoW (Harpez, 2002). Disadvantages for the organization are: difficulties in application of centralized management, investment in training and new supervision methods, possible harm to organizational commitment and identification, changes in work methods, costs involved in the transition to telecommuting (e.g. the purchase of special equipment) (Harpez, 2002). The most important disadvantage for society is that teleworkers might get isolated and excluded from other members of society (Baruch, 2012).

The expected reduction in carbon emissions and costs were measured for the office setting in this research and of all other offices of the company. It is expected that each employee that participates in NWoW will save 365 kilos carbon per year. The maximal savings would then be 2% of carbon reductions a year when 50% of employees makes use of a flexible working place once a week. Furthermore, the application of flexible working places could lead to a reduction of 20% of the required amount of working places when less people are present at the office at the same time. Cost savings can then be achieved because of lower fuel costs and rent for office space. The expected savings are €245.000 on the total fuel costs and €75.000 on office rental for an office of 2500 m². An evaluation of the NWoW has to indicate whether the assumption that 50% of employees will use a
flexible working space once a week is too optimistic or not, because this new work style might not be preferred by all employees.

In the office setting in this research, NWoW has resulted in a flexible working environment in which different workplaces are offered to fit specific tasks (see Figure 2-2). There is an open-office space that facilitates working and interacting with colleagues (A), there are silent spaces for concentration tasks (B), and there are meeting areas (C). To facilitate working from another location, the majority of employees received a laptop on which they can access all necessary services to perform their job.

![Figure 2-2: Flexible working environment in the office setting.](image)

### 2.3 Conclusions

Previous research has shown that feedback can be an effective persuasive method to stimulate energy conservation behaviors (Abrahamse, Steg, Vlek & Rothengatter, 2005; Darby, 2001; Fischer, 2008). Also group feedback has been tested, and appeared to be effective in an artificial setting with Japanese participants (Midden, et al., 2011). But with Dutch participants, group feedback was only effective when additional individual comparison feedback was provided. The current research investigates whether group feedback is an effective method to stimulate energy conservation in an office setting in the Netherlands.

For designing the feedback intervention and evaluating its effectiveness, several influential factors have to be taken into account. Energy saving behaviors are more likely to be performed when: (1) attitudes towards conservation are positive, (2) people have and perceive to have control over the behavior, (3) social norms are directed towards energy conservation, and (4) people’s current habits do not obstruct the formation of new habits. Furthermore, the organization’s management should clearly communicate desired behavior and their advantages to its employees. Also barriers and opportunities of technological installations and NWoW have to be taken into account. In the office setting, presence sensors for lighting make it for example impossible for people to turn the lights off manually in certain spaces. The introduction of the NWoW has also led to a new office lay-out with more open office spaces. As a result, large parts of the office building need lighting and climate control during the whole working day.

### 2.4 Methodology

The purpose of this research is to investigate the influence of group feedback on office workers’ energy consumption. Furthermore, this research aims to get more insight in employees’ usage of office space and equipment, so that saving potentials can be determined. Therefore, information is needed about the current behaviors of employees to determine in which way they could be improved. A survey is performed to gain this information. A field study is then performed to test the
effectiveness of a group feedback intervention on employees’ electricity consumption. The power consumption data that is collected in this field study is also analyzed to determine inefficient electricity consumption and on the basis of that information, we discuss possible savings. Finally, a focus group is organized to gain qualitative insight in the effectiveness of the group feedback on employees’ behaviors. Below, these three studies are further described.

2.4.1 Survey
In this chapter, it has been discussed that behavioral determinants are important factors that can influence people’s behavior. It is therefore of interest to get more insight in the current state of these behavioral determinants in the investigated office setting. With the survey, employees’ attitudes towards and execution of several sustainable behaviors are investigated. This information is a useful guidance to determine which sustainable behaviors are not performed often yet, but which have potential to be performed in the future because attitudes towards the behaviors are positive. Furthermore, insights from the survey give more general insight in the awareness of sustainable behaviors by employees and to what extent pro-environmental behaviors are embedded in the organizational culture. Also the role of social norms in the organization is further explored.

2.4.2 Field study
In the field study power consumption data is collected with electricity meters. On the basis of this consumption information, group feedback about the electricity use for office equipment is presented to employees on a centrally placed dashboard. The electricity consumption data is used to test whether the power consumption changes as response to the feedback presentation. Furthermore, the information is used to analyze space and equipment usage patterns and to determine occupation and energy consumption inefficiencies and possible improvements.

2.4.3 Focus group
In the focus group, a group of employees is asked for their opinions about and behavioral and attitudinal changes as response to the provided feedback in the field study. The focus group is performed to provide additional qualitative information, besides the power consumption data, about the effectiveness of the feedback intervention. This qualitative study also provides more insight in actual behaviors and the experience with the feedback intervention. Furthermore, the focus group provides more information about the possible role that a feedback intervention can play to reach those goals and which preferences employees have regarding the design of the feedback.
3 Survey

This survey investigates employees’ attitudes towards several work-related sustainable behaviors and it investigates which of these behaviors are currently executed by employees and how often. Attitudes and behaviors are investigated for two reasons. First, it provides more insight in the current character of behaviors of the employees. Second, it provides a guidance to determine which sustainable behaviors are not performed often yet, and should thus be stimulated with a feedback intervention.

The sustainable behaviors in this survey relate to three topics, which are associated with the use of office space and equipment and the NWoW: (1) conserving energy by avoiding unnecessary use of installations and equipment, (2) reducing CO₂ emissions by changing transportation behavior and (3) reducing waste and improve recycling. For this research, it is assumed that behavioral changes are needed and expected to be possible for sustainable actions that are (a) not yet performed frequently by the employees, and (b) evaluated positively. A positive evaluation is necessary because the overview of behavioral determinants indicated that positive attitudes increase the likelihood that a behavior is performed (Ajzen, 1991). Also self-efficacy, social norms, and habits appeared to be important behavioral determinants. Current habits are investigated with questions about the frequency of performing a behavior. It is also investigated whether employees talk to each other about sustainable behaviors. This should give some insight in the current social norm. Self-efficacy is not explicitly included in the survey to avoid an overload of questions in the questionnaire, because that could lead to a low response rate. However, comments of respondents at the end of the questionnaire provided some insight in the perceived self-efficacy. Respondents’ comments are therefore discussed separately in this chapter.

3.1 Method

3.1.1 Participants and procedure
All participants were employees who work in the office building that is the research setting of this study. The participants included both employees who work in an environment in which NWoW has been implemented, as well as employees who work in a traditional office space. Employees were approached in September 2012 to fill in an online web survey. Fifty-two employees were first approached in person and on the same day invited by email to fill in the questionnaire. A week later, these persons received a reminder. This second email was also sent to 71 other employees, who could not be invited the first time because of absence. From the 123 invited persons, 62 employees filled in the questionnaire. This is a response rate of 50.4%.

3.1.2 Material
The sustainable behaviors included in the questionnaire were for a large part based on a questionnaire which is part of WWF’s practical environmental programme called Green Office. The aim of this programme is to reduce greenhouse gas emissions and the ecological footprints of offices (WWF, 2009). WWF’s questionnaire is intended for employees in the offices in the programme, and it measures the employees’ level of eco-friendliness and how this develops. The original questionnaire
consists of 17 questions. Four questions about air circulation in front of radiators, disposable dishes, hazardous waste and waste from electric and electronic equipment were excluded. These items were excluded because they are outside the scope of the current research. A few sustainable behaviors were added because they are relevant for this particular office. These behaviors are “recycling of coffee cups” and “working on a worksite close to an employee’s dwelling”.

In total, the questionnaire consisted of four modules. The complete questionnaire as was presented to the respondents can be found in Appendix A. The first module consisted of questions about people’s attitudes about specific sustainable behaviors and general sustainable actions. The second and third modules consisted of questions about respondents’ currently performed behaviors. The fourth and last module consisted of six general questions about the respondent and a possibility for respondents to note comments and remarks.

The fifteen questions in the first module had to be answered on a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). In module 2, people had to indicate on a 5-point Likert scale how often they perform ten specific behaviors, ranging from 1 (rarely or never (0-20% of the cases)) to 5 (always (80-100% of the cases)). Module 3 included four multiple choice questions.

3.1.3 Data analysis
The data from the survey were analyzed in several ways. Descriptive analyses were done to test both the average attitudes and the average frequency of behaviors. Thereafter, a regression analysis was performed to determine the relation between subjective norms and people’s attitudes and behaviors.

3.1.4 Measures
Answers on the attitude and behavior questions were combined to form measures of overall attitude ($\alpha = .734$) and overall behavior ($\alpha = .710$). The Cronbach’s $\alpha$’s above 0.7 indicated that the items of the questionnaire together form a good scale to represent overall attitude and behavior. The overall behavior measure does not include the items “turning lights off” and “using teleconference” because these items were not consistent with the other items. This is not a surprising finding because the descriptive analysis showed that these two behaviors are not performed frequently by many people. Probably, because people do not have control over all lights and the use of teleconference is not applicable to everyone’s job. Furthermore, to check whether the amount of dimensions can be reduced by grouping variables, e.g. printing variables, transportation variables, etc., a factor analysis was performed. The analysis indicated that no such grouping is possible.

3.2 Results
3.2.1 Description of respondents
Participants’ (75.8% male) ages ranged from 20 to 61 years with a mean age of 36 years ($SD = 10.9$). Furthermore, 45.2% of respondents completed a HBO study (Higher education) and 27.4% a WO
study (University). One respondent completed a postgraduate study and the other participants completed a lower form of education. These results indicated that this sample group is not representative for the whole society. A typical respondent in this sample was a highly educated man in his early adulthood. Furthermore, 24.2% of respondents work in the flexible office environment and are thus familiar with the NWoW. It has to be noted that the majority of the respondents had an energy-related job and they were therefore no laymen regarding sustainable behaviors.

### 3.2.2 Attitudes towards sustainable behaviors

Overall, the employees reported positive opinions about all sustainable behaviors. This assumes that the respondents are well aware of the importance of sustainable measures. This is not surprising because most people have energy-related jobs. The sustainable actions that were evaluated most positive are “turning off the monitor when computer is not used”, “activating energy-saving functions on computer”, “turning the lights off”, “digital archiving” and “companies have to take responsibility for their environmental impact”. We noted that employees have less positive attitudes towards transportation behaviors. “Limiting car use” received as many positive as negative evaluations, therefore the average opinion is neutral (3.05). Attitudes were also less positive about “avoiding rush hours” and “driving economically”. These results suggested that there is more resistance to changing transportation behaviors than to other pro-environmental behaviors. So, although most people are positive about NWoW principles, there appear to be boundaries to people’s willingness to change behaviors. Transportation preferences can be related to the location of an employee’s home and the location of the office. The office building in this study is close to a train station; therefore it is easily accessible with public transportation. The average attitudes for each sustainable behavior are presented in Table 3-1.

<table>
<thead>
<tr>
<th>Sustainable behaviors</th>
<th>Average attitudes (scale from 0 to 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turning off monitor</td>
<td>5.40</td>
</tr>
<tr>
<td>Activating energy-saving functions on computer</td>
<td>5.19</td>
</tr>
<tr>
<td>Turning off lights</td>
<td>5.08</td>
</tr>
<tr>
<td>Digital archiving</td>
<td>5.02</td>
</tr>
<tr>
<td>Responsibility companies</td>
<td>5.00</td>
</tr>
<tr>
<td>Printing efficiently</td>
<td>4.89</td>
</tr>
<tr>
<td>Separating office waste</td>
<td>4.84</td>
</tr>
<tr>
<td>Responsibility employees</td>
<td>4.74</td>
</tr>
<tr>
<td>Using teleconference instead of business trips</td>
<td>4.71</td>
</tr>
<tr>
<td>Working on nearest jobsite</td>
<td>4.34</td>
</tr>
<tr>
<td>Encouraging colleagues</td>
<td>4.31</td>
</tr>
<tr>
<td>Turning off office equipment instead of stand-by</td>
<td>4.29</td>
</tr>
<tr>
<td>Driving economically</td>
<td>4.26</td>
</tr>
<tr>
<td>Avoiding rush hours</td>
<td>4.02</td>
</tr>
<tr>
<td>Limiting car use</td>
<td>3.05</td>
</tr>
</tbody>
</table>

Table 3-1: Average attitudes towards sustainable behaviors (*n* = 62, *M* = 4.61).

### 3.2.3 Frequency of sustainable behaviors

All averages of frequency of performing specific behaviors are shown in Table 3-2. The most often reported behaviors are related to waste reduction, recycling and printing efficiently. This corresponds to the positive attitudes about these behaviors. The use of teleconference instead of business trips is done the least, while attitudes about this behavior were quite positive. This is
possibly caused by the fact that not all employees have to make business trips and in practice not all business trips can be replaced by teleconference calls. Encouraging colleagues to behave sustainable also did not occur very often. This finding is in agreement with the less positive attitudes about the encouragement of colleagues. People might have objections to this measure because it could affect the working atmosphere.

Another finding that corresponds to the previously found attitudes is that employees not frequently perform sustainable transportation behavior. As well as for business trips as for commuting, a passenger car is used by the majority of employees (75.8% for business trips and 80.7% for commuting). It was also found that people who use a passenger car only occasionally drive economically. Furthermore, almost two-thirds of employees travel during rush-hours. According to some respondents, avoiding rush hours does not correspond with the current organizational culture. However, 14.5% of respondents indicated that they do travel outside rush hours. So it might depend on someone’s function whether traveling outside rush hours is possible, but results suggest that rush hours could be avoided more often than is currently done.

More remarkable results were found for the behaviors related to lighting and office equipment usage. The attitudes about these behaviors were mostly positive while the frequencies of performance are around average. Lights are not turned off frequently and many employees also do not frequently turn off their monitor, do not completely turn off office equipment when it is not used and 21% has not installed energy-saving functions. Only attitudes about turning off office equipment were not very positive, in contrast to the positive attitudes about turning off monitor, activating energy-saving functions and turning lights off.

<table>
<thead>
<tr>
<th>Sustainable behaviors</th>
<th>Average frequencies of behaviors (scale from 0 to 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycling coffee cups</td>
<td>3.89</td>
</tr>
<tr>
<td>Printing efficiently</td>
<td>3.66</td>
</tr>
<tr>
<td>Separating office waste</td>
<td>3.53</td>
</tr>
<tr>
<td>Digital archiving</td>
<td>3.44</td>
</tr>
<tr>
<td>Turning off office equipment instead of stand-by</td>
<td>3.19</td>
</tr>
<tr>
<td>Turning off lights</td>
<td>3.18</td>
</tr>
<tr>
<td>Turning off monitor</td>
<td>2.97</td>
</tr>
<tr>
<td>Driving economically</td>
<td>2.82</td>
</tr>
<tr>
<td>Encouraging colleagues</td>
<td>2.05</td>
</tr>
<tr>
<td>Using teleconference instead of business trips</td>
<td>1.97</td>
</tr>
</tbody>
</table>

Table 3-2: Average frequencies of behaviors \((n = 62, M = 3.07)\).

The most important finding is that sustainable office equipment behavior is only performed occasionally while the attitudes were positive. This offers opportunities for improving the energy efficiency, for example by activating more energy-saving functions on computers. By this measure, more electricity could be saved during working hours. Behaviors that will be most difficult to influence on the short term are the transportation behaviors because the majority of people now uses a car and is not positive about reducing car use.
3.2.4 Social norms
Social norms were explored by looking at the opinions about encouraging colleagues and the degree to which employees already encourage their colleagues. Results suggested that opinions towards encouraging colleagues were moderately positive because the average opinion towards encouraging colleagues (\( M = 4.31 \)) was somewhat below the average of all opinions (\( M = 4.61 \)) presented in Table 3-1. Results in Table 3-2 suggested that people do not often encourage their colleagues because the average score of encouraging behaviors (\( M = 2.05 \)) was below the average of all behaviors (\( M = 3.07 \)).

Furthermore, we compared attitudes and behaviors regarding encouraging colleagues for flex workers and for traditional workers. We expected that attitudes and the frequency of mutual encouragement more often occurs among flex workers, because they have another work culture in which the NWoW was introduced. Analyses did not provide evidence that flex workers have more positive attitudes towards encouraging colleagues (\( M = 4.60, p = 1.18 \)), than traditional workers (\( M = 4.21, p = 1.18 \)), \( t(60) = -1.11, p = 0.27 \). However, flex workers indeed encourage colleagues more often (\( M = 2.67, p = 1.29 \)), than traditional workers (\( M = 1.85, p = 1.02 \)), \( t(60) = -2.52, p = .01 \).

These results suggest that when social norms are more clearly directed to pro-environmental behavior, people are probably more motivated to behave sustainable and thus mutual encouragement is more accepted. We tested this assumption by investigating whether sustainable behaviors and other factors influence encouraging behavior. Therefore we performed a regression analysis in which frequency of encouraging colleagues was the dependent variable and educational level, whether someone works in a flexible working environment or not, opinions about encouraging behavior and overall frequency of behaving sustainable were the predictors. Results suggested that someone’s level of education (\( B = .170, p < .05 \)), whether someone works in a flexible office environment (\( B = .707, p < .05 \)), opinion about encouraging colleagues (\( B = .248, p < .05 \)) and the overall frequency of performing all other sustainable behaviors (\( B = .101, p < .05 \)) positively influence encouragement of colleagues, \( F(4) = 20.086, p < .05 \). These results are further discussed in the discussion section of this chapter.

3.2.5 Comments of respondents
3.2.5.1 Self-efficacy
Participants’ comments suggest that self-efficacy especially is a problem in the case of turning off lights. Lights are now not frequently turned off. A lot of people indicated that this action is inapplicable. This is probably caused by the presence of many presence sensors that regulate the lights. People therefore have low control and this will lead to a lower intention to perform the behavior. The behavioral control in rooms with presence sensors cannot be improved. But a concern is that people also perceive that they do not have control in rooms without presence sensors, while they actually have control. In these rooms, employees have to turn the lights off with a light switch. One respondent also indicated that employees have no control over energy-saving settings when they make use of virtual workstations. The settings are controlled centrally and cannot be changed individually. It should be made clear to employees in what situations they are able to change energy-saving settings. A third control problem was mentioned according to printing efficiently. This is not
possible when certain official documents have to be printed because there are printing guidelines for these documents. It is not in the power of an individual employee to change these guidelines.

3.2.5.2 Social norm
In an office environment, social norms relate to the corporate culture and the pressure of other colleagues to behave sustainable. A few respondents commented that a change in the current corporate culture is needed, for employees as well as for the management. According to one respondent, the current culture does not stimulate teleworking and driving outside rush hours. This is true for only one part of the office building, in which the NWoW is not yet implemented. Furthermore, a respondent indicated that the working location and working hours depend on other colleagues, because people often have to co-operate. These factors do not illustrate a social pressure but more a social obstacle to behave sustainable.

3.3 Discussion and conclusions
The results from the survey show that almost all employees have positive attitudes towards sustainable behaviors that are related to their work. As a result there is no equal distribution between negative and positive attitudes. This unity can partly be explained by the composition of the sample group, which does not represent the whole society. So apparently, the employees all believe that sustainable actions should be taken, not only by companies but also by the employees. This is not surprising, because most employees have an energy-related job.

The goal of this survey was to indicate which behaviors are not yet frequently performed and therefore could be stimulated to reduce the company’s environmental impact. It is expected that the stimulation of behaviors has the best results when people already have a positive attitude towards the behavior. Three behaviors that are evaluated very positive but are performed relatively little are turning off the monitor, activating energy-saving measures and turning off lights. The presence of motion sensors makes it impossible for employees to turn some lights off manually. A fourth behavior that could be performed more often is turning off office equipment instead of setting it in the stand-by mode. People had less positive attitudes towards this action so we expected that it will be more difficult to stimulate this behavior. However, this behavior also involves desk appliances and is therefore closely related to turning off monitor and activating energy-saving measures. These four sustainable behaviors, which are related to efficient electricity use for office equipment and lighting, will therefore be included in the field study in which a group feedback intervention attempts to improve these behaviors.

Additional results suggested that social norms and self-efficacy have an effect on the performance of a behavior. Employees have a moderate positive attitude towards encouraging colleagues and in practice they rarely encourage their colleagues to behave more sustainable. However analyses showed that flex workers encourage colleagues more often than traditional workers. Other results suggested that flex workers who are highly educated have a positive opinion towards encouraging colleagues and who in general more frequently behave sustainable are more likely to encourage their colleagues to behave the same. This result could mean that when all employees perform more
sustainable behaviors, they are more likely to communicate about it and encourage each other. This could result in a corporate culture in which sustainable behaviors are embedded more. The results suggested that the corporate culture among flex workers is already more in favor of sustainable behaviors than the culture among traditional workers. A possible explanation could be that the introduction of NWoW has led to a change in corporate culture. Because the organizational culture potentially has a great influence on sustainable behavior, it will be taken into account in both the field study and the focus group.
4 Field study

In this field study, the effectiveness of group feedback to a real group of colleagues is tested. As mentioned, this study extends on previous research in which group feedback was tested in a lab setting (Midden et al., 2011). The first research question which is investigated in this field study is:

*RQ1: What is the influence of group feedback on the electricity consumption by a group of office workers for the use of office equipment?*

Based on the results of the 10:10 campaign (10:10, 2012), Midden et al.’s (2011) experiment in Japan, and results of previous studies that investigated the effect of feedback interventions (Fischer, 2008; Abrahamse et al., 2005; Darby, 2001), it is expected that employees will consume less electricity for the use of office equipment when they receive feedback about their consumption. The first hypothesis therefore is:

*H1: Employees consume less electricity for office equipment when they receive group feedback about their consumption compared to when they receive no feedback about their consumption.*

The results from the survey suggest that feedback should focus on the stimulation of sustainable behaviors related to efficient electricity use of office equipment. A distinction was made between different types of office equipment, such as printers, computers, and lights. To make the feedback more appliance-specific, the feedback in this field study consists of separate information about three different equipment groups: desk equipment, collective equipment and lighting. Desk equipment includes computers, laptops and monitors and collective equipment includes printers, videoconference systems, coffee machines, water cooler and a refrigerator. An important difference between these three groups is that desk equipment is used individually while the lighting and collective equipment are used by all employees. Furthermore, lighting is in most spaces automatically controlled by presence sensors. This makes lighting different from collective equipment, which can fully be controlled by the employees.

According to the Theory of Planned Behavior (Ajzen, 1991), people are more likely to perform a behavior when they perceive that they have control over the behavior. Also the social environment and attitudes play a role. Results from the survey indicated that employees evaluated sustainable behaviors for desk equipment more positive than other sustainable behaviors. It is therefore expected that people will conserve most energy for desk appliances, because employees have more control over those behaviors and have more positive attitudes towards the behaviors. Behaviors to decrease power consumption by lighting are expected to be performed the least because the actual control is low due to the presence sensors and there is a high dependency on colleagues’ behaviors. The second hypothesis therefore is:

*H2: When employees receive group feedback about their consumption, they conserve more electricity for desk equipment than for collective equipment (2A), and conserve more electricity for collective equipment than for lighting (2B), compared to when they do not receive any feedback.*
The second research question for this field study is concerned with the saving potentials in the office. It is not expected that all these savings can be realized with the feedback that is provided in this study. However, saving potentials could indicate whether other behaviors should be targeted in the future and whether technological and organizational improvements are needed. The saving potentials are interesting because they can determine whether investments in energy conservation strategies will actually pay off. The second research question has an exploratory nature and is formulated as follows:

*RQ2: Which savings can be realized in the office by making more efficient use of the office space and equipment?*

### 4.1 Method

#### 4.1.1 Feedback characteristics

In this study, the feedback form that is investigated is *evaluated factual group feedback*. Group feedback indicates that feedback about employees’ joint consumption is provided to all employees. Because of the NWoW principles, it is complicated to provide every employee with individual feedback about his or her own consumption, because employees can work on different locations during the week and could switch desks during the day if they want to. Moreover, a part of the office equipment is used collectively. Therefore feedback will be given to the group as a whole about the total consumption of the group. The feedback is factual, because consumption is displayed in Watts. This factual information is evaluated with speedometers with a color scale ranging from green to orange to red. The Measures section further explains the formulation of the color scales. The color scale should make it easy for the office workers to process the evaluation, while at the same time the Watts should give more insight in real consumption. The pointer on the speedometer indicates the current consumption compared to the average consumption during that same hour on weekdays in the reference week. So the evaluation is based on a historic comparison. Next to the speedometers a floor map is displayed which presents occupied desks (=orange color) and unoccupied desks (=grey color). This floor map should give people a clear overview of the occupation of desks and should also support them in choosing a desk according to NWoW agreements. As mentioned, the feedback is specific for three equipment groups: desks, lighting and collective equipment. The feedback is provided continuously so that the relation between behaviors and consumption can almost directly be observed by participants. To improve the effectiveness of the feedback, employees are told at the beginning of the treatment to keep their electricity consumption as low as possible. The visualization of the speedometers is presented in Figure 4-1. The design of the entire dashboard with speedometers and the floor map, is presented in Appendix B.
4.1.2 Office setting and participants

The research setting, in which the study is performed, consists of two wings on the ground floor of an office building in which the N WoW is implemented. The office space consists of a mix of meeting rooms, separated rooms for one or two persons and open-office space. Based on the N WoW concept, the office space is divided into three zones which are based on different work activities: concentration workplaces, computer workstations and informal meeting places. In total, there are 34 desks and 8 meeting areas. More details about the monitored office equipment are listed in Table 4-1.

<table>
<thead>
<tr>
<th>Equipment group</th>
<th>Appliance</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desk equipment</td>
<td>Desks</td>
<td>34</td>
</tr>
<tr>
<td>Lighting</td>
<td>Lighting zones</td>
<td>25</td>
</tr>
<tr>
<td>Collective equipment</td>
<td>Printers</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Videoconference systems</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Coffee machine</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Refrigerator + electric water boiler</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Water cooler</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4-1: Details of monitored office equipment

4.1.3 Research design

A within-subject design is used for this study, which means that the same participants, in this case a group of employees, take part in both treatment conditions. The electricity consumption of the employees is first monitored during one reference week. After that, the consumption of the group is monitored during two weeks in which the group receives feedback about the electricity consumption. For further control, simultaneous power consumption measurements were done in another office building. These control data should indicate whether possible effects of the feedback treatment are unique for the office building where feedback was presented. The design of the field study is presented in Table 4-2.

<table>
<thead>
<tr>
<th>Week</th>
<th>Electricity measurements</th>
<th>Treatment</th>
<th>Control measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Baseline measure</td>
<td></td>
<td>Electricity measurements in second office</td>
</tr>
<tr>
<td>Week 2</td>
<td>Treatment condition</td>
<td>Feedback and saving goal</td>
<td></td>
</tr>
<tr>
<td>Week 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4-2: Field study design

Figure 4-1: Graphic representation of the speedometers with evaluative factual feedback about the electricity consumption of three equipment groups.
4.1.4 Materials

To gather data about the electricity consumption, hard- and software from Plugwise is used. The Plugwise system consists of a network of intelligent sensors which register power consumption of connected appliances (Plugwise, 2012). Figure 4-2 presents a schematic representation of the principle of the Plugwise system. For this study, plugs were used to measure electricity consumption. Such plugs are put between a socket and an appliance plug. All power consumption data is stored by the plugs and transmitted to the Plugwise software installed on a computer. This software offers an overview of the power consumption, CO₂ emissions and realized costs savings. The Plugwise software gives appliance-specific information because each appliance is connected to one plug. Information is offered about appliances’ current power consumption in W and historical consumption in kWh. The historic data presents power consumption per hour or in larger time units.

![Figure 4-2: Schematic representation of the Plugwise system.](image)

In this study, all appliances from a single desk are connected to one plug. A picture of the placement of the plugs for desk equipment is presented in Appendix C. For lighting, each lighting zone is connected to at least one plug. The collective appliances are individually connected to a plug, except for the refrigerator and water cooker, which are combined in one plug.

To present the feedback to the employees, a dashboard is used. The dashboard is a touchscreen of 21.5” which is placed on a central location in the hallway where most people enter the building. It is positioned on the service desk, so it is in people’s sight and on a good height for people to interact with it. A picture of the placement of the touch screen and floor map on which the location of the dashboard is indicated, are included in Appendix D. The touchscreen functions make it possible for people to switch between three frames: the floor map of the entire office space, the floor map of the left wing, and the floor map of the right wing. The speedometers always remain present at the left side of the screen. Because of these interactive functions, also clicking movements are monitored to see whether people interact with the dashboard. The number of interactions with the dashboard is out of the scope of the current research question, but might be interesting for further investigation.
4.1.5 Measures
The scale of the speedometers is based on the power consumption during the reference week. To correct for the average occupation for a specific time of the day, the speedometers’ scales change every hour and match the average consumption during that hour on weekdays in the reference week. The border between the orange and red part equals the average consumption during the reference week. The left border of the orange part is the average consumption minus 10%. This should make it not too easy to reach the green part, but also not impossible. Furthermore, the green part represents 50% and the red part 40% of the scale. For clarification, only the color scales of the speedometers change every hour, the pointers on the speedometers continuously change with a short delay of a few seconds.

During lunch time, from 12:00 to 13:00, the scale for the consumption of desks is adjusted. This is done because most people leave their desk for 30 minutes for lunch. While they are absent, they could save electricity. Tests were done to check the saving potential of a computer in the standby mode. It appeared that the most common computer setup, which is a laptop in a docking station and a separate monitor, consumes 50% less power in standby mode compared to the active mode. It is therefore assumed that the maximum possible savings during the lunch hour can be up to 25%, because people leave their desk for half an hour in which they could save 50%.

The occupation information on the floor map is based on the consumption of each desk. Desks are displayed as occupied when the consumption is above 10 W. This threshold is set so that unoccupied desks where equipment, such as a monitor, is left on are not displayed as occupied.

4.1.6 Procedure
People were informed via email a week in advance that Plugwise plugs would be installed in the office environment. They were also told that a dashboard would be placed a few weeks later, on which the usage of the office environment would be displayed. At the beginning of the first treatment week, employees received a description of the information on the dashboard and the interactive functions of the dashboard. Furthermore, they were instructed to try to limit their electricity consumption by making use of the information on the dashboard.

4.2 Results
4.2.1 Effectiveness of feedback
Table 4-3 presents an overview of the total consumption and occupation for each week and the contribution of each equipment group to the total power consumption. Also the average power consumption per hour of occupation is presented. It can be noticed that lighting is by far the largest contributor to the total consumption, on average about 76%. Desks consume the lowest amounts of electricity during each week, on average around 10%.
<table>
<thead>
<tr>
<th>Week</th>
<th>Total (kWh)</th>
<th>Desks (kWh)</th>
<th>Collective equipment (kWh)</th>
<th>Lighting (kWh)</th>
<th>Occupation (hours)</th>
<th>Desks (kWh/occupation hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference week (1)</td>
<td>463.4</td>
<td>48.1</td>
<td>66.5</td>
<td>348.8</td>
<td>1993</td>
<td>0.0241</td>
</tr>
<tr>
<td>Treatment week (2)</td>
<td>504.3</td>
<td>46.4</td>
<td>69.1</td>
<td>388.8</td>
<td>1890</td>
<td>0.0246</td>
</tr>
<tr>
<td>Treatment week (3)</td>
<td>455.4</td>
<td>43.4</td>
<td>65.4</td>
<td>346.6</td>
<td>1777</td>
<td>0.0244</td>
</tr>
</tbody>
</table>

Table 4-3: Overview of power consumption (in kWh), occupation (in number of hours that desks were occupied) and the power consumption of desks per occupied hour, in the reference week and two treatment weeks.

4.2.1.1 Hypothesis 1
A mixed model analysis was performed to test the first hypothesis. A mixed model analysis was used because the data can be seen as repeated measures because all 24 hours are repeated each day, for 21 days in a row. The first hypothesis was stated as follows: *employees consume less electricity for office equipment when they receive group feedback about their consumption compared to when they receive no feedback about their consumption.* The number of attendees was also included in the model, because we expected it to be an important predictor of power consumption. In contradiction with the hypothesis, the results of the analysis provided no evidence that support that average total consumption in week 1 ($M = 2.76, SD = 3.42$) is higher or lower than the average total consumption in weeks 2 and 3 ($M = 2.86, SD = 3.63$), $F(1, 168.06) = 0.08, p = 0.78$. As expected, the number of attendees did have a significant influence on total consumption, $F(1, 178.72) = 3783.71, p = 0.00$.

The same analysis was done for the second office, to check whether the results are different for the two offices. Also in the second office, the average total consumption in week 1 was not significantly different from weeks 2 and 3, $F(1, 291.60) = 1.61, p = 0.21$.

4.2.1.2 Hypothesis 2
To test the second hypothesis, also a mixed model analysis was performed. Again, the number of attendees was included in the model. The hypothesis was stated as follows: *when employees receive group feedback about their consumption, they save more electricity for desk equipment than for collective equipment (2A), and save more electricity for collective equipment than for lighting (2B), compared to when they receive no feedback.* In confirmation with hypothesis 2A, the results provided evidence that average desk consumption in week 1 ($M = 0.29, SD = 0.36$) was higher than in weeks 2 and 3 ($M = 0.27, SD = 0.35$), $F(1, 264.57) = 5.04, p=0.03$. Again the results suggested that number of attendees is a predictor of consumption of desks, $F(1, 174.54) = 16436.40, p = 0.00$. No evidence was provided that feedback had an effect on the consumption of collective equipment, $F(1, 263.02) = 2.42, p = 0.12$, or on the consumption of lighting, $F(1, 162.11) = 0.25, p = 0.62$. Therefore, hypothesis 2B was not confirmed by the results.

In the second office, results of the analysis provided no evidence that power consumption for desk equipment differed over the three weeks, $F(1, 364.04) = 2.04, p = 0.16$, or for lighting consumption,
$F(1, 294.68) = 2.74, p = 0.10$. However the results provided evidence that suggest that in the second office, the consumption of collective equipment was higher in week 1 ($M = 0.44$, $SD = 0.14$) than in weeks 2 and 3 ($M = 0.43$, $SD = 0.16$), $F(1, 312.50) = 6.77, p = 0.01$. This is an unexpected finding. However, it has to be noted that the consumption of collective equipment in the second office was lower in the second week but higher in the third week compared to the first week. This might indicate that the consumption of collective equipment in the second office fluctuates more.

The results of the mixed model analyses indicated that in both feedback conditions, the number of attendees was the most important predictor of the power consumption of desks, collective equipment, lighting and total consumption. However, when feedback was presented, the number of attendees was no longer the single predictor of consumption of desks, but feedback also influenced the power consumption. In another office, no difference in desk consumption was found between the three weeks.

### 4.2.1.3 Additional analyses

Additional analyses were performed to get more insight in the consumption of desk equipment and to investigate what might have caused the differences in power consumption between the reference week and the treatment weeks. First, it was investigated at what time of the day savings are realized. Second, power consumption differences between weeks were investigated per zone and per individual desk.

**Consumption differences over the day**

It was investigated whether other effects of feedback occur on the equipment groups when only certain moments of the week are taken into account. The mixed model analyses that were performed to test the hypotheses were repeated for the first office, this time taking only work hours into account. It was assumed that work hours are between 7:00 – 19:00. The results of these analyses did not indicate new effects. It was even found that when only work hours are included, there was no longer an effect of feedback on consumption of desks, $F(1, 33.77) = 0.53, p = 0.47$. This might suggest that the effect on desk consumption is larger outside work hours, however this suggestion is not confirmed by the data, $F(1, 24.33) = 3.96, p = 0.06$.

Because the mixed model analysis could not indicate whether the savings are realized during or outside work hours, Graph 4-1 was also analyzed to look for other possible explanations for the difference in power consumption of desks in the reference week and the treatment weeks. The graph shows that the consumption pattern of desks is somewhat different in the treatment weeks. The average consumption per desk seems to decrease during lunch time, while this not obviously occurs in the reference week. A mixed model analysis that only took the lunch hour into account, could not confirm this difference, $F(1, 11.00) = 1.71, p = 0.22$. 


Graph 4-1: Average daily power consumption per active desk, displayed for the reference week and the treatment weeks.

Consumption differences for zones and desks
Changes in electricity consumption were also explored for certain zones in the office space, and for individual desks. This information could provide more insight whether only certain zones or desks were responsible for reductions in power consumption, or that all desks contributed to the savings. In Appendix E, a floor map is included on which the different zones are indicated. The number of desks included in each zone depends on the possibility for people behind those desks to interact with each other. Therefore, concentration spaces form single zones because such desks are isolated from other desks. Graph 4-2 presents the electricity consumption for each zone in the three weeks.

Graph 4-2: Electricity consumption differences between the reference week (week 1) and the treatment weeks (weeks 2 and 3) for each zone. The electricity consumption is presented in kWh and equals the total consumption divided by the number of hours the zone was occupied.
When visually analyzing the bars in the graph, we did not notice a reduction in electricity consumption by all desks in the two treatment weeks compared to the reference week. Only in zone 10 and 11, average electricity consumption per hour appears to have dropped during the treatment weeks. In zone 13, the consumption only decreased in the third week. In all other zones, the electricity consumption appears to either have remained equal, increased, or fluctuated over the weeks.

The interpretation of these graphs did not provide evidence that electricity consumption was reduced by all desks in the office space. However, these data could provide more insight in the influence of colleagues on people’s power consumption behavior by analyzing whether consumption patterns are similar for desks in the same zone. Similar patterns could indicate that colleagues encouraged each other to reduce electricity consumption. Graph 4-3 presents the power consumption patterns for the desks in zone 10 and 11. The consumption patterns of all other desks can be found in Appendix F.

Graph 4-3: Electricity consumption per occupied hour for the desks in zone 10 and zone 11.

The graph did not clearly show that consumption patterns are similar for desks in the same zone. However in zone 10, the consumption decreased (from week 1 to week 2) for both desks, which might indicate that people who used those desks, have influenced each other. Moreover, desk 27 and desk 28 were the only not-flexible workplaces in the office setting which were constantly used by secretaries. Therefore, it can be assumed that these desks were always occupied by the same persons. All other desks were flexible work stations which could be used by all employees. Therefore, changes in individual electricity consumption cannot be distracted from this information.

4.2.2 Saving potentials

This section discusses the second research question which was formulated as follows: Which savings can be realized in the office by making more efficient use of the office space and equipment? Based on power consumption data from Plugwise, explorative analyses were performed to answer this question. First, occupation patterns in the office space are described and inefficiencies regarding the occupation are identified. Second, the same is done for power consumption patterns and inefficiencies both outside and during work hours.
4.2.2.1 Occupation patterns

In an average week, the occupation was lower on Mondays and Fridays compared to the other working days. Table 4-4 presents the average maximum occupation for each working day. An occupation around 50% means that only half of the desks was used. The most efficient way to occupy the office space in that situation would be to cluster all employees in one part of the office space so that in other parts of the building climate control and lighting are not needed and can thus be saved. Occupation data showed that people did not cluster but spread over the whole office space. The following phenomena were observed:

1. The left and right wing were always both in use. Even when the occupation in both wings was about 50%.
2. Double offices and single concentration workplaces were used even when desks were free in the open-office space.
3. Multiple double offices were occupied by one person at the same time. During three weeks, this was the case in 41% of the work hours (7:00 – 19:00).

A likely reason for the first phenomenon is that two different departments of the company made use of the same office space. As a result, people from the same department tended to cluster in ‘their own’ wing. The second phenomenon may have been caused by the zoning in the office space, which encouraged people to choose a workplace that meets their activities of that day. The third phenomenon is more striking, because double offices could be used for the same activities. Although two of the four double offices are designated as computer workstations, they can also be used as concentration workplaces because a door can be closed to keep noise outside. Apparently, people preferred to have a double office for themselves instead of sharing it with someone else. When looking at the total occupation of each desk during a week, some desks were clearly more often occupied than other desks. The occupation of desks is visualized in Figure 4-3, where the orange part of the bars represents the percentage of office hours that the desk was occupied.

<table>
<thead>
<tr>
<th>Day</th>
<th>Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon</td>
<td>56%</td>
</tr>
<tr>
<td>Tue</td>
<td>73%</td>
</tr>
<tr>
<td>Wed</td>
<td>78%</td>
</tr>
<tr>
<td>Thu</td>
<td>83%</td>
</tr>
<tr>
<td>Fri</td>
<td>53%</td>
</tr>
</tbody>
</table>

Table 4-4: Average occupation on weekdays.

Figure 4-3: Occupation of desks in the left wing, based on the number of hours that the desks were occupied. The orange bar represents the percentage of office hours that the desk was occupied.
The frequency of occupation varied greatly per desk, namely from 141 hours in three weeks to 10 hours in three weeks. The large differences in occupation hours suggested that employees have a preference for certain desks. More favorable desks appear to be in double offices. Furthermore, we observed that people do not prefer desks where they sit with their back towards the passage. A likely reason is that people do not like to be approached from behind. So, although NWoW strived to stimulate people to use different workplaces that match their activities, employees appear to have a preference for certain workplaces.

4.2.2.2 Power consumption patterns

Outside work hours

In an average week, about 97% of power was consumed during weekdays and around 3% during weekends. On weekdays, lighting consumed the most power (± 79%). During weekends, normally all lights were turned off because they are controlled by presence sensors. The collective equipment however was not turned off at the end of the week and was therefore still consuming power in weekends (85% of total consumption in weekends). The other 15% of weekend consumption was induced by computer workstations which were not completely turned off. On average, 39% of all monitors were still in standby mode at the end of the day instead of turned off. A monitor in standby mode consumed around 3 Watts, this is not much, but it counts when multiple monitors are unnecessarily left on. Table 4-5 presents the average consumption per week that occurred outside work hours. These hours include the weekend days and the hours before 7:00 a.m. and after 7:00 p.m. on weekdays.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Consumption</th>
<th>Costs/week</th>
<th>Costs/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desks</td>
<td>6.3 kWh</td>
<td>€0.38</td>
<td>€19.54</td>
</tr>
<tr>
<td>Collective equipment</td>
<td>29.4 kWh</td>
<td>€1.77</td>
<td>€91.83</td>
</tr>
<tr>
<td>Lighting</td>
<td>10.8 kWh</td>
<td>€0.65</td>
<td>€33.80</td>
</tr>
<tr>
<td>Total</td>
<td>46.4 kWh</td>
<td>€2.78</td>
<td>€144.68</td>
</tr>
</tbody>
</table>

Table 4-5: Total average power consumption per week outside work hours for three equipment groups. Costs are based on an electricity price of €0.06 per kWh.

The information in Table 4-5 indicates that collective equipment is by far the largest consumer outside work hours. Graph 4-4 presents the distribution of the collective equipment. The coffee machine and videoconference systems appear to be the largest consumers.
According to these insights, electricity savings outside work hours can be realized by turning more desk and collective equipment off at the end of the work day. Monitors can quite easily be turned off by employees. However turning off collective equipment will be more difficult, because some equipment cannot be turned off, such as the refrigerator. Furthermore, employees may not feel responsible to turn shared appliances off. A possible solution would be to connect the appliances to a time switch which automatically turns the appliances off. Lighting is already controlled automatically by presence sensors. They might have be on outside work hours because cleaners or other persons were in the building.

**During work hours**

Inefficient power consumption during work hours occurred when lighting, desks or collective equipment were on unnecessarily. Here, unnecessary consumption implies that equipment could completely or partly be turned off without disturbing work activities.

Collective equipment can hardly be turned off without disturbing people’s job performance. A possible, but drastic, measure is adjusting the number of facilities to the number of people present.

Lights could be on unnecessarily in a couple of situations: a) When people are spread over multiple rooms while they could use less office space by clustering, b) When lights are on while no one is present. The first phenomenon relates to inefficient occupation, this was already discussed. The second phenomenon can occur when lights switch on when somebody just passes a room. This is a result of the sensitivity of the presence sensors. Another limitation of the presence sensors is the relatively long automatic switch-off time of lights. Now, lights switched off after about 15 minutes. This means that for example during a half an hour lunch break, lights were off for only 15 minutes while they could have been off for 30 minutes.

Unnecessary desk consumption occurred when people left their equipment on when they left their workplace. This often occurred during lunch breaks and during business meetings. The power consumption data indicated that in total, 101 hours in three weeks, desk equipment was left on in the four double offices while no person was present. These hours were identified when one or two desks were active, while the lights in that room at the same time were turned off. On average, this means that each desk was unnecessarily turned on 4 hours a week, which equals 7% of work hours.
4.3 Discussion and conclusions

Previous research in which the effect of group feedback on energy conservation was tested (Midden et al., 2011), did not find an effect of group feedback in a Dutch sample. But, because that study was performed in a lab setting, group cohesiveness between members of a group was probably low. This study tried to overcome that limitation by testing a group feedback intervention in a real-life setting where group cohesiveness is expected to be high. The first hypothesis for this study stated that less energy would be consumed when employees receive group feedback about their joined consumption. The second hypothesis expected that energy conservation would be highest for desk equipment, second highest for collective equipment and least highest for lighting. The results only partly confirm the second hypothesis, because an effect of feedback was found on desk equipment, while no effect of feedback was found for the other equipment groups or all equipment taken together.

Additional analyses did not provide evidence that the decreased electricity consumption of desks were generated at certain times of the day, or by certain zones or desks in the office space. The electricity consumption patterns of desks could also not provide convincing evidence that electricity consumption is influenced by other desks in the same zone. However, the only two traditional desks in the office space both presented electricity savings. It might be that those employees influenced each other, but more research is needed to confirm this.

Occupation and power consumption patterns during three weeks were explored to investigate the possible savings in the office space. Analyses showed that office space was used inefficiently, and thereby also lighting and climate installations, because people tended to spread over the entire space instead of cluster in one part of the building. This spreading might be related to the occurrence of more favorable desks. Outside office hours, unnecessary consumption occurred because collective equipment and some desk equipment were not completely turned off. During office hours, most inefficient consumption occurred when people did not turn off their equipment, when they were not using it.

The findings of the group feedback study contribute to existing theories that group feedback can indeed influence energy conservation within a group with high cohesiveness. But, group feedback was mainly effective for influencing individually controlled behavior. The findings further indicate for practical implications, that group feedback in an office can be an effective tool to stimulate more sustainable behaviors of office workers.

The influence of feedback is expected to be larger when certain limitations of the current research are overcome. Limitations of the current research were for a large part caused by constraints of the office environment. One influential factor was the NWoW environment, which made it difficult to gather individual consumption data for all types of equipment. Without individual data, it is not possible to indicate who contributed to the savings and who did not. Another restriction was that feedback could only be given on a single dashboard. Therefore, people were not automatically confronted with the feedback but had to make effort to walk to the dashboard. Furthermore, the scale of the speedometers was based on just one week of baseline measures. Because the power consumption in this week could not be compared to other weeks, it was not clear whether the power consumption in that week was unusual or comparable to a regular week. This could have influenced
the evaluation on the color scale during the treatment weeks. Finally, because the study was conducted in a real office environment, it was not emphasized to employees that they were under investigation. This was done on purpose, so that the study would assemble an introduction of such a dashboard in a neutral office setting. However, because the Plugwise plugs had to be installed first, it did not remain unnoticed by employees that power consumption was monitored. Although the monitoring of power consumption could easily be noticed, it cannot be said with certainty that everyone paid enough attention to the instruction mail to know the purpose of the dashboard.

In future research, the effectiveness of group feedback to a group with high cohesiveness should be further investigated, by testing whether the effectiveness of group feedback increases when the feedback can more easily be observed, for example by projecting it on a larger screen or making it available online. Also a longer period of baseline measurements is desirable, so that the power consumption can be evaluated more realistically.

Furthermore, additional qualitative research could provide more insight into the effectiveness of group feedback. Although the feedback in the current study was not effective for all equipment groups, the positive findings for desk equipment suggested that an improved feedback intervention might be able to stimulate other sustainable behaviors as well. To evaluate the effectiveness of this feedback intervention and the possible effectiveness in the future, more background information is needed about user’s perceptions and experiences with the feedback. To gather this information, a qualitative research is also part of this study, namely a focus group. The method and results of the focus group are described in the next section.
5 Focus group

This focus group explores changes in people’s behaviors and attitudes as response to the presentation of group feedback. Furthermore it investigates people’s evaluation of the provided feedback and its future success. A focus group is a qualitative research method that is often used to explore people’s opinions and experiences of a certain phenomenon. The methodology typically involves one or multiple group interviews about a phenomenon guided by a moderator. Focus groups are particularly useful to get a better understanding why certain behavior occurs. Because of its exploratory nature, focus groups can be a source of new ideas and hypotheses (Poels, Kort, & Ijsselsteijn, 2012).

The aim of the focus group is to get more background information about the user interaction with the dashboard. The results of the field study provided more information about power consumption and occupation patterns. It also showed that the presence of feedback actually influences the energy conservation of desks. This study aims to determine which behaviors and attitudes led to those results. Furthermore, because the feedback did not lead to savings for all equipment groups, strategies should be devised to make the dashboard with feedback more effective. Four questions are investigated with this focus group, in which the term feedback refers to the dashboard with group feedback as well as the Plugwise system:

(1) What were positive characteristics of the feedback?
(2) What were negative characteristics of the feedback?
(3) In what way did the feedback affect user’s behaviors and attitudes?
(4) How could the feedback be improved?

5.1 Method

One focus group with five employees was organized. It was decided to perform just one group interview instead of multiple group interviews, because only 34 employees work in the relevant office space. The group was composed of four men and one woman (P1 – P5). All of them work on the same department and their functions in the company are somewhat similar. It has to be noted that all participants had energy-related jobs, so they were not laymen in the field of energy efficiency in buildings. The focus group took 60 minutes. This is quite a short time for a focus group, but the duration had to be kept limited, otherwise people would not be willing to participate during office hours. Participants received a free lunch for their participation.

The focus group was structured in the following way:

Introduction
First, the goal and topic of the group interview was explained. Participants were also informed about the sound recordings that were made, and they were told what behavior was expected of them during the meeting.

Individual task
At the beginning of the meeting, every participant received several green, pink and yellow Post-Its. They were asked to write three positive remarks on the green Post-Its, three negative remarks on the
pink Post-Its, and three improvements of the feedback on the yellow Post-Its. Each comment had to be written on a new Post-It.

**Group discussion**

The group discussion covered the largest part of the group interview. Participants could freely talk with each other about several topics. The discussion had the form of a semi-structured interview in which four pre-determined topics were discussed. These topics did not have to be discussed in a certain order, but to keep an overview, the moderator sometimes steered the discussion in a certain direction. The four topics that were discussed are: (1) Positive characteristics of the feedback, (2) Negative characteristics of the feedback, (3) Influence on user’s behaviors and attitudes, and (4) Feedback improvements. The Post-Its were used to start the discussion and to further guide the discussion about topics 1, 2 and 4.

**Discussing images**

After the group discussion, three images were presented to the participants. These three images are included in Appendix F. Two images were screenshots of the dashboard. The other image was a graph of the power consumption of desks and collective equipment during a random day. Participants were asked to indicate which inefficiencies they noticed on the images. The first image presented several double offices that were at the same time occupied by only one person. The second image presented a situation in which the lights were off in a room while the desks were still active. The graph illustrated that consumption of desks increased during lunch time while consumption of collective equipment decreased. It also showed that both equipment groups are consuming power before and after office hours.

5.2 **Results**

The results of the focus group are structured according to the four core topics. The original Dutch quotes are translated to English.

5.2.1 **Question 1: What were positive characteristics of the feedback?**

Overall, participants seemed to agree that the dashboard led to more awareness of power consumption and occupation.

“The presence of the dashboard already lets you think about energy.” (P4).

They indicated that they thought more about the topic and also more often talked about the topic with others. Participants said that another advantage of the dashboard was the simple and clear presentation of the information, which made it possible to see the occupation at a glance. It was also found attractive and interesting because the dashboard was a modern touch screen. The entire system was seen as a useful source of information with which ‘smart’ things can be done.

“...a very positive thing [of the system] is the collection of measurement data. You can do a lot of things with those data. Favorite workplaces can be determined. Also consumption,
occupation and hours that people work can be determined so that the performance of installations can be improved.” (P2).

5.2.2 Question 2: What were negative characteristics of the feedback?

One participant emphasized that a major inconvenience of the system was that the sockets had to be placed underneath the desks. To connect for example a laptop, people had to go under their desk to connect it to the socket. Something that withheld participants from interacting with the dashboard was its location.

“I did not attentively look at it because there are people sitting behind the desk... You feel obliged to start a conversation with them, otherwise you just stand there.” (P4).

Also some people do not pass the dashboard because they enter the building via another entrance. The people who did pass the dashboard, found the appearance of the screen not attractive enough.

“Your eye has to fall on it, otherwise you just pass it after you have seen it twice.” (P5).

“The display should be larger.” (P2).

Participants also found the information on the screen not inviting and difficult to interpret.

“The information on the screen is too stationary.” (P5).

“The speedometers are nice, but it does not tell me whether the consumption is good or bad. Especially as a layman, what does so many kW mean?” (P1).

“.you cannot interpret the information because you have no historical data. It is better when the interpretation is already done, because then you will recognize it.” (P5).

Furthermore, the purpose of the dashboard was not clear for the participants.

“The purpose and usefulness [of the dashboard] was unclear... You miss that if you are not familiar with it [as visitor].” (P1).

“After seeing it twice, you only use it to check which workplaces are still available.” (P5).

“I find the presence of employees more interesting than the power consumption.” (P3).

Some limitations of the Plugwise system were also mentioned.

“If someone leaves his laptop active [while he leaves], the desk looks occupied while it is not.” (P4).

“The consumption data is anonymous.” (P3).
5.2.3 Question 3: In what way did the feedback affect user’s behaviors and attitudes?

Overall, there was a lack of awareness and knowledge about the individual contribution to the power consumption.

“You do not know how you can change it or you have the feeling that you cannot make a difference.” (P4).

Some people were also not motivated to change their behavior.

“If it is clear in advance that it will yield nothing, then it is not worth the effort.” (P3).

“You should be triggered to look at it, [for example] because new information is presented.” (P5).

Participants think they will be more motivated when social influences start playing a role.

“If you are held accountable [for your behavior] [by your department], than that can be an incentive.” (P5).

“How do you make sure that people take action? I think with a competition... I believe the group feeling works very well.” (P1).

5.2.4 Question 4: How could the feedback be improved?

To encourage interaction with the dashboard, participants would like the information to become available via an application or website on which information regularly updates. The location of the dashboard should also be improved.

“The display should be on a place where you automatically bump into, and where you can also stop to request certain information.” (P5).

To make it more attractive, new information should be presented on the screen during the day. Furthermore, diverse information should be presented, such as statistics, historical data, energy tips, tricks, fun facts, season trends and broadcasts. Also other information should be displayed, such as traffic jams, weather conditions and NWoW agreements. Moreover, the interpretation should be easier.

“Present a graph or translate it to for example number of car rides.” (P5).

Regarding NWoW, participants say that people have to use the office space in the designated way: they should pick a desk that matches their working activity and people should remove their properties when they do not use the desk. To accomplish this, colleagues have to agree on certain rules and also act according to those rules. If someone is acting in the wrong way, he or she should be pointed to the rules. But to facilitate these behaviors, all workplaces should be equal and be equipped with the same facilities.

Other elements that the participants would like to include in the dashboard are: booking of desks and meeting facilities, seeing who is using a desk (e.g. by making a connection with the login on
computers), connect agendas of persons and meeting facilities, and indicating type of workstation on the dashboard. Participants were asked how they thought they would be more motivated to make more efficient use of equipment and office space. One suggestion was to add a game component.

“I would like to quantify workplaces so that you get more points in the ranking list when you always choose a less favorable desk. Or a reward system so that you get something at the end of the month.” (P1).

Awareness could be raised by reminding people to desired behaviors.

“Pop-ups should be placed to remind you to turn off your monitor at the end of the day. Then you are pointed to certain behavior and then you learn from it”. (P2).

Participants state that a clear target might also increase motivation, especially when the saving potential is high. The saving potential could be increased when the building management is connected to the system and when the whole building is included. This way, large parts of the building do not need climate control and lighting on days with a low occupation. Several ideas came up to improve efficient use of the building: people should be steered to a certain part of the building, the lights should turn off faster when no one is present, presence sensors should be less sensitive to movements outside the room, and power consumption outside office hours could be limited by connecting appliances to time switches.

5.3 Discussion and conclusions

The results of the field study (Chapter 4) suggested that group feedback had influenced the power consumption at desks. However, the results could not indicate which behaviors had changed due to the presence of the feedback. This had to be further investigated in the focus group. This focus group was conducted to evaluate the effectiveness of the feedback and possible effectiveness in the future. Four questions were central in the focus group: 1) What were positive characteristics of the feedback? 2) What were negative characteristics of the feedback? 3) In what way did the feedback affect user’s behaviors and attitudes?, and 4) How could the feedback be improved? The results of the focus group suggested that the presence of the feedback on the dashboard already led to more awareness of energy consumption. However, participants found the presentation of power consumption not triggering enough to take action to conserve energy. They indicated that they did not know what they could personally do to reduce consumption and they also did not have the feeling that their effort would lead to significant savings. The participants thought that the feedback would be more effective when a game element is included, such as a competition. Previous research indeed suggested that a competitive game element could lead to energy savings in households (Geelen, Brezet, Keyson, & Boess, 2010), so it might also be an effective method in other settings. Furthermore, participants would find the dashboard more interesting when more diverse information is presented on it, such as energy facts and information about traffic jams.

These findings suggest that the group feedback did not lead to conscious behavior changes. Nevertheless, an effect was found of feedback on the power consumption of desks. A possible explanation might be that the dashboard with feedback functioned as a subliminal stimulus. A
research by Winkielman et al. (2005) suggested that subliminal stimuli are able to influence people’s behavior, without people being consciously aware of their reaction to the stimuli. So, group feedback might have led to unconscious changes in employees’ behavior where they were not aware of. It might be that the presence of the dashboard led to increased awareness of energy consumption, which has resulted in unconscious sustainable behaviors. For organizations, this could mean that they can stimulate behavioral changes by only presenting information about energy consumption.

This study has several limitations, first, only one focus group was done because of the small number of employees that use the relevant office space. With more focus groups, more opinions and experiences can been collected, but that was not necessary for the scope of this research. Another limitation of this focus group was the duration which had to be kept short. Otherwise people would not be willing to participate during work hours.

Future research should investigate the potential of the suggested feedback improvements. Although the participants of the focus group thought that for example a competition would be effective, it should be taken into account that such a game can raise resistance of some employees. Employees might for example disapprove such a game because of privacy concerns. Or because they feel they are forced to act in a way they do not appreciate.
6 General discussion

It is of interest to both organizations and society to realize more energy efficiency in office buildings. For organizations, improving energy efficiency is a popular Corporate Social Responsibility strategy (MVO Nederland, 2012). For society, realizing more energy efficiency in buildings is important because buildings are responsible for almost 40% of total energy consumption of a country (Pérez-Lombard et al., 2008). Nowadays, many strategies to reduce the energy consumption in office buildings are based on technological innovations. However, to reach energy efficiency, also building occupants’ behaviors could contribute to more efficiency because behaviors by themselves can realize savings and behaviors can also influence the effectiveness of implemented technologies (Jazizadeh, 2012).

Previous research has provided evidence that energy conservation behavior by users can be stimulated by employing persuasive technologies, for example by presenting feedback to users (e.g Midden & Ham, 2012). More specifically, findings of a previous study suggested that group feedback is effective to stimulate energy conservation among Japanese persons but not among Dutch persons (Midden et al., 2011).

In the current research, we argue that also for Dutch participants, group feedback can be effective. However, we argue that the earlier research by Midden et al. (2011) had several limitations. A first limitation of that study was that artificial groups were included in the experiments. Based on earlier reasearch and theorizing (Karau & Williams, 1993; Mullen & Copper, 1994) we expected that real groups perform better on group tasks. Another limitation of that study (Midden et al., 2011) was that the participants received feedback in an artificial setting instead of in a real life setting. Therefore the current study investigated the effectiveness of a group feedback intervention to stimulate energy efficient behaviors within a real life setting with real groups. An office environment in which the NWoW had been implemented, formed the setting for this research. The main research question formulated for the study was: In what way can group feedback interventions contribute to more efficient use of office environments with the New Way of Working? Also two sub-questions were formulated: (1) What is the influence of group feedback on a group’s energy consumption within a field setting? And (2) What managerial insights follow from the analysis of employees’ usage of office space and equipment?

First, a survey was performed to get more insight in current attitudes and behaviors of employees in that specific office. The results of the survey showed that the frequency of performing efficient behaviors regarding the use of electric office equipment were around average. However, attitudes about these behaviors were above average. Therefore, the field study attempted to change these behaviors. Furthermore, the survey indicated that employees were least positive about behaviors related to sustainable transportation; these behaviors were also not often executed. This finding suggested that although sustainable transportation is an important element of NWoW, not all employees are willing to change these behaviors. In the second study, a field study, the effectiveness of group feedback on electricity consumption for lighting, collective equipment and desk equipment was tested. We expected that realized savings would be highest for desk equipment, second highest for collective equipment and lowest for lighting.
The results of the field study suggested that group feedback was effective in stimulating energy conservation, but only for desk equipment. So, group feedback was indeed able to influence energy saving behaviors among Dutch participants. Midden et al. (2011) indicated that group feedback was only effective in collective societies as Japan and that it was not effective in a more individualistic society as the Netherlands. However, the results of the current study suggested that also in the Netherlands, a group feedback intervention is able to influence conservation behavior. This implicates that a group feedback intervention could be a useful method to reduce energy consumption in offices. So, organizations should consider the implementation of this intervention when they want to reduce their energy consumption. But also in other settings where groups are responsible for the energy consumption, for example in schools, group feedback could lead to energy savings.

In this study, no evidence was found that the electricity consumption of lighting and collective equipment changed after the feedback was presented. A possible explanation for this finding could be that the operation of desk equipment is more under individual control than lighting and collective equipment. Therefore, people’s behavioral control is higher and it costs people less effort to reduce electricity consumption for desk equipment. More research is needed to investigate in what way group feedback could also influence energy consumption behavior for other appliances.

After the field study, a focus group was organized to investigate people’s opinions about the feedback intervention and to investigate in what way employees changed their behaviors as response to the feedback. Participants of the focus group indicated that they did not adjust their behaviors as response to the feedback presentation. Some participants mentioned that it was not clear in what way they had to behave to realize savings. Moreover, they felt they were not able to realize significant savings with their own behavior. Findings from both the field study and the focus group suggested that the presentation of group feedback did not lead to more conscious energy efficient behaviors. The group feedback might however have led to unconscious energy conservation behavior. Furthermore, additional analyses could not find evidence that electricity consumption is influenced by the behaviors of colleagues who work on a desk close by. In the focus group, employees expressed the feeling that conserving energy is not embedded in the current organizational culture. This might be the reason why employees did not encourage each other.

To provide an answer to the second sub questions ‘What managerial insights follow from the analysis of employees’ usage of office space and equipment?’, the electricity consumption data and insights from the focus group were analyzed. The answer to this question is further discussed in the next paragraph Managerial insights.

6.1 Managerial insights

Based on the analyses of the use of office space and equipment, we describe a set of managerial recommendations to decrease electricity consumption and optimize the occupation of the workplaces. Furthermore, on the basis of insights from the focus group, recommendations about the design of the energy display are provided. Below, recommendations are separately discussed for: (a) electricity consumption, (b) The New Way of Working, and (c) the visualization of the feedback on the dashboard.
Electricity consumption

Electricity consumption patterns were analyzed during and after work hours. Almost 10% of total power consumption in a week is consumed outside work hours because collective equipment and monitors are not turned off. Monitors can quite easily be turned off by employees, but employees probably feel less responsible to turn off collective equipment. To stimulate people to make more efficient use of appliances and office space, more strategies are necessary. During the focus group, participants provided several suggestions to improve employees’ motivations. These insights from the focus group together with other findings led to the following recommendations:

- The provision of group feedback can lead to reductions in the energy consumption, but more savings can probably be realized when the feedback is further developed.
- Management has to communicate energy saving targets more clearly to employees;
- Employees have to be informed about desired behaviors and the saving potentials of these behaviors should be explained;
- Social norms could be used to motivate employees, because people are expected to confirm with these norms when they are held accountable for their behavior by colleagues;
- Time switches have to be installed to automatically switch off collective appliances after work hours.

New Way of Working

Insights from analyses of occupation patterns indicated that employees tended to spread over the entire office space and they appeared to have a preference for certain desks. Most favorable desks were desks in separated spaces (e.g. double offices) and desks where people cannot be approached from behind. Participants of the focus group indicated that they often choose a certain workplace as response to other employees’ behavior. According to the participants, workplaces are often not used in the way they were designated for the NWoW; concentrations spaces are for example used as phone booths. Recommendations for management to improve the performance of the NWoW are:

- Strengthen the NWoW agreements and clearly communicate those agreements to employees, but also to visitors who occasionally make use of the office space;
- Make every workplace equally attractive by offering the same facilities at each workplace;
- Adjust the office setting so that there are no unattractive workplaces where people can be approached from behind;
- Measure noise production in each work zone to get more insight in the use of workplaces. This information could indicate whether concentration zones are indeed more quite than computer workstations where informal conversations are allowed (see Figure 6-1).

Figure 6-1: Noise measurement to indicate use of NWoW zones.
Feedback visualization on dashboard

In the focus group, employees indicated that the feedback as was presented in the current research was too static to remain attractive and interesting. Also the location of the dashboard made it unattractive to interact with the dashboard. Several possible improvements of the feedback presentation emerged during the focus group:

- Position the dashboard on a strategic location where people automatically notice it.
- Make the feedback available via other media, e.g. website or smart phone application.
- Present feedback about electricity consumption in a clear way. Statistics or energy facts could be added. Also metaphors could be used to facilitate the interpretation of the energy feedback, e.g. express consumption in number of car rides, trees or melted ice.
- Besides energy feedback, also other information could be presented on the screen, such as NWoW agreements and information about traffic jams.

6.2 Limitations and future research

For the current research, available resources and equipment were used to facilitate the introduction of the feedback intervention. To present the feedback, the already available touch screen was used as display. This screen might not have had the optimal size to attract the attention of employees and visitors; it was relatively small. Due to technical limitations, the feedback could not be presented via an application or website. Therefore, the feedback was only provided at one central place where people had to walk to, to perceive the feedback. A (web) application would have been a useful complement to the touch screen because employees would then be able to approach the feedback from their workplace. For future research, feedback should be provided via multiple media, or should be made more visible on a larger screen.

Because of time constraints, the field study only covered three weeks. These weeks might not be representative for the regular electricity consumption in the office. To correct for accidental electricity consumption changes, the electricity consumption was also monitored in a second office during the same weeks of the field study. To determine regular electricity consumption patterns, data should be gathered over a longer period. The electricity consumption after the feedback presentation could also be monitored for a longer period to gain more insight in the long term effect of the feedback on people’s consumption behaviors.

For the field study, a Plugwise system was used to gather electricity consumption data. A major limitation of this system was that it only provided historic electricity consumption per hour. Smaller time units could have provided more information about actual behaviors, for example whether electricity consumption decreased during a 30-minutes lunch break. In the current study, suggestions of behavioral changes were based on self-reported behaviors from participants of the focus group. Energy data per minute instead of per hour could also have provided better information about when people occupy and leave their desk. To overcome this limitation, the power consumption of the most common workstation, a docking station for laptop and a separate monitor, was directly monitored via Plugwise. This provided information about the usual consumption and in what cases consumption
was above or under average. Under average consumption could mean that the equipment was not on the entire hour. Above average consumption could mean that extra devices were connected, such as a phone adapter.

For this study, it was assumed that in a group of employees, the cohesiveness was higher than in artificial groups, such as in the experiment of Midden and colleagues (2011). However, the cohesiveness was not measured to prove this assumption. Furthermore, it was assumed that the high cohesiveness leads to a better group performance. Future research could get more insight in the effect of group cohesiveness by incorporating two different groups in a feedback study, one which is clearly cohesive and another group which is not cohesive.

Although the implementation of NWoW in the office space created new opportunities to make more efficient use of office space, e.g. via clustering, it also induced some limitations. First, the NWoW was introduced at the time of this research. It is therefore likely that employees were not yet used to the new working practices. As a consequence, employees might still prefer some desks, especially desks in somewhat separated spaces such as the double offices. A second limitation of NWoW is that employees did not have a fixed desk, so individual feedback about electricity consumption could not easily be provided. Also individual conservation behavior could therefore not be observed.

As in many studies, also in this study, the presence of the researcher might have had an influence on the results. Due to the presence of the researcher and the visible installation of the electricity meters, employees were well aware that their electricity consumption was monitored. It was difficult to prevent this phenomenon during this study.

6.3 Conclusions

So, in what way can feedback interventions contribute to more efficient use of office environments with the New Way of Working? This research suggested that the presentation of group feedback influences Dutch people within an office environment to reduce the energy consumption for desk equipment. Extending earlier research that did not find effects of group feedback in an artificial group (Midden et al., 2011), the current study provided evidence that group feedback is not only effective in a lab setting with artificial Japanese groups, but is also effective in a real life setting with a real Dutch group. The current research did not provide evidence that group feedback can stimulate reductions in electricity consumption of collective equipment and lighting. Insights from the focus group could also not indicate in what way employees’ behaviors changed after the feedback presentation.

Results of the focus group study suggested that the group feedback did not lead to conscious energy conservation behavior. Participants did however indicate that their energy awareness increased after the group feedback was provided. The feedback presentation also stimulated conversations between employees about energy consumption in the office space.

The increased awareness and energy-related conversations suggested that as result of the feedback there is increased interest in energy efficiency. This could have as a result that energy efficiency becomes more strongly embedded in the organizational culture. A change in organizational culture
cannot only lead to more commitment to energy efficiency by employees, but could also have a positive effect on an organization’s image. An improved reputation is also accomplished by the presence of an energy display with feedback in the building, because it can be perceived by clients and visitors.

Insights from the focus group study suggested that group feedback has the potential to realize more electricity savings. Participants of the focus group indicated that the group feedback presented in the current study did not make clear what they could do to reduce their electricity consumption and whether their own effort would lead to considerable savings. As a result, employees were not motivated to make an effort to reduce electricity consumption. They proposed that social norms could increase their motivation, when they are held accountable for their behavior by colleagues. Employees also indicated that stronger social norms would stimulate them to comply with NWoW agreements. These results suggested that if the group feedback would be made more motivating and when social norms are more in favor of energy efficiency, employees might be more committed to energy conservation and this could lead to larger energy reductions.

Regarding the NWoW, employees perceived feedback about the occupation of desks as a useful tool. On the basis of the visualization of the occupation, employees could see which spaces are occupied, and with that information, people could choose their desk. Employees expected that the performance of the NWoW would be improved when the types of workstations are more clearly presented on the dashboard. Also the possibility to reserve a workplace is desired by employees. For the management, the monitoring of occupation provided useful information about the capacity of the office building and use of desks according to the NWoW agreements.

At the beginning of this thesis it was stated that it is important for society that energy efficiency in office buildings has to be improved. Based on the results of this research, it can be concluded that a group feedback intervention can realize energy savings in offices. In addition, more energy savings can probably be realized when the feedback presentation is improved and when the organizational culture is more in favor of energy efficiency.
Bibliography


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Appendices

Appendix A: Original survey questionnaire (in Dutch)

Duurzaam gedrag op kantoor
Hartelijk bedankt voor uw deelname aan dit onderzoek. Dit onderzoek gaat over duurzaam gedrag van werknemers van BAM binnen kantoren. De vragenlijst bestaat in totaal uit vier onderdelen en het invullen ervan zal ongeveer 10 minuten van uw tijd in beslag nemen. Alle gegevens zullen vertrouwelijk behandeld worden en niet worden verstrekt aan derden.
Door op 'Doorgaan' ('Continue') te klikken begint de vragenlijst.

Onderdeel 1
Hieronder volgt een aantal stellingen over het gedrag van werknemers binnen een bedrijf. Het gedrag dat omschreven staat in deze stellingen kan de milieu impact van een bedrijf verlagen. Geef voor iedere stelling aan in hoeverre u het met die uitspraak eens bent. Uw gedachten over een stelling hoeven niet gelijk te zijn aan uw eigen gedrag.

1. Documenten moeten digitaal gearchiveerd worden om zo het aantal uitgeprinte documenten te verminderen. *
   
   Heelmaal niet mee eens  1  2  3  4  5  6  7  Heelmaal mee eens

2. Onnodig printen moet vermeden worden, maar wanneer er toch geprint wordt, moet er efficiënt gebruik worden gemaakt van de ruimte op het papier (bijvoorbeeld dubbelzijdig printen, meerdere pagina's op één vel en open ruimtes beperken). *
   
   Heelmaal niet mee eens  1  2  3  4  5  6  7  Heelmaal mee eens

3. Werknemers moeten het licht uitschakelen wanneer zij een ruimte (kantoor, toilet, berging) verlaten. *
   
   Heelmaal niet mee eens  1  2  3  4  5  6  7  Heelmaal mee eens

4. Kantoorapparatuur moet geschermd worden door werknemers. *
   
   Heelmaal niet mee eens  1  2  3  4  5  6  7  Heelmaal mee eens

5. Op computers moeten energiebesparende functies ingeschakeld worden (bijvoorbeeld monitor automatisch uitschakelen of slaapstand automatisch inschakelen wanneer de computer voor een bepaalde tijd niet gebruikt wordt). *
   
   Heelmaal niet mee eens  1  2  3  4  5  6  7  Heelmaal mee eens

6. Kantoorapparatuur (computer, monitor, printer) moet volledig worden uitgeschakeld in plaats van in de stand-by modus worden gezet wanneer het niet gebruikt wordt. *
   
   Heelmaal niet mee eens  1  2  3  4  5  6  7  Heelmaal mee eens
7. Wanneer een computer niet gebruikt wordt, moet de monitor uitgeschakeld worden. *

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8. Teleconferentie is een goed alternatief voor zakenreizen. *

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9. Het gebruik van de personenauto voor werkverkeer moet beperkt worden door meer gebruik te maken van alternatieve vervoerswijzen (bijvoorbeeld lopen, fietsen, openbaar vervoer en carpoolen). *

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10. Spitsuren moeten vermeden worden om van en naar het werk reizen. *

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11. Er moet gereden worden met een zuinige rijstijl om het brandstofverbruik te verminderen (bijvoorbeeld bij lage toerentalen al schakelen naar een hogere versnelling, met gelijkmatige snelheid rijden, motor afzetten bij een korte stop). *

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12. Colleagues moeten elkaar aanspreken om zich milieuvriendelijker te gedragen. *

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13. Werknemers moeten werkverkeer verminderen door een dichtbijzijnde werklocatie te kiezen (bijvoorbeeld een regiokantoor of thuis) wanneer hun werkzaamheden van die dag dat toelaten. *

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14. Bedrijven moeten rekening houden met de gevolgen van hun activiteiten voor het milieu. *

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15. Werknemers moeten hun werkgever helpen om de milieuimpact van het bedrijf te verminderen. *

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Onderdeel 2
Hieronder volgt een lijst met stellingen over duurzaam gedrag dat door werknemers van een bedrijf vertoond kan worden. Wilt u voor iedere handeling aangeven hoe vaak u deze zelf uitvoert? Indien een vraag niet op u van toepassing is, dan kunt u de antwoordmogelijkheid ‘n.v.t.’ kiezen.

1. Ik archiveer documenten digitaal zodat ik ze niet hoeft uit te printen. *
   - Altijd (80-100% van de gevallen)
   - Bijna altijd (60-80% van de gevallen)
   - Vaak (40-60% van de gevallen)
   - Sommig (20-40% van de gevallen)
   - Zelden of nooit (0-20% van de gevallen)
   - N.v.t.

2. Ik probeer onnodig printen te voorkomen, maar wanneer ik toch print, dan print ik dubbele zijde en maak ik optimaal gebruik van de ruimte op het papier. *
   - Altijd (80-100% van de gevallen)
   - Bijna altijd (60-80% van de gevallen)
   - Vaak (40-60% van de gevallen)
   - Sommig (20-40% van de gevallen)
   - Zelden of nooit (0-20% van de gevallen)
   - N.v.t.

3. Ik schakel het licht uit wanneer ik een ruimte verlaat (kantoor, toilet, berging). *
   - Altijd (80-100% van de gevallen)
   - Bijna altijd (60-80% van de gevallen)
   - Vaak (40-60% van de gevallen)
   - Sommig (20-40% van de gevallen)
   - Zelden of nooit (0-20% van de gevallen)
   - N.v.t.

4. Ik scheid afval op het kantoor. *
   - Altijd (80-100% van de gevallen)
   - Bijna altijd (60-80% van de gevallen)
5. Wanneer elektronische kantoorgevallen (computer, monitor, printer, etc.) niet gebruikt wordt, laat ik deze niet in de stand-by modus staan maar schakel ze volledig uit.*

- Altijd (80-100% van de gevallen)
- Bijna altijd (60-80% van de gevallen)
- Vaak (40-60% van de gevallen)
- Soms (20-40% van de gevallen)
- Zelden of nooit (0-20% van de gevallen)
- N.v.t.

6. Ik zet de monitor van mijn computer uit wanneer ik deze niet gebruik.*

- Altijd (80-100% van de gevallen)
- Bijna altijd (60-80% van de gevallen)
- Vaak (40-60% van de gevallen)
- Soms (20-40% van de gevallen)
- Zelden of nooit (0-20% van de gevallen)
- N.v.t.

7. Als alternatief voor zakenreizen maak ik gebruik van telepresence (of andere middelen om te vergaderen op afstand).*

- Altijd (80-100% van de gevallen)
- Bijna altijd (60-80% van de gevallen)
- Vaak (40-60% van de gevallen)
- Soms (20-40% van de gevallen)
- Zelden of nooit (0-20% van de gevallen)
- N.v.t.

8. Ik heb een zuinige rijstijl om zo brandstof te besparen (bijvoorbeeld bij loge toerentalen of schakelen naar een hogere versnelling, met gelijkmatige snelheid rijden, motor afzetten bij een korte stop).*

- Altijd (80-100% van de gevallen)
- Bijna altijd (60-80% van de gevallen)
9. Ik recycle papieren (koffie)bekers door deze in de daarvoor bedoelde kokers weg te werpen.
- Altijd (80-100% van de gevallen)
- Bijna altijd (60-80% van de gevallen)
- Vaak (40-60% van de gevallen)
- Soms (20-40% van de gevallen)
- Zelden of nooit (0-20% van de gevallen)
- N.v.t.

10. Ik spoor mijn collega’s aan tot milieuvervriendelijk gedrag.
- Altijd (80-100% van de gevallen)
- Bijna altijd (60-80% van de gevallen)
- Vaak (40-60% van de gevallen)
- Soms (20-40% van de gevallen)
- Zelden of nooit (0-20% van de gevallen)
- N.v.t.

Onderdeel 3
Hieronder volgt nog een aantal vragen over uw gedrag. Bij deze vragen gaat het er niet meer om hoe vaak u gedrag vertoont, maar wat u doet in bepaalde situaties. Kies bij iedere vraag het antwoord dat het meest op u van toepassing is. Indien geen van de antwoorden op u van toepassing is, dan kunt u de antwoordmogelijkheid ‘Anders’ (‘Other’) kiezen en deze toelichten.

1. Zijn energiebesparende functies op uw computer ingeschakeld (bijvoorbeeld monitor automatisch uitschakelen of slaapstand automatisch inschakelen wanneer de computer voor een bepaalde tijd niet gebruikt wordt)?
- Ik gebruik geen computer
- Ja, ik gebruik een laptop waarop de energiebesparende functies zijn ingeschakeld
- Ja, de energiebesparende functies van mijn computer zijn ingeschakeld
- Nee, maar ik schakel mijn computer en de monitor wel altijd uit na het werk
- Nee, en ik laat mijn computer ook altijd aan na het werk
- Ik weet niet of de energiebesparende functies op mijn computer ingeschakeld zijn
2. Welk vervoersmiddel gebruikt u voor zakenreizen binnen Nederland?

- Ik doe geen zakenreizen
- Het openbaar vervoer (bus, trein, metro, tram)
- Een personenauto
- Anders: [ ]

3. Hoe legt u de afstand af tussen uw woning en uw werk?
   *Indien u gebruik maakt van meerdere vervoersmiddelen, kies dan het antwoord waarmee u de grootste afstand aflegt.*

- Te voet en/of fietsend
- Met het openbaar vervoer (bus, trein, metro, tram)
- Door te carpoolen
- Met mijn eigen auto
- Anders: [ ]

4. Kijkt u met een auto naar uw werk tijdens spitsuren?

- Ja, ik rij met een auto tijdens spitsuren
- Nee, ik rij met een auto buiten spitsuren
- Nee, ik ga te voet, fietsend of met het openbaar vervoer naar het werk
- Anders: [ ]

Onderdeel 4
Dit laatste onderdeel bestaat nog uit een paar algemene vragen.

Wat is uw geslacht?

- Man
- Vrouw

Wat is uw leeftijd?

Wat is uw hoogst voltooide opleiding?

- Geen
- Lagere school
- Vakschool of huishoudschool
- Mavo, VMBO, mavo, 3-jarig HBS, handelschool
- Middelbaar beroepsonderwijs (MTS en vergelijkbaar)
- Havo, VWO, Lyceum, Gymnasium of 5-jarig HBS
- Hoger beroepsonderwijs (HTS en vergelijkbaar)
- Universiteit of Technische hogeschool
- Postdoctorale opleiding

Wat is uw gezins situatie? *
- Alleenstaand
- Bij mijn ouders
- Met partner
- Met partner en één of meer kinderen
- Met vrienden
- Anders:

Wat is uw functie binnen het bedrijf?

Doe u uw werk af met andere collega's? *
- Nee, ik heb mijn eigen werkomgeving
- Ja, ik deel mijn werkomgeving met een andere collega
- Ja, ik deel mijn werkomgeving met twee of meer andere collega's
- Ik maak gebruik van flexwerkplekken
- Anders:

Heeft u na het invullen van deze vragenlijst nog op- of aanmerkingen dan kunt u deze hieronder noteren:

Einde vragenlijst
Hartelijk dank voor het invullen van deze vragenlijst. Indien u nog vragen heeft over dit onderzoek dan kunt u via bregje.vos@bamtechniek.nl contact met mij opnemen. Als u graag een samenvatting van de onderzoeksresultaten zou willen ontvangen dan kunt u mij dit via hetzelfde e-mailadres laten weten. U kunt deze vragenlijst nu afronden door op 'Instructen' ('Submit') te klikken.
Appendix B: Feedback presentation

Desks on floor map:
- Occupied
- Free

Speedometers:
- Below norm
- On norm
- Above norm
Appendix C: Installation of Plugwise plugs at desks

Connection of Plugwise plug to socket above the desk:

Installation of sockets underneath the desk:
Appendix D: Placement of touch screen
Appendix E: Floor map with zoning
Appendix F: Power consumption patterns of individual desks

- Week 1
- Week 2
- Week 3
Appendix G: Images presented in focus group

1. Screenshot that visualizes spreading over the office space (in multiple double offices only one desk is occupied).

2. Screenshot that visualizes desk equipment that is unnecessarily left on (desks are active in double offices while the lights are off).

3. Graph which shows that the electricity consumption of desks is not decreasing during lunch time.