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**The feasibility of saving energy in challenging organisational contexts: Testing energy visualisation in a social services office in the United Kingdom**

Christine Boomsma<sup>a</sup>, Julie Goodhew<sup>a</sup>, Sabine Pahl<sup>a</sup> and Rory V. Jones<sup>b</sup>

<sup>a</sup> Plymouth University, School of Psychology, Portland Square, Drake Circus, Plymouth, PL4 8AA, United Kingdom.

christine.boomsma@plymouth.ac.uk (Corresponding author)

julie.goodhew@plymouth.ac.uk

sabine.pahl@plymouth.ac.uk

<sup>b</sup> Plymouth University, School of Architecture, Design and Environment, Roland Levinsky Building, Drake Circus, Plymouth, PL4 8AA, United Kingdom.

rory.jones@plymouth.ac.uk

**Abstract**

The workplace offers opportunities for energy savings, but few studies have evaluated the effect of energy feedback in offices. This paper reports a case study of an energy visualisation intervention among social care staff. The research examined the role of feedback design (simple graphs vs. visualisation) and discusses the feasibility of implementing a near real-time visual feedback intervention into a work setting with staff keenly aware of their primary job roles. The findings show a staff sample with positive beliefs towards energy saving, but bounded by low feelings of self-efficacy, weak social norms, and perceived barriers in the office. Feedback may have supported feelings of collective efficacy and encouraged staff to talk with colleagues about ways to save energy. But engagement with feedback – and energy use in general – was limited. Energy use was embedded in other concerns and issues, such as a strong team culture and wider problems in the building. The case study highlights the complexities of energy-related behaviours in the workplace and the role visualising energy could play in this context. Engagement will be a key challenge in achieving successful feedback initiatives; we provide recommendations to tackle this challenge and identify areas for future research.

*Keywords:*

Energy use, Feedback, Visualisation, Workplace behaviour

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## 1. Introduction

Research on energy saving has primarily focused on households, however 14% of UK annual energy use results from the service sector (e.g. Local Authorities, banking, tourism etc.; DECC, 2014). Although energy consumption at home is now understood better, research on energy use in the office is lacking (Greaves, Zibarras, & Stride, 2013; Matthies, Kastner, Klesse, & Wagner, 2011; Murtagh et al., 2013; Smith & O'Sullivan, 2012). Specifically, evidence on intervention strategies to motivate energy saving in the workplace is inconclusive (Matthies et al., 2013). It also remains to be seen whether findings from studies on home energy use can be translated to the workplace. The workplace offers a 'distinct' context (Murtagh et al., 2013) that warrants further investigation (Carrico & Riemer, 2011).

A number of barriers might prevent individuals from engaging in energy saving activities in the workplace, but opportunities have been identified as well. It is assumed that individuals in the workplace, compared to the domestic context, feel less personally responsible for energy use through a lack of direct financial interest (Murtagh et al., 2013). Further, shared appliances might reduce opportunities for employees to save energy as well as reducing the perceived impact of their actions (Carrico & Riemer, 2011). But the organisational context also provides opportunities for energy saving. Compared to households, a lower variety of electrical appliances is found at least in office workplaces, and behaviour may be embedded in fewer different practices than at home (Murtagh et al., 2013). However, the complexity of energy-related behaviours in the workplace should be noted, with factors such as organisational roles and work objectives that can work against energy saving (see Bull, Lemon, Everitt & Stuart, 2015; Coleman, Irvine, Lemon & Shao, 2013 for an overview). On the other hand, employees provide a 'captive audience' – low cost communications can easily reach the target group. Moreover, energy related behaviours in the workplace are regularly observed by colleagues, making them more susceptible to social norm interventions (Carrico & Riemer, 2011). Beyond direct financial motives, individuals might have other reasons to save energy at work (e.g. supporting the organisation or caring for the environment; Matthies et al., 2011). But more research is needed to investigate how we can utilise these motivations and promote energy saving behaviours in the organisational context.

This paper describes an exploratory field study that implemented an energy visualisation intervention, using a near real-time feedback display, in a UK Local Authority office housing social services (e.g. children social care) employees. This research responds to a call for studies in real-world organisational settings, which are able to capture important context-individual interactions (Carrico & Riemer, 2011). The study is set in an environment where high demands are placed on staff working on difficult cases with constant time pressures. This is within an organisation culture where financial cuts and redundancies are commonplace due to continued pressure on the UK public sector to make budgetary savings. Next to the results of the energy visualisation intervention, the paper will also discuss the challenges and barriers involved in implementing a

feedback display in this workplace context. Before discussing the study, the next sections will review previous studies in both the domestic and organisational context that have informed the current research.

## **2. Feedback: Making energy use visible?**

Energy has been described as invisible, abstract and intangible (Brandon & Lewis, 1999; Fischer, 2008). It is difficult to understand how much energy is used overall, and how energy is connected to what people do in their day-to-day life (Burgess & Nye, 2008). In a recent study members of the public were asked to draw what they thought energy looked like (Bowden, Lockton, Gheerawo, & Brass, 2014). The drawings ranged from end-points of energy use (e.g. plug sockets), nature images (e.g. trees, sun), to more abstract images. The results showed varied, sometimes opposing views, highlighting the difficulty of visualising energy.

There has been a push in the literature towards 'making invisible energy visible' (Darby, 2006; Hargreaves, 2010; Hargreaves, Nye, & Burgess, 2010), in particular by providing feedback. Feedback provides individuals with information on energy consumption or savings, often using devices such as in-home displays (Abrahamse, Steg, Vlek, & Rothengatter, 2005). Feedback can increase the relevance of behaviour by linking consumption to specific actions, and in turn, increasing a sense of control (Fischer, 2008). Thus feedback has the potential to empower householders (Thøgersen, 2005) through increasing knowledge on energy consumption, enabling householders to see the outcomes of their efforts, and providing social encouragement and support for further savings (Thøgersen & Granhoj, 2010). This taps into three factors known to influence energy conservation: knowledge, motivation and ability (Steg, 2008).

A meta-analysis of feedback studies found savings in energy consumption between 5 and 12% (Fischer, 2008). Compared to other interventions, Abrahamse et al. (2005) conclude that feedback can be very effective in changing energy behaviours in households, especially when provided frequently. Approaches that combine different strategies tend to be even more effective; for instance, goal setting can be combined with feedback (Abrahamse et al., 2005).

### *2.1. Feedback in the workplace*

Some studies have been conducted showing mixed support for the effect of energy feedback in the workplace. In 1996, Siero, Bakker, Dekker and Van den Burg tested the use of feedback amongst staff in a metallurgical plant. Two types of feedback were examined: a graphical display with energy saving results for the whole unit (updated weekly), and a comparative feedback condition where - in addition to the above - workers received information on the energy saving results of two other units. Both types of feedback reduced energy wasting behaviour, especially the comparative feedback. More recent studies have mainly used university offices. Carrico and Riemer (2011) report a 7% reduction in energy use after a feedback intervention amongst university staff across twenty-four buildings. The feedback consisted of a monthly email with a graph depicting the building's energy use, along with goal setting information. In a small scale study by Coleman, Irvine, Lemon and Shao (2013) paper-based feedback was provided to four staff in their research department using in-depth energy and occupancy data. They suggest that the feedback helped raise awareness and identify energy saving opportunities. Murtagh et al. (2013) examined the effect of near-real time feedback in

university buildings using the MyEcoFootprint gadget, which displayed a colour (red/amber/green) reflecting last week's energy efficiency. The gadget directed staff to a website with more in depth energy information (e.g. by hour, day and week). Individual feedback was provided, monitoring the electrical appliances connected to power sockets at the person's desk. Energy use reduced during the intervention period, compared to baseline, especially near the end of the sixteen week intervention. However, the same reduction was found for the participants who registered to use the gadget (necessary to get access to the website information), and those who did not. Also, accessing the website (i.e. number of times accessed and duration of visit) did not relate to energy use. The authors suggest feedback had a weak effect and highlight that staff reported a 'syndrome' of reasons for not saving energy while recognising that saving energy was a socially desirable thing to do. Murtagh et al. (2013) suggest office workers may lack a positive aim for saving energy, and initial motivations may not have been strong enough to overcome technical issues and barriers.

Indeed, Darby (2010) stresses that feedback may not automatically increase energy saving behaviour. Specifically, few studies consider the relevance of feedback design (Fisher, 2008). Visual imagery research can offer crucial insights into feedback design while technological advances have made it possible to move beyond the rather factual numbers and graphs commonly used to represent energy use. Visual imagery is closely linked to emotions (Holmes & Mathews, 2010; Zajonc, 1984), has qualities to condense complex information, and can quickly convey strong easily remembered messages (Nicholson-Cole, 2005; Sheppard, 2005). More artistic visualisations might be able to keep an audience interested for longer compared to pragmatic visualisations (Pierce, Odom, & Blevis, 2008). So far, research evaluating the effect of visual imagery in energy feedback is limited. As argued by Darby (2008), there is 'plenty of room for more visible, accessible information on energy use, in real time and retrospectively' (p.500). Some scholars have recently attempted to use more artistic, visual, displays – moving away from only using graphical information – to increase engagement. Chen et al. (2012) used a virtual aquarium to provide feedback on energy use in university offices; the amount of species and biodiversity reflected energy use. In one of the test offices an initial decrease in energy use was found, followed by a slight increase. A more consistent reduction in energy consumption was found in the second test-office. But the study was limited by its small sample size ( $N = 40$ ). The Greenview project (Bull, Stuart, & Everitt, 2012), designed a university wide campaign aimed at staff. An app was developed providing access to near-real time feedback on energy consumption in campus buildings. Each building was illustrated by an animation of an endangered species – happy, neutral and sad animations depicted energy use below the normal range, within the normal range and above the normal range, respectively. The report does not provide data on the impact of the app on energy consumption. However, only 7% of staff downloaded the app and based on a focus group with eleven stakeholders the authors note the need to maximise engagement further.

### **3. The current research**

Our research explores a combination of feedback, goal setting and visual imagery in the workplace. Rather than a university setting the current study focuses on UK Local Authority employees in social care services. In this challenging organisational context this paper examines and discusses the feasibility of implementing a visual feedback display, as well as exploring the effectiveness of the intervention in terms of energy-related

beliefs, perceptions and behaviour. We use a case study approach to illustrate the challenges of changing energy behaviour in the workplace using both quantitative surveys, qualitative responses and energy monitoring data. This mixed method approach enables a comprehensive account of the influences on, and the effect of, the energy visualisation intervention (Bryman, 2006). We will draw out lessons that highlight the differences between energy use in the domestic and workplace setting, and inform the design of future energy saving campaigns in the organisational context.

## **4. Method**

### *4.1. Participants and setting*

The research was carried out in collaboration with a Local Authority who selected a building in a city centre location that was used as office space. The building consisted of five floors; the ground floor was excluded as there were few staff, and not all staff had computer access (a requirement for the intervention phase). The remaining four floors had a similar open-plan office layout and could house approximately 300 members of staff in total. The majority of staff worked in social services, such as child protection. The Local Authority has a hot-desking policy and most staff did not have an allocated desk, but in practice hot-desking was rarely used and staff mostly remained on the same floor with their team.

### *4.2. Procedure*

Three stages of research were carried out, all focusing on electricity use in the building. Gas consumption was not measured in this study because it was not sub-metered by floor and staff had no manual control over the heating (in terms of heating period, temperature or areas). In stage one, six weeks before the start of the intervention, a baseline survey was distributed among staff to investigate the factors that might influence workplace electricity consumption in this specific setting. In stage two, a website showing a real-time electricity display was developed and made available to staff for six weeks. The intervention was framed as the 'Know Your Floor campaign', and started three weeks after data collection for the baseline survey was completed. Posters on each floor advertised the website, and a link to the website was sent out to all staff on Floor 1, 2, 3 and 4 by email. Eleven staff members (i.e. team leaders and admin staff) acted as contact persons in the building to send the correct website link to staff on each specific floor. The first email also included a set of FAQ's about the website (see Appendix A). After the first week, a reminder email was sent at the start of each week which included additional feedback on the cumulative usage, specifically total electricity use on that floor for that week (in kWh and pounds), and average weekly electricity use on that floor (in kWh). Finally, in stage three, responses to the feedback display and barriers to engagement were examined through a follow up survey administered during the final three weeks of the intervention and semi-structured interviews with staff after the six week intervention phase.

### 4.3. Feedback design

Four different websites (one for each office floor in the building) linked directly to the building's real-time electricity data. A website was designed because other options (e.g. desktop widget) were not technically or organisationally feasible at this point. All websites contained the following elements:

1. *Data on current electricity use and average electricity use.* The top right corner of the website (see Figure 1a and 1b) displayed current ('now') as well as average use ('usually') in kilowatt (kW) specific to each floor, updating approximately every five minutes. The average use was calculated using baseline data from the previous five months, adjusted as new data came in, and was matched to the current use by time and weekday.

2. *Hints and tips.* The bottom right corner displayed a 'Hints and Tips' box with a different hint each week on ways to save electricity, aimed at electricity related actions that employees could control: lights, computers, and appliances in the kitchen. Based on the baseline survey, where staff indicated that avoiding waste was one of their main motivators to save electricity (see Section 5.1.4.), the hints used an avoiding waste of electricity frame. For example: "Did you know that 200 lights left on all day and night in this building use about 280 kWh a day? So switching the lights off at night could avoid wasting 52,000 kWh, that's over £5,200 a year".

3. *Visual feedback display.* The left half of the feedback website included the question: 'Is your floor using less electricity than usual?' with a visual feedback display underneath. The websites for Floor 1 and Floor 4 showed current and average use in a simple bar chart (see Figure 1a). The websites for Floor 2 and Floor 3 showed the same data using a more visually appealing and fun display (see Figure 1b), linking to one of the motivations mentioned by staff in the baseline survey: contributing to climate protection. This display showed a tree that gained leaves and flowers and became greener as current electricity use decreased compared to the average use. Also, a squirrel (linked to corporate branding: image used on internal staff website) appeared in the tree and moved to the front of the screen. In turn, the tree lost leaves and flowers and became less green as current electricity use increased compared to average use. A total of fifteen tree visuals were designed, each assigned to a 5% range in electricity usage (see Appendix B). Five months of baseline electricity data were observed to derive meaningful categories in the tree visual. For instance, the ranges could not be too wide as no (or only few) changes in the tree visual would be visible during a work day, nor could they be too narrow as the tree visual would change constantly even at very small changes in usage. A 'best' version of the tree visual was set for current electricity use at 35% less than the average use or better. This percentage reflected a significant saving but also a realistic goal that could be achieved while the office was in use during the day. The tree display included a small icon showing the best version of the tree as a goal (see Figure 1b). Both visual feedback displays were consistent with the numerical data in the top right corner of the website - specifically linked to each floor, time and weekday and updated approximately every five minutes.

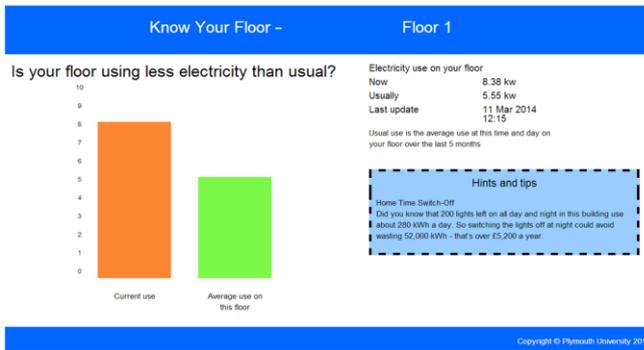


Figure 1a. The graph display (Floor 1 and 4)

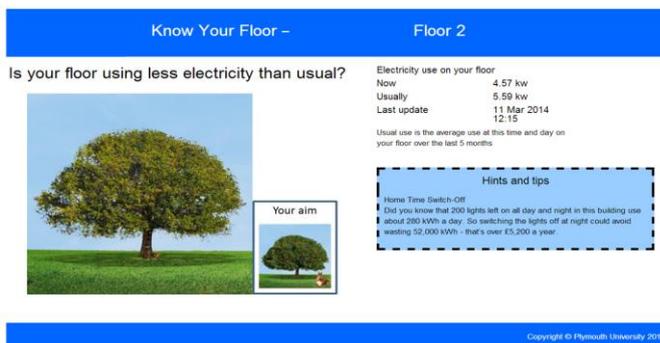


Figure 1b. The tree display (Floor 2 and 3)

#### 4.4. Measures

4.4.1. *Electricity consumption monitoring.* Electricity consumption data was collected at five minute intervals for each floor through an independent electrical sub-meter, which meant that the electricity consumption on each floor could be disaggregated from the building's total electricity consumption.

To monitor the electricity consumption of each floor, current transformers were clipped around the live phases of the electrical sub-meters. The meter system chip contained within the current transformers continuously sampled the current and averaged the consumption over the five minute period. This provided a more accurate measurement of the electricity consumption than taking a single measurement at the end of each five minute interval and ensured that no electricity consumption was missed and unrecorded. The current transformers were Class 1 metering devices with an accuracy of +/- 1%.

The current transformers automatically converted the current measurements into Kilowatts (kW) using a static assumed supply voltage and power factor. The current transformers stored the data: Current, Kilowatts (kW) and Time and Date for each five minute interval. The five minute data were then accessed and transferred wirelessly to a local data hub in the case study building and exported to a remote server using General Packet Radio Service (GPRS). The Kilowatt (kW) and Time and Date data could then be displayed on the feedback display in near-real time, as well as analysed by the researchers.

4.4.2. *Baseline survey.* An email with a link to the online baseline survey was forwarded by the contact persons to all staff on Floor 1, 2, 3 and 4. The survey could be filled in over a three-week period; two reminder emails were sent. Seventy-three staff members filled in the baseline survey (24% approximate response rate):

fourteen on Floor 1, twelve on Floor 2, nineteen on Floor 3, twenty-five on Floor 4, and three who did not work on a specific floor. Because of anonymity concerns demographics were not collected, but to gather some contextual information respondents were asked whether they were responsible for paying their own energy bills, this was the case for 90% of staff who responded to the baseline survey.

The baseline survey assessed personal, social and contextual factors that might influence electricity consumption, items were rated on a scale from 1(Strongly disagree) to 5(Strongly agree) unless stated differently.

*4.4.2.1. Beliefs on saving electricity at work.* Three items were included: saving electricity at work is too much of a hassle; I don't have time to think about saving electricity at work; there are many more pressing issues at work than saving electricity. A mean score was computed, items were recoded so a high score reflected positive beliefs, Cronbach's  $\alpha = .71$ .

*4.4.2.2. Personal norm.* The following items were included: I feel morally obliged to reduce my electricity use at work, regardless of what other people do; I feel guilty when I use a lot of electricity at work. A mean score was computed, Cronbach's  $\alpha = .62$ .

*4.4.2.3. Social norm.* To measure social norms respondents were first asked to rate two items: in our office you are expected to save electricity; my colleagues do what they can to save electricity (a mean score for these two items was computed, Cronbach's  $\alpha = .71$ ). In addition, respondents were asked how often they talked to their colleagues about the electricity wasted in their office; and about ways to save electricity in their office. The latter two items were rated on a scale ranging from 1 (Never) to 7 (Often).

*4.4.2.4. Self-efficacy.* Self-efficacy was measured by three items: I have control over how much electricity is consumed at work; I feel responsible for how much electricity is consumed at work; The things I do to save electricity at work have an effect. A mean score on self-efficacy was computed, the third item was omitted from the scale to increase the reliability, Cronbach's  $\alpha = .69$ .

*4.4.2.5. Collective-efficacy.* Next to self-efficacy, two items measured collective-efficacy: together, through joint effort, we can reduce electricity use at work; by avoiding unnecessary consumption we can save quite a bit of money on the Council's electricity bill. A mean score was computed, Cronbach's  $\alpha = .82$ .

*4.4.2.6. Ability to visualise.* Respondents were asked to rate on a scale ranging from 1(Not at all) to 7(Extremely) whether they could vividly imagine how much electricity is used in their office; and how electricity is wasted in their office.

*4.4.2.7. Motivation to engage in electricity saving at work.* Based on an item used by Matthies et al. (2011) respondents were asked to indicate on a scale ranging from 1(Not at all important) to 5(Extremely important), how important the following factors are in deciding to save electricity at work: that it contributes to climate protection; that it helps the council make financial savings; that it would avoid savings in other domains; that it provides an opportunity to try something new; that a lot of colleagues are trying to save electricity; that it helps future generations; that it avoids electricity being wasted.

*4.4.2.8. Current electricity saving actions.* Also based on a scale used by Matthies et al. (2011) respondents were asked to indicate on a scale ranging from 1(Never) to 5(Always) how often they conduct twelve electricity saving actions (for individual items, see Table 1). Participants could also tick a non-applicable box if the action

was not relevant to them. In addition, respondents were asked to respond to the more generic statement 'I actively look for things I can do to reduce electricity at work' on a scale ranging from 1(Completely disagree) to 5(Completely agree).

*4.4.2.9. Perceived barriers to electricity saving.* An open question asked respondents whether they perceived any barriers that prevented them from saving electricity at work. At the end of the survey, respondents were asked whether they had any further comments or questions.

*4.4.3. Follow-up survey.* After three weeks of the intervention, all staff on Floor 1, 2, 3 and 4 were sent another link to an online survey with a chance to win a shopping voucher as an incentive. The survey could be filled in over a three week period while the intervention was still running; two reminders about the survey were sent out. Fifty-two staff members (17% approximate response rate) completed the follow-up survey; eleven on Floor 1, fourteen on Floor 2, twelve on Floor 3, ten on Floor 4, and one who did not work on a specific floor. Participants entered a unique self-generated research code at baseline and follow-up to allow data matching but only seven respondents from the baseline survey also completed the follow-up survey. Thus, direct comparisons between the baseline and follow-up sample were not possible. The follow-up survey consisted of two parts:

*4.4.3.1. Feedback on the intervention.* First, respondents were asked how often they had visited the website: never, once or twice, once a week, several times a week, each day, several times a day, or an 'other' option where they were asked to specify. If respondents indicated that they had never visited the website they were asked the following open-question: 'There could be many reasons for not visiting the website, we are interested in your thoughts. Could you please explain why you have not visited the website so far?'

If respondents had visited the website at least once they were asked to select the floor(s) for which they had seen the website, and indicate which aspect of the electricity feedback website they found most useful. Finally, respondents were asked whether the information on the energy website was 'informative' and 'difficult to understand' on a scale ranging from 1 (completely disagree) to 5(completely agree).

*4.4.3.2. Personal and social factors.* Some of the items from the baseline survey were included a second time (using the same response scale), to measure beliefs ('Saving electricity at work is too much of a hassle'), personal norms ('I feel morally obliged to reduce me electricity use at work, regardless of what other people do'), self-efficacy ('I have control over how much electricity is consumed at work'), collective-efficacy ('Together, through joint effort, we can reduce our electricity use at work'), and social norms ('My colleagues do what they can to save electricity' and the two items measuring whether respondents talked to their colleagues about electricity waste/saving). Also, the items measuring ability to visualise were included again, and the item asking respondents whether they actively look for things they can do to reduce electricity at work. The full set of items could not be included a second time as feedback from the staff on high work pressures meant that the survey had to be kept as short as possible to increase the number of responses. As in the baseline survey, at the end of the survey, respondents were encouraged to share any further comments or questions.

#### 4.5. Semi-structured interviews

After the six week intervention phase a limited number of semi-structured interviews gathered more in-depth data. Part one of the interview explored what people found useful about energy displays and why. Participants were asked whether they would find it useful to know their electricity use at work, whether they had seen energy displays in the past, and whether they thought it would help them guide energy saving actions. Then participants were shown the electricity feedback displays designed for this research (some of the participants would have already seen these) and asked to respond in terms of – what is engaging about the displays, which elements would you look at first, what is missing from the displays etc. In the second part of the interview participants were asked more broadly about the barriers they experienced when saving electricity at work. Recruitment for the interviews occurred via email, inviting staff members who had, and had not, seen the website. Interviews took place outside of work hours, so participants received £20 in recognition of their personal time given. Nine staff members signed up for the interviews and four sessions were held (with 1-3 staff members each). One or two researchers were present, and the sessions were recorded with a digital voice recorder and analysed using NVivo to identify recurring themes across the transcripts and between employees (Braun & Clarke, 2006).

## 5. Results

### 5.1. Baseline survey findings

5.1.1. *Beliefs on electricity use and savings.* Staff had relatively positive beliefs towards saving electricity at work ( $M = 3.54$ ,  $SD = 1.09$ ) so they did not perceive saving electricity at work as too much of a hassle or time-consuming.

5.1.2. *Self-efficacy and collective-efficacy.* Collective efficacy was reported as higher compared to self-efficacy,  $t(72) = -8.18$ ,  $p < .001$ ,  $d = 1.04$ , Figure 2. So, staff felt that as individuals they did not have a lot of control over the electricity use but they believed that all staff together could save electricity.

To further assess staff's perceived ability to reduce electricity use at work, participants were asked whether they could vividly imagine how much electricity is used and wasted in the building. Mean scores on both items (on a 7-point scale) were relatively low – but staff found it easier to imagine how electricity was wasted in the office ( $M = 3.97$ ,  $SD = 1.93$ ), compared to imagining how much electricity was used in the office ( $M = 3.16$ ,  $SD = 1.94$ ),  $t(72) = -4.53$ ,  $p < .001$ ,  $d = .53$ .

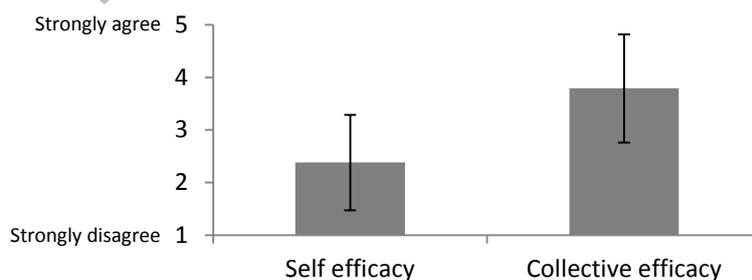


Figure 2. Mean score for self efficacy and collective efficacy at baseline. Error bars represent SD.

5.1.3. *Personal and social norm.* Personal norms to conserve electricity ( $M = 3.16, SD = 0.98$ ) were stronger than the perceived social norm ( $M = 2.68, SD = 0.94$ ),  $t(72) = 3.31, p = .001, d = .39$ . As an alternative measure of social norms, participants reported that they sometimes talked to their colleagues about the electricity wasted in their office ( $M = 2.36, SD = 1.63$ ), and about ways to save electricity in the office ( $M = 2.42, SD = 1.52$ ), with no significant difference between the two items,  $t(72) = -0.74, p = .460, d = .08$ .

5.1.4. *Motivations.* Seven factors were rated on importance in deciding whether to save electricity at work. The factors: 'that a lot of my colleagues are trying to save electricity' ( $M = 3.01, SD = 1.12$ ) and 'that it provides an opportunity to try something new' ( $M = 3.34, SD = 1.11$ ), were rated significantly less important than all other factors (at  $p < .001$ ). 'That it contributes to climate protection' ( $M = 3.93, SD = 1.10$ ), 'that it would avoid savings in other domains' ( $M = 3.95, SD = 0.91$ ), 'that it helps the council make financial savings' ( $M = 4.01, SD = .92$ ), 'that it helps future generations' ( $M = 4.08, SD = .89$ ), and 'that it avoids electricity being wasted' ( $M = 4.16, SD = 0.91$ ) were all rated as quite important with no significant differences.

5.1.5. *Current electricity behaviours and barriers to action.* Overall, the frequency of electricity saving actions was relatively high (see Table 1). In particular, staff reported shutting down their computer and switching off their own ceiling light after work, using the wall-mounted boiler for hot water, and never using a fan heater in winter.

Table 1

*Mean scores on electricity saving behaviours in the office*

Item	Mean (SD)	N*
Whenever I leave my office after work, I shut down my computer	4.95 (0.47)	73
Whenever I leave my office after work, I switch off the ceiling light above my desk	4.06 (1.54)	66
Whenever I leave my office for an extended period of time, I switch off the ceiling light above my desk	2.48 (1.72)	64
I switch off the lights when daylight is sufficient	3.86 (1.47)	71
I ensure that none of my appliances are left on standby	4.26 (1.14)	70
I ensure that my chargers are unplugged when not in use	4.13 (1.36)	55
In the winter, I use a fan heater at my desk (recoded; a score of 5 reflects never using a fan heater)	4.48 (1.06)	66
I only boil the water I need in the kettle	3.90 (1.53)	42
I make sure that the fridge or freezer door is not open for longer than necessary	4.60 (0.89)	70
I use the wall-mounted boiler for hot water	4.26 (1.46)	65
I switch off the lights after using a meeting room	4.41 (1.11)	70
Whenever I leave my office after work, I switch off lights in the office that are left on	3.92 (1.48)	63

\* Note: The reduced sample size for some of the items is due to the number of participants that ticked the 'non-applicable' box for this item.

A more general measure of electricity saving behaviour which asked staff to what extent they actively looked for things they could do to reduce electricity at work, had an average score just above the midpoint of the

scale ( $M = 3.30, SD = 1.15$ ). So, even though staff reported frequent electricity saving actions, this does not necessarily imply that they were actively looking for ways to save electricity. Actively looking for ways to reduce electricity correlated positively with (in order of correlation strength): personal norm ( $r = .57, p < .001$ ), talking with colleagues about electricity being wasted in the office ( $r = .54, p < .001$ ) and ways to save electricity ( $r = .50, p < .001$ ), self-efficacy ( $r = .43, p < .001$ ), beliefs on saving electricity at work ( $r = .40, p = .001$ ), collective efficacy ( $r = .32, p = .006$ ), being able to vividly imagine electricity waste ( $r = .29, p = .012$ ) and use ( $r = .27, p = .021$ ).

Box 1: Quotes illustrating the main barriers to electricity conservation identified by staff

Theme	Quotes
Theme 1: Others – attitudes and observed behaviours	<p><i>“colleagues do not attempt any effort to save power! a simple task to switch off monitors at the end of the day could save a lot of electrical consumption particularly over the weekend”.</i></p> <p><i>“other people think you are saving electricity by leaving computers on standby rather than turning them off completely - they think you use more energy re-starting them each time”</i></p>
Theme 1: Others – counterproductive actions	<p><i>“not everyone is aware or thinks much about this issue, I can only do my bit”</i></p> <p><i>“other people never turn lights off when they have finished in meeting rooms, I do this in the rooms near where I sit after the meetings have finished.”</i></p>
Theme 2: Office infrastructure – loss of individual responsibility and loss of opportunities	<p><i>“open plan office so many practices are common and could not be changed by an individual”.</i></p> <p><i>“hot-desking does diminish personal responsibility re; lights, windows open/closed etc.”</i></p> <p><i>“in hot desking and shared large office spaces everybody has different needs and there aren't lights directly over each desk and person, so things are always a compromise”</i></p>
Theme 2: Office infrastructure – technologies	<p><i>“printers / shredders etc have to be left on (in powersave mode though) all night. Not all ceiling lights have cords on to be able to turn them off individually”.</i></p> <p><i>“the open plan office arrangements mean that the lighting and heating cannot be adjusted for individual workers - if you are the last one in the office, you still have lighting for twenty people”.</i></p>
Theme 3: The heating system	<p><i>“also the heating is boiling, we don't need it so high, it's pumping out full and we have all the windows open!”</i></p> <p><i>“heating is not effective. There is no individual control on the radiators, therefore when it's cold we have to use electric heaters and when it's hot we have to have the windows open despite the heating being on.”</i></p>

Staff were also asked to describe any barriers that prevented them from saving electricity at work. Thirty-six people provided responses that were coded into recurring themes. The themes were: others (attitude, knowledge, perception of;  $N = 13$  comments), office infrastructure ( $N = 10$  comments), heating in the building ( $N = 8$  comments), old equipment ( $N = 5$  comments), and low priority ( $N = 3$ ). The three most common themes are described below, see quotes in Box 1.

*Theme 1: Others.* Thirteen staff commented on how other people detract from the goal of saving electricity. Staff felt they were not able to realise achievable savings due to counterproductive actions by others.

*Theme 2: Office Infrastructure.* The office infrastructure also provided a barrier to electricity savings. Staff described the office hot desking arrangement and open-plan office lay-out as limiting personal accountability. Also, differing needs of staff resulted in compromises to achieve a comfortable working environment. The by-product of this collective compromise and loss of individual responsibility was the loss of opportunities to conserve electricity and an undermining of individual feeling of efficacy. Technologies too can work against efforts to conserve electricity, although these comments may also reveal a lack of awareness on available controls.

*Theme 3: The Heating System.* The focus of the current study was on electricity use, but eight people spontaneously described the gas-fired heating system in the building as a potential for conserving energy (not electricity).

## 5.2. Discussion baseline findings

This group of staff were positive about conserving electricity, with multiple reasons to do so. Their personal moral obligation to conserve electricity was higher than the social norm perceived within the office. Yet, staff believed that by working together collectively, electricity savings could be achieved. Staff already reported frequent electricity saving actions. But, qualitative comments from staff identified barriers that prevented them from doing more, such as the infrastructure of the office. Another indicator of social norms was the frequency with which staff talked to one another about electricity saving and waste. The results showed that staff did not talk with their colleagues about electricity saving and waste very often. This is important to take into account because, next to personal norms, the frequency with which staff talked to their colleagues about electricity strongly correlated with whether they actively looked for electricity conservation behaviours. Another factor which was associated with looking for electricity conservation behaviours was the ability to imagine electricity use in the office. The results showed that staff were able to imagine the electricity wasted in their office to some extent – but reported finding it more difficult to imagine the electricity used in their office.

## 5.3. Electricity consumption monitoring findings

Electricity consumption data are reported below, focusing on describing the data pattern over the six weeks for each floor rather than statistical analysis, similar to previous studies (cf. Matthies et al., 2011).

*5.3.1. Total electricity consumption.* First, the total weekly electricity consumption on each floor during the six-week intervention period is presented and compared to the average weekly electricity consumption measured during the five month baseline period (see Figure 3). Over the combined six week intervention period, electricity use on Floors 2 (tree display) and Floor 4 (graph display) fell by 4.8% and 13.9% respectively, compared to an equivalent of six weeks baseline electricity consumption (i.e. average weekly baseline consumption for the floor multiplied by six). With the exception of Weeks 4 and 6 on Floor 2, where 1.0% and

0.7% increases in electricity consumption were recorded, Floors 2 and 4 made electricity savings during each intervention week (see Figure 3). But, the percentage of electricity savings achieved on Floors 2 and 4 degraded over the intervention period. The total electricity consumptions on Floors 1 (graph display) and 3 (tree display) over the combined six week intervention period were slightly higher (0.6% and 1.1%) than would have been expected during a six week period of baseline electricity consumption. Figure 3 shows that the overall higher electricity demands during the combined six week period were mainly the result of large increases in usage during Weeks 3 and 4.

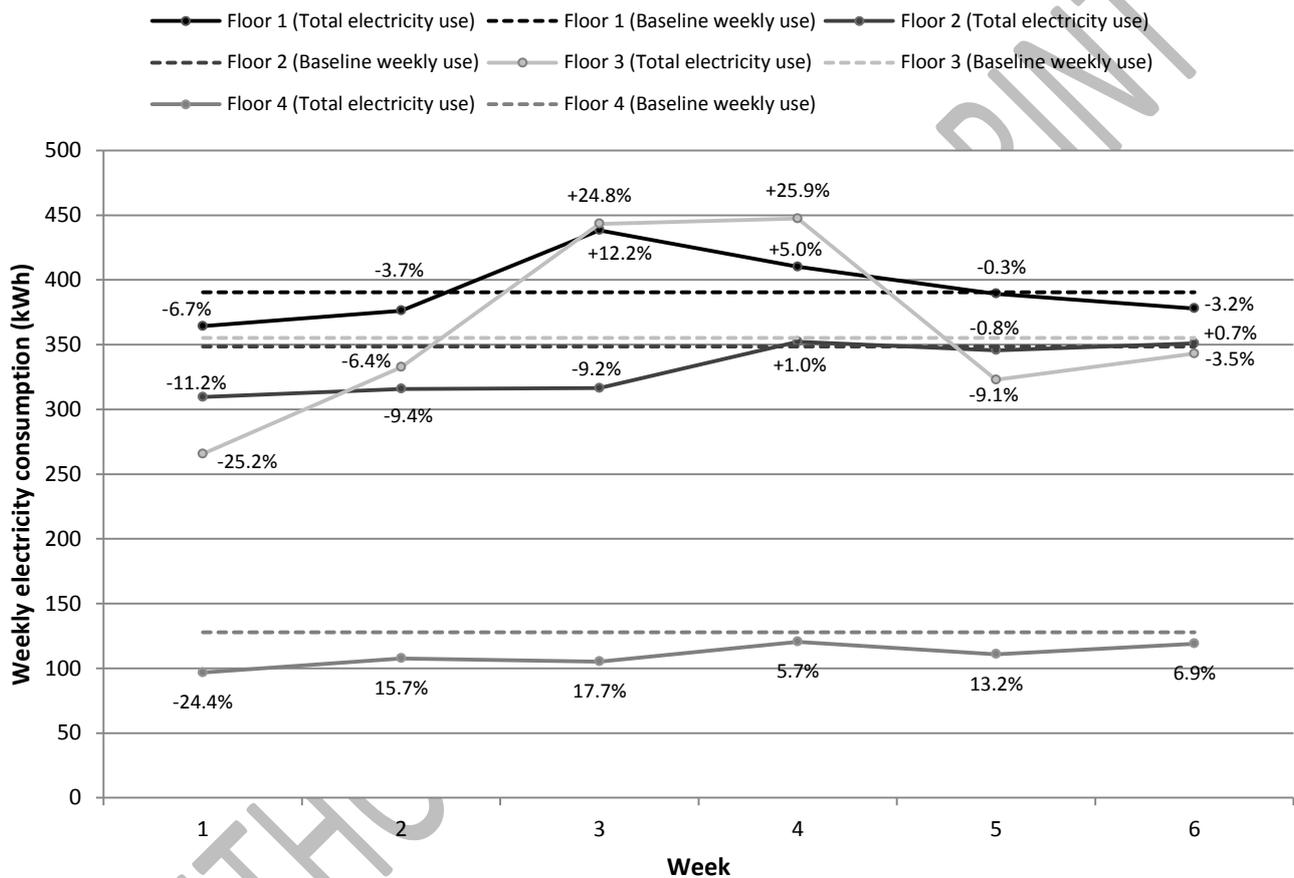


Figure 3. Week-on-week change in total electricity consumption during the intervention period on Floor 1 (Graph), Floor 2 (Tree), Floor 3 (Tree) and Floor 4 (Graph), compared to average weekly baseline consumption on each floor.

5.3.2. *Electricity consumption during non-work hours.* The electricity savings achieved during non-working hours accounted for a large proportion of the total electricity savings. On Floor 2, 52% of the electricity saved during the intervention period could be attributed to non-working hours and for Floor 4, this figure was 22%. In line with the total weekly electricity consumption results, during Weeks 3 and 4, the non-working hours electricity consumptions on Floors 1, 2 and 3 increased. But, over the combined six week intervention period, all four floors made reductions in electricity consumption compared to an equivalent of six weeks non-working hours baseline consumption (i.e. average weekly baseline non-working hours

consumption for each floor multiplied by six), Floor 1 saved 2.3%, Floor 2: 6.5%, Floor 3: 4.3% and Floor 4: 17.9%.

#### 5.4. Follow-up survey findings

Only seven participants from the baseline survey also completed the follow-up survey, thus direct comparisons between the baseline and follow-up sample were not possible.

5.4.1. *Engagement with feedback.* The majority of respondents (64%) to the follow up survey reported that they had never visited the feedback website, 29% reported visiting once or twice, 4% reported visiting once a week, and 4% reported visiting more than once a week, see Table 2.

Table 2

*Number of participants who reported visiting the feedback website per floor*

		Floor 1 (Graph display)	Floor 2 (Tree display)	Floor 3 (Tree display)	Floor 4 (Graph display)	Hot desk	Unknown floor	Total
Visited the website	Yes	5	4	7	2	0	1 (Graph display)	19*
	No	6	10	5	8	1	3	33

\*Note: Of those who did visit the website, most viewed the feedback display for their own floor. There is one exception: one person on Floor 2 visited the website for the Floor 1 and Floor 2 display (Graph and Tree, respectively).

In total, slightly more people indicated that they only visited the tree display ( $N = 10$ ) compared to the graph display ( $N = 8$ ). But these groups are too small to conduct statistical analyses on the difference between viewing different displays. So, the quantitative analyses will focus on the difference between those who did, or did not, visit the feedback website.

Staff reported three main reasons for not visiting the display, with the prominent barrier being lack of time ( $N = 13$ ): “no time, I am interested but my workload is so much that I do not have a minute to look into this”; followed by not being aware of the display ( $N = 9$ ): “I was not aware of it or the benefits of doing so”; and work pressures ( $N = 8$ ): “Too busy with work”. In addition, two members of staff provided alternative reasons (i.e. new member of staff, and low priority).

Website views were recorded when people visited the website but as there was only one IP address for the building it was not possible to identify unique views. The website was visited 291 times in total. The Floor 1 display was visited 60 times, Floor 2 display 66 times, the Floor 3 display 91 times, and the Floor 4 display 74 times. Figure 4 shows that there was a peak in visits between 9.00 and 12.00 and between 16.00 and 18.00, and a small peak around lunch time. The data also indicates that the majority of visits was in Week 1 of the intervention ( $N = 170$ ), followed by a large drop in views in Week 2 ( $N = 19$ ) and Week 3 ( $N = 24$ ). The views picked up again in Week 4 ( $N = 44$ ), when the follow-up survey was sent out, and decreased again after ( $N = 19$  in Week 5 and  $N = 15$  in Week 6).

5.4.2. *Evaluation of the website.* The participants who reported visiting the feedback website found the information on the website informative ( $M = 4.05$ ,  $SD = 0.52$ ), and not difficult to understand ( $M = 2.16$ ,  $SD =$

0.96). Staff were also asked to describe which aspect of the feedback website they found *most* useful in understanding the electricity use on their floor. The actual (real time) consumption was seen as most useful (6/18), with the comparison between actual and average also seen as useful (4/18). Qualitative data on the use of the tree and graph display are reported in Section 5.6.1.

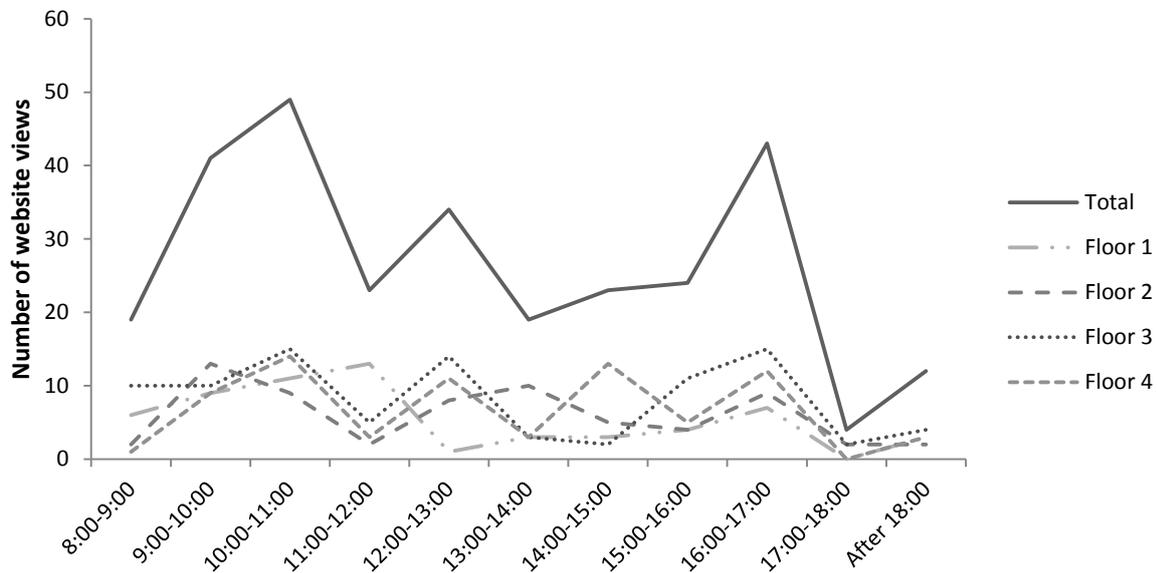


Figure 4. Total number of website views for each time period over six weeks, per floor

#### 5.4.4. Responses to the feedback website.

5.4.4.1. *Personal and social norm.* Staff who visited the website ( $M = 3.05$ ,  $SD = 1.96$ ) reported talking to their colleagues more about ways to save electricity in the office, compared to those who did not visit the website ( $M = 1.90$ ,  $SD = 1.27$ ),  $U = 194.00$ ,  $N_1 = 19$ ,  $N_2 = 31$ ,  $p = .034$ . And, a marginal significant difference between participants who had ( $M = 3.16$ ,  $SD = 1.89$ ), and had not ( $M = 2.19$ ,  $SD = 1.56$ ), visited the feedback website was found for the extent to which staff reported talking to their colleagues about the electricity wasted in their office,  $U = 207.50$ ,  $N_1 = 19$ ,  $N_2 = 31$ ,  $p = .067$ . No significant difference was found between staff who had visited the website and those who had not for social norm ( $M = 2.95$ ,  $SD = 0.97$ , and  $M = 2.87$ ,  $SD = 0.81$  respectively),  $U = 272.00$ ,  $N_1 = 19$ ,  $N_2 = 31$ ,  $p = .627$ , and personal norm ( $M = 3.68$ ,  $SD = 1.25$ , and  $M = 3.29$ ,  $SD = 1.51$  respectively),  $U = 257.00$ ,  $N_1 = 19$ ,  $N_2 = 31$ ,  $p = .440$ .

5.4.4.2. *Self-efficacy and collective-efficacy.* Both participants who did ( $M = 2.53$ ,  $SD = 1.07$ ), or did not ( $M = 2.48$ ,  $SD = 1.24$ ), visit the feedback website reported that they had limited control over how much electricity is consumed at work,  $U = 279.00$ ,  $N_1 = 19$ ,  $N_2 = 31$ ,  $p = .749$ . Participants who visited the feedback website did report a stronger belief ( $M = 4.32$ ,  $SD = 1.00$ ) that, as a group, staff in the building could reduce electricity use at work, compared to participants who did not visit the website ( $M = 3.74$ ,  $SD = 1.18$ ),  $U = 199.00$ ,  $N_1 = 19$ ,  $N_2 = 31$ ,  $p = .042$ . Furthermore, there was a non-significant trend that staff who visited the website, compared to those who did not, found it easier to imagine how much electricity was used in their office ( $M = 3.68$ ,  $SD = 1.92$ , and  $M = 3.00$ ,  $SD = 1.90$  respectively), and how much electricity was wasted in their office ( $M = 4.79$ ,  $SD = 1.69$ ,

and  $M = 4.13$ ,  $SD = 1.98$  respectively),  $U = 232.00$ ,  $N_1 = 19$ ,  $N_2 = 31$ ,  $p = .203$  and  $U = 237.50$ ,  $N_1 = 19$ ,  $N_2 = 31$ ,  $p = .247$ , respectively.

*5.4.4.3. Electricity saving beliefs and actions.* There was also a non-significant trend that people who visited the feedback website thought electricity saving at work was more of a hassle (if visited  $M = 2.05$ ,  $SD = 1.18$ ; if not visited  $M = 1.61$ ,  $SD = 1.02$ ),  $U = 224.00$ ,  $N_1 = 19$ ,  $N_2 = 31$ ,  $p = .118$ , but that they actively looked for things to reduce electricity at work ( $M = 3.79$ ,  $SD = 0.92$ ), compared to those who did not visit ( $M = 3.45$ ,  $SD = 1.15$ ),  $U = 241.50$ ,  $N_1 = 19$ ,  $N_2 = 31$ ,  $p = .272$ . However, these non-significant trends need to be interpreted with caution.

### *5.5. Discussion follow-up findings*

The main functions of the feedback website were to communicate real time electricity usage and set that use in the context of normal usage, and indeed these were the two aspects which staff found most useful. Providing feedback on electricity use at work appears to be associated with discussion of electricity use among the staff, with staff who visited the website talking more frequently to their colleagues about electricity saving, compared to those who did not visit the website. Visiting the website was also associated with collective efficacy, with staff feeling more able to save electricity in the office as a group. There was some indication that providing feedback may have also enabled staff to imagine electricity use and waste more readily, but this needs further investigation.

However, the results particularly indicate problems with engaging staff. Only a minority visited the feedback website, which meant that the tree and graph group could not be compared as intended. And only seven participants filled in both the baseline and follow-up survey which again limited the effects that could be investigated. The differences in responses between staff visiting the website and staff who did not could indicate the effect of the website or reflect prior individual differences. The responses highlight the problem of engagement, time and work pressures as the main reasons for staff not accessing the feedback website.

### *5.6. Semi-structured interviews findings*

Interview responses provide additional insight into the process of implementing an energy visualisation intervention into a time-pressured challenging office environment. The interviews were structured around two parts: the use of the feedback website (i.e. how employees attended to electricity use information and the implications this has for presenting energy data) and barriers to engagement. Responses from part one highlight two emerging uses of the feedback website: making electricity use meaningful and connecting electricity use to actions. Responses from the second part highlight what captures employee attention and other barriers to electricity conservation in the workplace.

#### *5.6.1. Use of the feedback website.*

*5.6.1.1. Making electricity use meaningful.* The feedback website provided visual feedback of electricity use, with the aim of making electricity use more tangible. How the tree visual helped in making electricity use more meaningful is reflected in this quote:

*"I knew Floor 2 was bad....from the picture. When you look at the figure, I am an average person; I have no clue what the numbers are. It's just kilowatt, I know that is electricity something. I don't know if it is good or if it's bad. You put me picture of a dying tree, yes, I know, oh that is bad. A picture of a tree or a random number, then I will look at the tree. It jumps out. If I looked into it, the numbers, but it's boring".*

The enhanced visual, using a tree, had the advantage of engaging employees in the changing health of the tree which also provided an easily grasped goal; employees knew what to aim for. In doing so it provided a measure of whether current usage was 'good or bad' and a comparison of how far the current use was from the desired state: *"...our tree's like this and it should be like that. Or your tree is like this and we want it like that".*

However, not all employees experienced the same ease in drawing out meaning from the tree visual. For some, the graph display provided a clearer message:

*"Well you can just see straight away that... that we're using less than average. Which is the message isn't it? Whereas with the tree, the tree it's like... Good or bad compared to the number of leaves isn't it? We don't necessarily link it to average use".*

Generally, preference for the graph or the tree visual seemed to be down to personal choice and employees' ability to engage with numerical data:

*"For me, I'd prefer a simple graph, and if you're talking about targets and about making change I need to see what change needs to be done by how much, otherwise I can't gauge it, and then I'm like ah well it's never going to happen. That's terrible isn't it but at that tree I'm like, well I don't know what needs to be changed so".*

It has been suggested that certain numeracy skills, i.e. the ability to understand numbers, may be needed to comprehend energy feedback displays (Buchanan, Russo & Anderson, 2015). Here, this might be reflected in a preference for the graph display for some employees whereas others found the tree display more meaningful.

The environmental frame reflected by the tree further helped to connect the electricity data with a meaningful outcome, for some this was positively evaluated:

*"It is relevant. It makes a point without slapping you in the face with it. It reminds you that it is the environment. You want to see the next tree to see if it is any better".*

But a money frame was important too. Employees felt very keen to conserve Local Authority money as they directly experienced the effect of money shortages. However, at the same time there was bitterness over low salary increases and perceived inefficiencies in the Local Authorities' finance systems, e.g.: *"Do not go down the money route. Pay raise of 1% ooh! Everyone is bitter about it".* Therefore using Local Authority money as a frame for electricity use could engage some employees but irritate others.

**5.6.1.2. Connecting electricity use to actions.** The need for the electricity data to connect to meaningful actions was clearly stated by staff:

*"I went straight to the electricity use on the floor. I was trying to think what that actually means. I was thinking, Ok, ok what does that mean, or how can it be reduced, how much electricity does that use. How much does a light bulb use? Some info would be really helpful and oh....it's there actually".*

This information was provided by the hints and tips section on the website. Further quotes also reflect positively on providing this:

*"It draws your attention to actual real life sort of oh what can I do about it, then it's like well here's one thing I can do."*

*"That hints is interesting, it puts it in to more of a thing that I can understand. I don't understand at all 351 kilowatts or whatever. To say that a fridge left on for that long uses that much and that is how much it costs....it makes more sense".*

The connection between electricity use and actions came up again when participants discussed the near-real time feedback which afforded an appreciation of the degree of change throughout the day. Once attention was drawn to the changing usage this naturally generated a connection with employees' actions at the time:

*"It is amazing how quickly it goes up actually, 10 o'clock, 7.4[kW]. I need to check who is in the office, if there is a lot of a people [sic] in the office or not. On a Friday afternoon, there will be a lot less consumption than on a Tuesday morning. So that's in the morning 9.25, It's Floor 3. Floor 2 uses a lot don't they [Whispers] What are we doing wrong? [Laughs] Em. That's quite high there as normally it's about..."*

#### *5.6.2. Barriers to engagement.*

*5.6.2.1. Capturing employee attention.* Throughout different aspects of the field study engagement and participation was relatively low. This highlights a key challenge when providing employees with access to any energy (use) information at their place of work (see also Bull et al., 2012; 2015; Murtagh et al., 2013). Some responses suggested the tree was good at attracting positive attention: *"I think you are just automatically drawn to the tree"*. Employees' responses show that whilst willing to engage in electricity saving in general, time constraints and busyness at work (*"Yeah, well people are very, very busy"*) were named as important factors in attending to the displays. These social care staff clearly felt primarily engaged in other roles.

*"Sometimes people rush out of the meetings with 27 action points and its life or death and they have got to get this child now. They rush out the room and they are not thinking 'have I checked the window?'"*

*"The stuff that we deal with it is so overwhelming. I am dealing with children that are in royal c..p[sic] and you know.....we are not focussed on the environment".*

Particularly in this very challenging work environment energy data should be very quick to access in order to grab attention, as illustrated by one staff member:

*“it just becomes so unimportant in comparison with the fire-fighting you’re doing with work. And it shouldn’t be, and I guess if it was up somewhere and your attention was drawn to it and you could just glance very quickly”.*

5.6.2.2. *Other barriers to electricity conservation.* Two of the barriers identified in the baseline survey emerged in the interviews (i.e. office infrastructure and heating in the building). These responses illustrate the ‘syndrome of reasons’ (Murtagh et al., 2013) which can work against energy conservation in the office. First, one issue in the building was employees leaving computers locked whilst they were not at their desk, despite Local Authority instructions to switch off the computer if the desk is unattended for two hours or more. This behaviour was due partly to concerns originating from the shared working environment and hot-desking policy. This was linked to convenience:

*“You have got to come back and you have to find a seat, find the right chair, get my stuff, whereas if you left it you could come back and carry on. They want to be with their team. If you have managed to get a seat with your team. You might have to find yourself sitting with a different team”.*

But there were also important security and support issues, which were driving employees to secure their workspace:

*“Everyone needs to be part of a team. Have that support around them. If you are in a team you know the cases the team have, you know where they have been. You could have gone to a meeting. The team realise that you have not come back to the office and you were at a visit”.*

Thus, a strong team culture combined with the Local Authorities’ hot desking policy was linked to electricity use in the building. One of the other issues in the building: the heating system, also illustrates the importance of taking the context of the feedback intervention into account. Although not related to electricity use, the focus of this study, employees were very concerned about the building’s heating system.

*“When you are working in this building on a hot day and you are sat down next to a radiator and the radiator is on and you’re thinking, why? (laughs) ..em...or you are opening windows. You’re opening a window because you can’t control the heat. Especially at a time when we are being told that money is in short supply (laughs)”.*

So, employees were encouraged to save electricity in an environment with obvious energy waste outside their individual control. Despite complaints to the estates department about the heating system employees did not perceive any changes, leading to a general distrust of and frustration with the system:

*“[...] I cannot do anything about my localised heat, because it’s all dealt with centrally. I don’t know where these thermostats are, they are supposed to be up like up there somewhere, checking the readings, keeping it at 20 degrees. Never have I been in a room at [our building] which is 20 degrees, its either freezing or boiling. It does not seem to work, whatever the system is”.*

## **6. General Discussion: The feasibility of saving energy in a challenging organisational context**

Previous research on changing energy-related behaviours in the workplace has focused largely on university staff. Participants in the present study were predominantly employed in child protection and social work. This made for an important case study cohort of very busy staff in a challenging context, keenly aware of their primary role with little capacity to use their time on saving energy. Here we will discuss the main findings and challenges of changing energy-related behaviours in this context that emerged from the study.

Despite this challenging context, overall employees reported positive beliefs with regards to saving electricity at work, and a range of electricity saving actions with a variety of reasons for doing so. Response rates for the surveys were reasonable, but it was difficult to engage employees with the feedback website. This led to small sample sizes in the experimental groups. There were some promising results with staff who had visited the feedback website reporting a stronger feeling of collective efficacy, as well as talking more to their colleagues about ways to save electricity in the office. In addition, the consumption data suggests a potential electricity saving during the intervention period for both energy visualisations (graph and tree). But, the variability in electricity consumption makes it difficult to assess the impact of the feedback website, and opens up questions around infrequent and uncontrolled events in the office which could affect electricity use, for instance there might be periods of increased occupancy, new equipment installed in the offices, or new members of staff.

The lack of engagement with the displays limited our analyses. Time pressures and work priorities were an important factor here – given their job demands employees felt that they did not have the time to think about electricity conservation. Electricity use was not a priority at work, and the uncertainty around control and responsibility with regards to energy further complicated this. Moreover, the results revealed many reasons which could underlie wasteful energy behaviours and showed how electricity use was embedded in other concerns, such as vital team support. Although similar challenges are likely to be experienced in other workplace settings staff in the current social care context reported being very aware of their important primary role. This also raises questions around the moral implications of adding energy concerns to these employees' lives. The finite pool of worry literature suggests that people only have so much capacity for worry (Linville & Fisher, 1991).

The building itself also posed an important challenge, and again emphasises the need to consider the wider context of the intervention. Staff expressed their concern about the heating system and the resulting energy loss they perceived from this at multiple occasions throughout the project. It was felt that this issue was outside of their control and trust in the system was low, also due to other problems in the building unrelated to energy (e.g. leakages, broken down lifts). Noticeable and visible issues such as these may have reduced feelings of personal responsibility in staff to conserve electricity.

These challenges emphasise that energy use in the workplace is by no means less complex than energy use in the home as also noted in recent studies (e.g. Bull et al., 2015). In this research we see how social and organisational structures, work pressures, job roles, and the building, all interact and add to the complexity of the system. Importantly, issues such as these are unlikely to be solved just by providing employees access to energy use information and shows the importance of taking the context of the feedback intervention into

account during the development and evaluation phase. Recent initiatives (e.g. the International Energy Agency DSM taskforce 24; IEA DSM, 2015) have started to unravel the complexities of energy-related behaviours to facilitate behaviour change. To move the field forward, calls for more systematic evaluations of intervention programmes for household energy use (Steg, 2008) should also apply to research investigating energy use in the workplace. So, evaluations should focus not only on the effect of the intervention, but also examine the factors that made the intervention (un)successful, in order to inform and improve future interventions. Mixed method designs, such as the one used in the current paper, which utilise the potential of each approach to answer different types of research questions, are ideally suited for this purpose. Although important lessons can be learned from research on household energy conservation, the workplace offers a very distinct and complex context, where different types of organisations and work tasks might offer distinct challenges that need to be overcome to successfully engage with staff. This calls for a contextualised approach (cf. Clayton et al., 2015) which considers the transactions between employees and their social/physical environment, and tailored interventions which take the characteristics and challenges of the specific workplace setting into account.

## **7. Conclusion**

Recently, researchers and policy makers alike have become increasingly aware of the need to study the energy saving potential of the service sector. We propose that particularly challenging contexts need to be investigated to test the potential and feasibility of energy saving interventions in the workplace. The case study presented in this paper draws out challenges and opportunities at various stages of implementing near-real time visual energy feedback. There is limited capacity for engagement when people are very pressured in their primary role. Especially in this context, there is a need for simple, intuitive, attention-grabbing energy feedback that does not require much cognitive analysis. Visualisations could fulfil this role, but it is essential for management and the context to be responsive; for instance, by making the building the best it can be before expecting behaviour change from employees. Engaging staff with any energy-saving intervention is likely to be an important challenge and it requires further research - feedback interventions will need to work with the complexities present in each workplace setting to be successful at reducing energy consumption.

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