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Individual energy use and feedback in an office setting: A field trial

Niamh Murtagh [a,*], Michele Nati [b], William R. Headley [b], Birgitta Gatersleben [a], Alexander Gluhak [b], Muhammad Ali Imran [b], David Uzzell [a]

[a] School of Psychology, University of Surrey, Guildford, Surrey GU2 7XH, UK
[b] Centre for Communications Systems Research, University of Surrey, Guildford, Surrey GU2 7XH, UK

HIGHLIGHTS

- First study on individual energy use and feedback in offices.
- Field trial with 83 office workers, measuring plug load at desks over 18 weeks.
- Feedback resulted in energy reduction although not consistently.
- Sizeable minority did not engage with the feedback.
- Lack of motivation to conserve energy evident in focus groups.

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ABSTRACT

Despite national plans to deploy smart meters in small and medium businesses in the UK, there is little knowledge of occupant energy use in offices. The objectives of the study were to investigate the effect of individual feedback on energy use at the workdesk, and to test the relationship between individual determinants, energy use and energy reduction. A field trial is presented, which monitored occupant energy use and provided individual feedback to 83 office workers in a university. The trial comprised pre- and post-intervention surveys, energy measurement and provision of feedback for 18 weeks post-baseline, and two participant focus groups. The main findings were: statistically significant energy reduction was found, but not for the entire measurement period; engagement with feedback diminished over time; no measured individual variables were related to energy reduction and only attitudes to energy conservation were related to energy use; an absence of motivation to undertake energy reduction actions was in evidence. The implications for energy use in offices are considered, including the need for motivations beyond energy reduction to be harnessed to realise the clear potential for reduced energy use at workdesks.

1. Introduction

How much electricity do people use at their workdesks and how prepared are they to change their energy use behaviour? These are important questions in the context of energy consumption and demand response. Energy use by computing in offices has contributed to growth of nearly 30% of final energy demand in the European services sector between 1990 and 2009 (EEA, 2012). As part of its policies for reduction of energy consumption, the UK Government is planning a national deployment of smart meters to small and medium-sized businesses, as well as domestic premises (DECC, 2011). Although there is a growing body of literature on energy use by households, little research has yet investigated individual energy use in the office. The current study addresses this gap with a multi-method study of energy use and the effect of individual energy feedback at the workdesk.

Feedback is argued to be essential to address the invisibility of energy use (Burgess and Nye, 2008) and as an enabler to reducing energy consumption, and a variety of feedback interventions has been trialled in homes. In the absence of studies on the effect of feedback on individual energy use in offices, domestic studies may shed light on the effectiveness of feedback for energy conservation. Empirical research has shown mixed results. In a study which provided two alternative, innovative forms of visualisation to 52 participants over 2 weeks, participants reported increased awareness of energy use but there was little impact on energy consumption (Kim et al., 2010). A similar outcome was found in an intervention which provided a highly sophisticated feedback application called EcoIsland (Shiraishi et al., 2009). EcoIsland incorporated aspects of gaming and included

* Corresponding author. Tel.: +441483 682879; fax: +441483689553.
E-mail addresses: n.murtagh@surrey.ac.uk, murtagh.n@googlemail.com (N. Murtagh).

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cooperative and competitive social goals, and affective and proxy economic rewards for energy conservation over 4 weeks. Again, the participant families reported increased energy awareness but no significant change was found in energy use. A further study found that energy use *increased* for some households in all conditions, and that in only one condition[1] was there a significant difference in the number of households with reduced versus increased consumption (Brandon and Lewis, 1999). The most recent and extensive UK report, comprising four major trials with participant households numbering between 1300 and 7100, concluded that an overall 3% reduction had been achieved by in-home electricity displays (AECOM/Ofgem, 2011). However, one of the trials showed no positive effect of real-time displays; a second found reductions of 0.7 to 1.5% for three interventions out of seven, increases of 8.4 to 14.1% for three other intervention types and no significant change for the seventh intervention. In contrast, several extensive meta-analyses, reviewing a combined total of 110 studies, have concluded that feedback is generally effective (Abrahamse et al., 2005; Ehrhardt-Martinez et al., 2010; Faruqui et al., 2010). The evidence then suggests that feedback can lead to energy conservation but with wide variability. Such mixed findings demand further explanation of the factors which may influence use of energy feedback, energy consumption and behaviour change towards reduction. One approach is to examine the extent to which individual psychological factors play a part. In this paper, we combine psychology and engineering approaches to examine individual energy behaviours. Factors beyond the individual will also have an influence and other perspectives may offer additional insights. However, our focus here is on the individual, based on extensive evidence for the relationship between individual psychological factors and pro-environmental behaviours including energy use. We describe this evidence after first considering empirical findings on engagement with electricity feedback and energy use in the workplace.

Two aspects of interest from studies in the home relate to engagement with the feedback technology, and change of engagement over time. In the AECOM studies outlined above, the only trial which measured how often participants accessed their feedback data found that fewer than half checked their data more than twice. This finding is particularly important as no other published study to our knowledge has provided data on engagement with feedback. Furthermore, most studies which measured response to feedback over weeks or months noted decreasing effect (Hargreaves et al., 2010). Ueno et al. (2006) found a deterioration after just 2 weeks, and van Dam showed that reduction was not sustained beyond 4 months (van Dam et al., 2010). A possible implication is that engagement may be a predictor of energy reduction and that diminishing engagement may be a cause of attenuation of effect but this has not been examined empirically. In the current study, we aimed to address these gaps by examining engagement with feedback, the change of engagement and its relationship with energy reduction over time.

In contrast to the extensive number of studies on domestic energy use and feedback, relatively few investigations have focused on energy behaviour at work (Davis and Challenger, 2009; Scherbaum et al., 2008) even though energy practices, and response to energy feedback, may differ between home and work domains. Perception of responsibility for energy consumption may be stronger for the householder but not salient for the employee, and this may in part relate to economic responsibility: The householder may engage with feedback in order to save money on electricity bills in contrast to the employee who has no visibility of the cost of energy use. The wider variety of electrical appliances in the home may make energy behaviours more complex in this domain, embedded in a wide variety of practices, including cooking, cleaning and entertainment (Shove, 2003). Social norms too may differ between home and work: Approximately two-thirds of European households are multi-occupancy (EEA, 2001) requiring negotiation around energy use (Hargreaves et al., 2010). The workdesk, in contrast, is likely to be under the control of the individual, albeit subject to group or organisational norms. Investigating the workdesk may therefore help to tease out individual from social factors in response to feedback. The work domain thus offers a distinct context in which to examine energy behaviour and one which has received little attention in the literature.

Among the few studies in the workplace, Siero et al. (1996) used an observational measure to assess the energy behaviour outcomes of two types of intervention, and found evidence for energy reduction. Three other studies: a simple intervention on radiator use in university buildings (Staats et al., 2000); an extensive intervention, which included redesigning communal areas and removing unnecessary equipment in a research facility (Lobato et al., 2011); and interventions based on group-level monthly feedback and peer education (Carrico and Riemer, 2011), all reported positive results. A study on German university buildings drew on psychological theory to design energy behaviour interventions and a combination of building-level energy readings and observational measures were utilised to evaluate intervention effectiveness (Matthies et al., 2011). However, previous studies have been limited in how energy behaviours could be measured. For most, only building energy consumption could be measured, at best monthly, and therefore only group-level feedback has been feasible, leaving individual-level energy use unexamined.

In domains beyond the workplace, there is evidence for the influence of individual factors on pro-environmental behaviours in general and on energy use in particular. A relationship between sociodemographic (e.g. age, income) and external factors (e.g. size of house, number of occupants) and energy use has been established in many domestic studies (e.g. Gatersleben et al., 2002). Environmental attitudes and beliefs, viewed as important to behaviour change because of their potential plasticity, have been established as predictors of pro-environmental behaviour (see meta-analysis by Bamberg and Möser, 2007) and have been shown to have a small but significant effect on direct energy use (Brandon and Lewis,1999; Gatersleben et al., 2002; Abrahamse and Steg, 2011). Beyond attitudes, two further psychological constructs have been related theoretically and empirically with pro-environmental behaviours: values and self-identity. Based on an extensive review, Dietz et al. (2005) conclude that there is evidence of moderately strong relationships between values and both intended and actual environmental behaviours. Theoretically linked with values but conceptually distinct, self-identity has also been established as a predictor of 'green' behaviours, including general pro-environmental behaviours (Gatersleben et al., 2012), specific actions such as green consumption (Sparks and Shepherd, 1992), and domestic energy conservation (Whitmarsh and O′Neill, 2010). Values and self-identity are argued to be of particular importance to policy makers because of their potential for consistent, durable and context-independent influence on behaviour (Axsen and Kurani, 2013; Dietz et al., 2005; Gatersleben et al., 2012). Based on the wealth of evidence for their relationship with pro-environmental behaviour, and because of their potential importance to policy and campaigning for energy reduction, our focus in the current study was to examine three individual psychological factors: attitudes towards energy reduction, pro-environmental or 'biospheric' values, and a pro-environmental identity, and their influence on energy use in offices.

It is worth emphasising that a weakness of much social science research on behaviour change, and psychological research in particular, is its reliance on reported rather than actual behaviour, despite evidence that self-report measures have low reliability (Eatough and Spector, 2013; Schmitt, 1994). In other words, what people say they do and what they do in practice can be two

[1] Condition was provision of PC-based comparison of current with previous year′s consumption by the household and a directory of energy saving information.

different things. Our proposed study offered an all-too-rare opportunity to compare self-report and actual behaviour: we measured the extent to which self-report measures of pro-environmental behaviour was related to actual energy behaviour and to engagement with energy feedback.

Matthies et al. (2011) argued for the importance of establishing the theoretical potential for energy saving of interventions in the workplace—a salient point with respect to real impact on greenhouse gas emissions and global warming. Research has demonstrated the potential for improvements in energy efficiency in offices. In southern Africa, a series of five audits of office buildings found that 56% of building energy was used in non-working hours (Masoso and Grobler, 2010) and a Californian study found that, across 11 office buildings, only one third of PCs were switched off after working hours (Webber, 2006). During the working day too, power consumption of unoccupied desks has been shown to remain at about half the occupied level (Torcellini, 2006, cited in Lobato et al., 2011). Although energy use of PCs and other desktop appliances is a relatively small proportion of overall building energy use (plug load in commercial buildings in US estimated at 5%, McKenney et al., 2010; computing in commercial buildings in UK estimated at 8%, DECC, 2012), we argue that investigating energy behaviour at the workdesk offers several important benefits. First, as noted above, office computing energy has contributed strongly to growth of final energy demand in European service industries in the decade to 2009 (EEA, 2012). Second, as suggested by Matthies et al. (2011), the workdesk may offer a simpler environment to understand behaviour. The majority of European households comprise two or more people (EEA, 2001), confounding effects of energy feedback in domestic settings. In contrast, at the typical office workdesk, with few exceptions, the individual has full control over the devices. Finally, the workdesk is particularly suited to examining individual energy use. With accurate and detailed, individual-level measurement, it is possible to explore one type of energy behaviour which can also increase understanding of more complex behaviours.

Measuring individual level energy consumption offers the potential for more targeted, and more effective, interventions but gaps remain in understanding energy behaviours within the workplace. In particular, more research is needed which explores individual factors and uses accurate, detailed measures of actual, personal energy use. The current study deployed state-of-the-art technology to measure energy use at individuals' desks and to provide personalised feedback: the first study to our knowledge to evaluate energy behaviours at this level of detail and to provide near-realtime individual feedback in an office setting. Feedback was provided on plug load, that is, on energy use by all electrical appliances connected to power sockets at the participants' desks. Building from previous studies in domestic and work premises, and seeking to address gaps on individual determinants of energy use and change prompted by feedback, our research questions were:

- Does personal feedback reduce energy use in an office environment?
- Does the effect of personal feedback relate to level of engagement with the feedback?
- Is energy reduction maintained over time?
- Do individual factors established as influencing energy or other environmentally-impacting behaviour (attitudes, values, environmental identity) explain energy use, engagement with feedback or reduction in energy use at work?
- What other factors influence individual energy use in offices?

2. Method

A research centre in a medium-sized university in the south of England was the site of the field trial. The department was part of a technical faculty and was housed over three floors in a single building. For convenience and to preserve anonymity, the department will be referred to as TechDept below. The building occupants comprised post-graduate students, researchers, lecturers and administrative and technical support staff. The field trial was conducted in five stages, summarised in Table 1, and the timeline is presented in Fig. 1.

2.1. Participants

As part of inviting all members of TechDept to participate in the full trial, general information on the trial was provided in advance of installation of the energy monitoring devices, with the choice of

Table 1
Field trial study stages.

Stage	Description
1	**Pre-intervention survey:** A questionnaire was distributed by email, to all eligible staff and students in TechDept, followed up with paper copies to non-respondents to increase participation. The survey asked about general pro-environment behaviour, attitudes to energy use at work, values and environmental identity. Participants were additionally provided with a brief description of the feedback application which would be provided to them, and asked their intention to use, and attitude to, the feedback application. Participation in the survey was voluntary and two prizes of vouchers worth £25 were offered, allocated by random selection from all completed surveys. A total of 59 completed questionnaires were returned (58% response rate)
2	**Energy use:** A monitoring device was installed at each workdesk ($n=83$) and all electric appliances at the workdesk were routed through the monitoring device. The energy data was transmitted to a central server, on which the data were aggregated into daily and weekly totals. As a reliability check, the ratio of expected data packets (one from each node every 10 s) to data packets received was calculated. Where the ratio of data packets received to packets expected fell below 0.8, the data for that node for that week was set to missing. Energy data was collected for 13 weeks before the feedback intervention was provided. This allowed for stabilisation and demonstration of reliability of the technical infrastructure. The 4 weeks before introduction of feedback were designated the baseline period
3	**Provision of feedback (MyEcoFootprint), engagement and energy use:** A feedback application called MyEcoFootprint (MEF) was provided to all participants ($n=83$). It consisted of a gadget installed on all work computers, which displayed red, amber or green depending on the user′s energy efficiency in the previous week. Clicking on the gadget connected the user to a website in which they could view their energy use by hour, day and week, historical data for up to 10 weeks, comparison against the average usage for their office and hints on saving energy. Data were displayed graphically and numeric tables were also available. Design of the feedback application was based on the findings of previous studies on persuasive feedback (Ham and Midden, 2010; Kim et al., 2010; Kuznetsov et al., 2010; Shiraishi et al., 2009). To ensure that the privacy and security of the energy data was maintained, access to individuals′ data was available only to the individual and the research team, and was protected by a randomly-generated, 32-digit, encrypted password
4	**Longitudinal engagement and energy use plus post-intervention survey:** MyEcoFootprint was available to participants for 18 weeks (the period was not notified to participants in advance). Collection of energy data was continuous in this period and participants then completed a second survey on attitudes to energy use at work, values and environmental identity (response rate 35%)
5	**Focus groups:** Two focus groups were conducted: one with participants who had used MyEcoFootprint, and one with participants who had not. MyEcoFootprint had been equally accessible to all participants

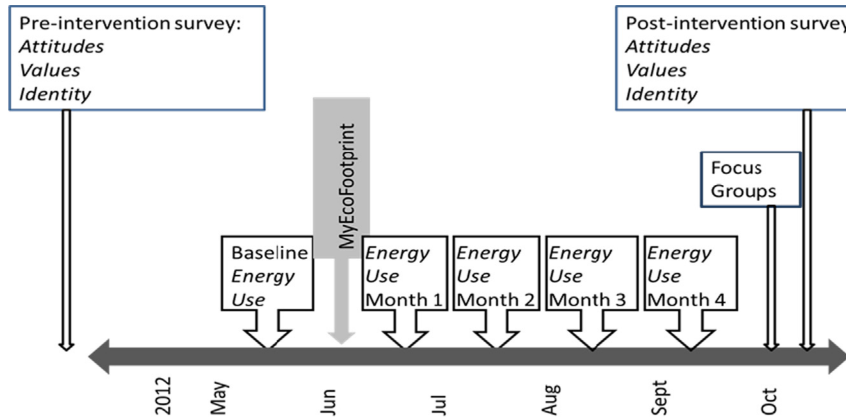

Fig. 1. Data collection timeline.

opting out. Four people opted out and no data were collected from them. Of the remaining 102 desks, 22 were excluded from the study for technical reasons (equipment could not be installed or had repeated problems) or due to a high turnover of occupant. The numbers of participants vary slightly in the analyses below due to change over time in the office context: participants left and joined, changed desks and participated in different stages of the trial.

2.2. Measures

Unless otherwise indicated, all scales comprised items rated on a 7-point scale, anchored at strongly disagree (1) to strongly agree (7).

Self-reported pro-environmental behaviour: Within the environmental psychology literature, a common and useful baseline measure is that of self-reported individual environmental concern or general tendency to undertake pro-environmental behaviour. Here, the self-report scale for general ecological behaviour (GEB; Kaiser and Wilson, 2000) was used with four additional items added on energy behaviour at work (e.g. I turn my PC off before I leave work/study for the evening). The final scale comprised 18 items addressing energy behaviour at work (4 items), domestic energy (4 items), waste (3 items), waste reduction (3 items) and travel (3 items) behaviours. Overall pro-environmental behaviour was calculated as the mean of all items. Internal consistency was acceptable (Cronbach′s alpha .64), that is, all of the items tapped similar meanings for respondents and is an indication that the scale was reliable.

Intention to use the feedback application was measured with two items: "I intend to use MyEcoFootprint to check on my power usage"; "I intend to check MyEcoFootprint regularly, to see how I′m using power". Internal consistency was good (Cronbach′s alpha .84).

Attitude towards technology, attitude towards energy saving: Attitudes were each measured with three items. Attitude to technology items were worded with reference to use of the feedback application, MyEcoFootprint; a sample item was "My opinion is positive about using MyEcoFootprint". Energy saving was worded with reference to reducing energy use at work; a sample item was "I believe it is a sensible idea to try to use less electricity at work". Internal consistencies were good (attitude towards technology Cronbach′s alpha=.75; towards energy saving Cronbach′s alpha=.78).

Values: From de Groot and Steg′s (2008) value orientations scale, the biospheric subscale was used. Four items tapped values concerning preserving nature, respecting the earth, preventing pollution and unity with nature and the measure was calculated as the mean of the four items. Internal consistency was good (Cronbach′s alpha .89).

Environmental identity: Environmental identity was measured following Terry et al. (1999). The items were "Being 'environmentally friendly' in what I do is an important part of who I am"; "I am someone who is concerned about the environment" and "I do not see myself as someone who cares about the environment" (reverse coded). Internal consistency was good (Cronbach′s alpha .79).

Energy behaviour: Energy was measured as kilowatt hours (kWh) per week.

Engagement with feedback: Two measures were taken of engagement with the feedback application MEF: the number of accesses by a participant to MEF and the total duration of access time in minutes per participant. In addition, a categorical variable was calculated for registration on MEF (Registered Yes/No), a prerequisite for access to data on the application.

3. Results

3.1. Stages 1–4: Energy use, engagement with feedback and survey data

Table 2 presents the demographics of respondents to the pre-intervention survey.

Means, standard deviations and correlations of the main variables are shown jointly with energy behaviour and feedback engagement measures in Appendix A.

Individual factors and self-reported behaviour: Table 3 presents individual linear regressions of self-reported pro-environmental behaviour and intention to use MyEcoFootprint onto attitudes, biospheric values and identity.

As expected, current self-reported pro-environmental behaviour was predicted by attitudes to energy saving, biospheric values and environmental identity. Of the predictors, biospheric values was strongest. Intention to use MyEcoFootprint was predicted by both attitudes to the technology and to energy saving and by biospheric values. Biospheric values also contributed to attitude to energy saving, as did environmental identity. As expected, current self-reported pro-environmental behaviour related to intention to use MyEcoFootprint.

Energy use: An audit of electrical devices at workdesks was conducted. Almost half of the desks held only a desktop PC and screen (n=30), and the same number had a further one or two devices. Additional devices included a docking station for a laptop (n=21), desk fan (14), additional screen (6) and re-charger for a mobile phone (5).

Energy use varied widely between desks, from near 0 to 21.42 kWh as a weekly total before feedback was introduced. To provide a comparison, three measures were taken of power

Table 2
Pre-intervention survey sample demographics.

	Sample (n=59)	TechDept overall
Response rate	58%	–
Age—mean (SD)	33 (8.46)	Not available
Gender (% female)	22%	16%
Type of work		
Student	52%	54%
Researcher	34%	42%
Lecturer	10%	14%
Support	3%	5%
Ethnicity		
White	41%	23%
Asian or Asian British	20%	22%
Black or Black British	3%	5%
Chinese	20%	22%
Mixed	3%	
Other	10%	28%

Table 3
Linear regressions onto individual variables.

Regression	Adj R^2	df=F	p	β
DV=Self-reported pro-environmental behaviour				
Attitude to energy saving	.10	1.55=7.52	.01	.35
Value—biospheric	.41	1.55=39.61	.00	.65
Identity—environmental	.21	1.55=15.85	.00	.47
DV=Intention to use MEF				
Attitude to technology	.46	1.45=39.57	.00	.68
Attitude to energy saving	.18	1.45=10.75	.00	.44
Value–biospheric	.14	1.45=8.77	.01	.40
Identity—environmental			ns	
Self-reported pro-environmental behaviour	.07	1.45=4.64	.00	.31
DV=Attitude to energy saving				
Value–biospheric	.09	1.55 =.6.38	.01	.32
Identity—environmental	.07	1.55=5.83	.02	.30

Note: DV is the dependent variable, the measure of interest. Adj (adjusted) R^2 ranges between 0 and 1 and indicates the proportion of variance for a population that is explained by the regression equation; degrees of freedom indicate the number of cases; a larger F statistic indicates higher probability of statistical significance; statistical significance p values below 0.05 indicate significance; standardised coefficient β is the relative weight of the variable; ns not significant.

consumption for a typical PC and screen installation. It should be noted that consumption will vary by PC configuration and by usage and the baseline figures are thus indicative. First, a PC and screen in a laboratory, set to active mode for an hour, consumed the equivalent of 3.4 kWh for 40 h (an indicative working week). As this may not represent 'typical' usage, an occupied workdesk was monitored for a working week and occupant presence was logged. The actual usage in a 40 h week was 2.02 kWh. Adjusted for hours of presence, the total for 40 h of presence was 2.75 kWh. The occupant used the PC for office applications (email, web searches, word processing). Finally, to allow for maximal usage, a PC, with a configuration identical to that of the workdesk PC, was set to run an application which required 100% CPU usage over 40 h. Consumption was 5.1 kWh. Fig. 2 presents the average weekly energy use over 3 months, showing the spread and the indicative baseline usages. The 4 weeks before introduction of feedback were designated the baseline period: the technical infrastructure was stable and reliable, and there was no office holiday closure. Across all participants for this baseline period, mean energy use was 7.38 kWh (SD=4.27, range.27–18.08 kWh), over three times the indicative 'typical' comparison total of 2.02 kWh and higher than the maximum consumption over 40 h of 5.1 kWh for a PC and monitor.

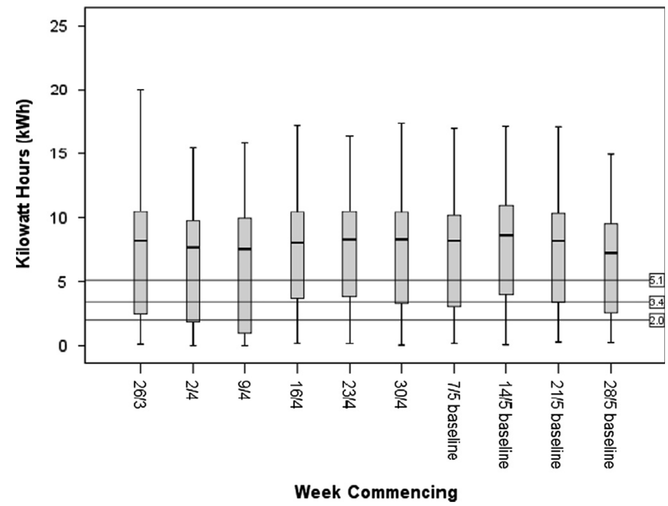

Fig. 2. Boxplot depicting spread of pre-intervention weekly mean energy consumption.
Note: Box shows values lying between 25th and 75th percentiles; bar indicates median value; extended lines show the range. Three indicative baselines of consumption are shown: 2.0 'typical', 3.4 always active, 5.1 maximal. Weeks 7/5–28/5 formed the baseline comparison period.

Table 4
Linear regressions of attitudes to energy saving.

Regression	Adj R^2	df=F	P	β
Baseline energy use	.16	1.37=9.16	.01	.43
Energy use Month 1	.08	1.35=4.07	.05	.32
Energy use Month 2	.09	1.37=4.84	.03	.34
Energy use Month 3	.08	1.35=4.49	.04	.33
Energy use Month 4	.10	1.36=4.99	.03	.35
Number of accesses			ns	
Duration of accesses			ns	
Reduction Month 1			ns	

To illustrate patterns of usage at individual desks, a random selection of six desks[2] has been plotted in Fig. 3. Daily usage is depicted in Fig. 3a. A pattern of lower consumption on Saturday and Sunday is visible for all nodes except Node 148, although only Node 143 appeared to switch off all energy usage for the weekend. Weekly use is depicted in Fig. 3b. Two nodes (Nodes 28 and 83) show relatively high overall usage, although the drop for Node 28 in August and September could suggest absence. Two nodes show a steep drop for week 28/5 and the preceding week (Nodes 54 and 9). Both registered to use feedback so the drop could be as a result of feedback. However, a reduction would have been expected 1 week later when the intervention was rolled out. Also, Node 9 remains low—this could indicate prolonged absence from the office or could represent use of a battery-powered laptop. For Node 148, energy use dropping to near zero for 2 weeks in July and 4 weeks in August/September may indicate holiday leave.

Engagement with feedback: Access to the feedback application, MyEcoFootprint (MEF), was provided to 83 users. Participants were made aware of the availability of feedback through (1) an informational email, (2) presence of the MEF gadget on their PC desktop, (3) a flyer placed on each desk during working hours during the week of installation, and (4) a promotional mug and coaster, with a reminder to check energy feedback, provided on each desk a few weeks later. A prerequisite for engagement with the application was registering: a minimal operation which

[2] Graphs depicting more than six desks became increasingly difficult to read and interpret.

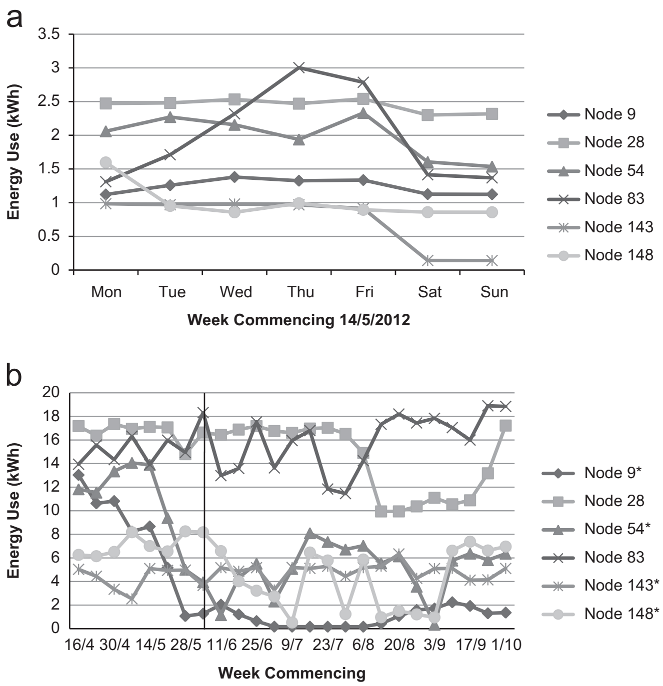

Fig. 3. (a) Energy usage by day for six random desks. (b) Energy usage by week for six random desks.
Note: *Indicates desk occupant was registered on MyEcoFootprint. ____ indicates provision of feedback.

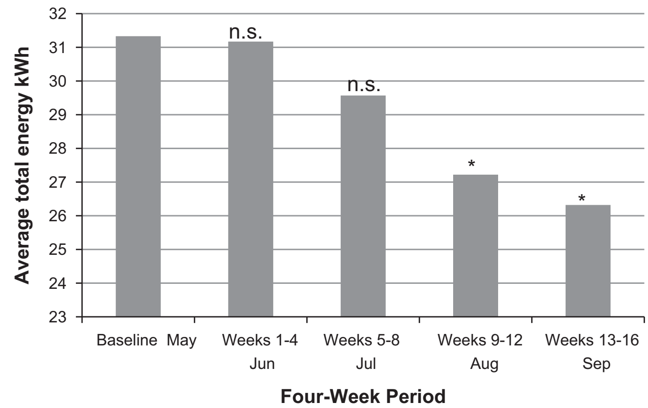

Fig. 4. Mean energy use per 4-week period. * Shows significant difference from baseline. ns=Non-significant.

required one click access to the website, entry of email address and a cut-and-paste of the randomised key. Of the 83 users, 59% registered on the application. The same proportion used MyEcoFootprint at least once. It is of note that less than two thirds of the sample took the first step to engagement with their energy usage by registering, or checked their personalised feedback at any time.

Although there was a moderate, negative correlation between engagement with MyEcoFootprint and energy consumption in the first 4-week period when all participants were included (number of accesses $r=-.29$, duration of access $r=-.28$, both $p<.05$, $n=74$), this correlation was not significant for the participants who had registered to use MyEcoFootprint ($r<.1$, $p>.7$, $n=36$). That is, although accesses to MyEcoFootprint were related to lower energy use across the full sample, the significance did not hold for the people who had registered to view their feedback: the number of times they accessed it, and the duration of access, did not correlate with their energy consumption or energy reduction. This implies an initial but weak effect of feedback. A possible interpretation is that feedback influenced energy reduction via a mediating variable such as awareness: registering on the application may have resulted in increased awareness and an effect on energy consumption, but further use of the feedback did not result in further change. Usage of MyEcoFootprint decreased significantly over the trial (mean number of accesses in weeks 1–4, 1.83; mean in weeks 13–16=.69, $t(36)=3.10$, $p=.00$).

Change in energy use: Average energy consumption remained close to that of the baseline period for the first four-week period. For the remaining three four-week periods of measurement, energy consumption reduced, and this was statistically significant for the final two four-week periods (see Fig. 4). The pattern was the same for the full sample and for the subsample who registered to use the feedback. Significant difference was found between total energy use in the baseline period and energy use in the first two four-week periods but the second two four-week periods showed a statistically significant drop. In Section 4, we consider the possibility of seasonal or other effects.

Individual factors and actual energy use: Correlations between individual factors, self-reported general environmental behaviour (GEB) and actual energy behaviour are shown in Appendix A. Energy behaviour in the baseline period correlated negatively with attitudes to energy saving, that is, the more positive attitudes were about saving energy, the less energy was used ($r=-.46$, $p=.00$, $n=38$) but did not correlate significantly with self-reported pro-environmental behaviour, biospheric values, environmental identity or intention to use MyEcoFootprint. That is, of the individual factors measured, only attitudes to energy saving correlated with energy use before feedback was presented.

Self-reported general pro-environmental behaviour (GEB) did not correlate with engagement with feedback or with actual energy usage. Intention to use MEF was not related to the number or duration of accesses over the 16-week trial but attitudes to using MEF were positively correlated with its use (number of accesses $r=.43$, duration of access $r=.36$, both $p<.05$). Attitude to reducing energy correlated with actual energy use in the baseline month and Month 1 although not with engagement with feedback or with reduction of energy use.

Regression analysis was conducted on the relationship between attitudes to energy saving and actual energy use, engagement with feedback (number of accesses and duration) and behaviour change (energy reduction). Table 4 presents the results: although attitudes predicted energy use throughout, attitudes to energy saving did not predict engagement with feedback or behaviour change.

As a further exploration of whether any of the measured individual factors differed significantly between those participants who had registered to use MEF and those who had not, *t*-tests were conducted. No significant difference was found for biospheric values or an environmental identity, but both attitudes to using MEF ($t=-3.73$, $p=.00$) and attitudes to reducing energy at work ($t=-2.12$, $p=.04$) showed significant difference, with both sets of attitudes more positive for those who had registered on MEF. None of the variables measured post-intervention (attitudes, biospheric values or identity) were related with MEF usage or energy reduction.

Age was found to correlate negatively with total energy use for all 4-week periods, though not with the number of electrical devices at the workdesk.

Summarising the findings on individual factors and actual energy use: values, identity or self-reported pro-environmental behaviour were not correlated with actual energy behaviour or with engagement with feedback. Only attitude to energy reduction was related to actual energy behaviour. Although this attitude was stronger for those who had registered to view their feedback, it did not correlate with engagement with feedback or with actual energy reduction.

3.2. Stage 5: Focus groups

Two focus groups were also conducted. Data on access to MyEcoFootprint was consulted to select participants. Focus Group 1 participants (Users) had registered on the application to view their energy feedback. Focus Group 2 participants (Non-Users) had not registered. There were five participants in each group, drawn from different offices. The mix of gender, ethnicity and work type in the groups were representative of the department overall. The interview schedules for both focus groups were identical, with the exception of additional questions about their views on the feedback application towards the end of the session for the users. The sessions were audio recorded and transcribed verbatim.

A thematic analysis, following the guidelines of Braun and Clarke (2006), was conducted using the software MAXQDA to record and organise codes and notes. Congruent with the guidelines, analysis proceeded inductively, that is, from the data, and aimed to provide a nuanced account of the group of themes which relate to why office workers do not conserve energy at their workdesk. From the full thematic analysis, Table 5 summarises and gives sample text segments for the main themes, to demonstrate the initial analysis and to show grounding in the data for the interpretative analysis below. To maintain participant privacy, neither energy use nor survey data were cross-referenced with focus group responses.

The dominant theme was labelled 'Reasons not to switch things off' and comprised 15 subthemes. These included the inconvenience of turning off a PC and the time taken to reboot, a technical problem with sleep mode on one operating system, a belief that the energy savings of switching off a PC was not worth the effort, the perception that most people in their office did not switch off, a belief that one did not need to switch off as the PC monitor would switch to sleep mode automatically or the security staff would switch off the light, work demands including wanting to leave

Table 5
Summary of main themes from focus groups.

Theme	Group 1	Group 2	Sample segment
Don′t care about energy use	2	4	G2/M3: I think, when you don′t pay the bill directly yourself, you don′t care that much
Wasted energy	5	5	G1/M4: During the summer, we have the windows open, during the morning for instance, if it′s not enough for the air-conditioning, and then someone comes in, feels a bit hot, and that′s fair enough, they put the air-conditioning on but the windows remain open…So, that′s a clear waste
Control: Heating/cooling	0	2	*G2. R: You were saying you don′t have control over [heating].* M5: Yes, it′s difficult and the system runs automatically. R: *And yourself, is it controllable?* M4: No, we have no control.M3: No.F1: No, I don′t think so. We just have those [indicates radiator] so it′s just we open the window
Control: Lighting	0	1	*G2. R: Coming back to lighting…do you feel you′ve got control over the lighting at your desk? Can you put it on or off as you want? F1*: Not really. I mean, there′s…I think two controls for the room, so just different parts of the room, so not individual on my desk
Issues of shared space	4	3	G1/M1: I think there are something like seven or eight researchers in our office and… when you say, shall I turn, for example, turn off the radiator, people may say it′s a bit cold or whatever. So, sometimes [laughing], funny situations happens—for example, you see a fan is running and the radiator is on as well. So, that′s the only local way you can control the heating. I mean, it′s not power-efficient, but that′s the only option to make sure everybody′s happy
Reasons to not switch things off			
"Syndrome of reasons"			
(In)Convenience/Speed	6	3	G1/M1: So people like to… keep the [PC] system on to make sure that, as soon as they′re in [at their workdesk], they can just continue what they were doing
Technical reason (failure/ speed)	6	0	G1/M2: Well, I personally have a problem, for example, that′s the technical problem with the… Linux machines. When I put it in the suspend mode, rather than the hibernate mode, when I try to boot it up again in the morning, I have problems—it doesn′t boot up properly.
It′s not worth it. Saving is too small	0	5	G2/F1: I mean, okay, turning off devices when I leave or anybody leaves, I mean, how much will that save for the eight to 10 h that it′s off?
Social norm	1	4	G1/M1: Also, there′s wallpapers [on PC screens]…when you leave the office, all the lights are off, all the wallpapers are showing up and…I don′t know [laughing]. It′s like a trend
Automation	1	3	G1/M4: But going onto the turning off the display, I never do that, but I do—I do have, sort of, the box ticked in the options somewhere that, after five minutes of inactivity or whatever it is, it switches itself off, and…then I don′t have to touch it
Work demands	1	3	G2/F1: Okay, some people do simulations so they don′t…can′t actually turn it off
Just don′t	0	3	G2/M4: When I will leave the room, I will not shut down the electricity [turn off the light]
(Lack of) incentives	1	2	G2/M3: Would there be an incentive to reduce it? Okay, if you give me a number and tell me that the other person next-door consumes half of it, the obvious question is "So what?" to be honest
Electricity as a commodity	0	1	G2/M4: Yeah. Sometimes [students] don′t care because they are not paying the bill. [Laughter] And sometimes they think that because we are paying £14,000 fees…[Laughter]
Political	0	1	G2/M3: Why should I care about reducing my 10 W consumption from my monitor when I know that big car industry is polluting or consuming gigawatts? They can get away with bribing or stuff like that. So, then the Government comes to me, as an individual, and says you have to reduce it because, sorry, they are way too powerful, and, oh, they are paying us, and we cannot, you know… No, sorry, no!
Someone else will do it	0	1	G2/M1: I think that Security will turn it off …when it′s very late
Technical myths	1	0	G1/M1: I heard from a friend of mine, he was telling me that, if you turn off your computer every day, I mean, somehow, in the long run, it will shorten the lifespan of your system
Habit (or lack of)	1	0	G1/M2: Usually, I don′t turn off
Want to but…			
Tried but failed	2	0	G1/M4: I tried that suspend/hibernate and it—I can′t remember which one I tried. It failed, in my case, so I just didn′t do it
Forget	1	0	G1/M2: During the day, sometimes yes [I put off the monitor], and sometimes I forget—for example, going temporarily out of the office to meet somebody else or going to, for instance the toilet or lunch

Key: Group 1 MEF Users, Group 2 Non-users. G1/2=Group 1/2. M1–M4=Male 1–Male 4. R=Researcher.

documents open (which relates to convenience), a strongly voiced belief that "the government" should not request users to save small amounts of electricity when others consumed much more, and so on. Taken individually, these reasons appear as rational justifications for not switching off PCs and lights, and are consistent with other studies of energy conservation (e.g. Stoll-Kleemann et al., 2001).

A thematic analysis allows for exploration of latent themes, that is, the method can include moving beyond the semantic content of the text and seeking to propose theoretical concepts which may help to explain the explicit text. Here, a total of 15 types of reasons were identified for absence of energy conservation. We sought theoretical insight to explain, on the one hand, simple actions (such as switching off a PC) which could save energy and required minimal physical and mental effort and only moments of time, and on the other, a plethora of reasoned motives why such actions were not carried out. Of the reasons offered by participants, we could differentiate three which appeared to indicate a thwarted desire to save energy: in two cases, a participant had tried to conserve electricity but the attempt had failed (his colleagues did not change their behaviour) and no further effort was made; in another case, the participant described switching off his monitor at night, but forgetting to when leaving his desk during the day. We grouped these under a superordinate theme of 'Want to save energy but…'.The remaining 12 reasons we grouped together as a "syndrome of reasons", borrowing the clinical term 'syndrome' to describe a pattern of symptoms which indicate an underlying condition. We now illustrate and then explain our theoretical account.

Different participants referred to different clusters of reasons. For example, in the following extract, when asked why people leave their PCs on, one participant (pseudonym Kate, non-user) refers to social norms, work demands and convenience:

> I don′t know – maybe that everybody else is doing it! I mean, okay, some people do simulations so they don′t…can′t actually turn it off, but I guess if, even if we are working on documents, so we just save it and minimise it so that – I mean, because when I′m working on one thing, I open 10 other things as well. So, if I shut down the PC, I have to start opening all of them again, and sometimes there are webpages which have been found after hours of searching, so I say, okay, everything is there and I start from the same point the next day. (Kate: line 49).

She later refers to the energy savings being too small:

> I mean, I would obviously want to use less, but the question is how. I mean, okay, turning off devices when I leave or anybody leaves, I mean, how much will that save for the 8 to 10 h that it′s off? (Kate: 66).

And later she mentions the number of devices per desk to query how electricity could be saved:

> I mean, okay, the work here is…I mean, we use a small number of devices individually, and that′s not going to go away for any of us, so what are the areas where energy consumption could be reduced? (Kate: 184).

In these extracts, Kate has drawn on five different reasons for not switching off and a similar pattern was noted for other participants.

As the focus groups had been selected on basis of engagement or non-engagement with the feedback application, we then compared responses between the two groups on reasons not to conserve energy. The examples of having tried to save energy came from the users, who also mentioned more often than the non-users technical reasons and convenience as explanation for not saving energy. However, the non-users group cited more reasons for not reducing energy use, and more often referred to energy saving not being worth it, that automation or somebody else would take care of it, that the government should target large energy users rather than them, that the cost of energy is included in student fees, that work demands prevented conservation and that others around them did not try to conserve energy.

The data showed that, in general, participants in both focus groups were aware that energy conservation is, to some extent, a socially desired behaviour. The pattern of difference between the groups suggested that some participants in the users' group had made some attempts to save energy—and their use of the feedback application supported this. However, the 'syndrome' or cluster of reasons suggested that others did not make any attempt at energy reduction and this was reflected in the high proportion of participants who did not access their personal feedback. So why did the participants not switch equipment off after using, despite their recognition that they should? Why have so many reasons for not doing a simple act? Our conclusion was that they did not want to—the participants had no, or little, reason, to commit a positive action and therefore they did not. Turning to psychological theories for further explanation and to the perspective of the individual as purposeful, it can be suggested that the non-engaged lacked a positive expected outcome (Bandura, 1997), goal (Gollwitzer and Bargh, 1996) or motive (Ryan and Deci, 2000). Without a positive aim to achieve (or a negative outcome to avoid), action did not occur. The users too had proffered a number of reasons for not saving energy (although not as many as the non-users): it may be that their initial motivations were not sufficiently strong to overcome technical issues or inconveniences. With only two focus groups and limited space, the analysis here of the qualitative data is necessarily limited. However, it should be acknowledged that alternative interpretations of the data are possible. From the participants' perspective, several of the reasons given may coalesce around motivations to use their worktime efficiently, to 'do a good job'. This is congruent with our interpretation above that there was an absence of motivation to save energy: within a work context, motivation to perform well may prevail over weaker motivations. More generally, motivations will vary between contexts and over time, and are multiple: a positive response to personalised energy feedback requires motivation to save energy to predominate, for an individual, within the given context and over time.

4. Discussion

A field trial was conducted over 22 weeks in a university office-based research centre. Individual energy use (plug load) at work-desks was collected, and after a 4-week baseline period, an application provided personal feedback on energy use. Surveys were conducted pre- and post-trial to measure self-reported pro-environmental behaviours, attitudes, values and environmental identity, and two focus groups were held at the end of the trial. Self-reported pro-environmental behaviour was not found to relate to actual energy use, engagement with feedback or reduction in energy use. The provision of individual feedback resulted in significant reduction in energy use only in the third and fourth 4-week periods. The level of engagement with feedback over the trial was not related to reduction in energy use. Measures of individual factors did not relate significantly to actual energy use, use of feedback or reduction in energy. The sole exception was a relationship between attitudes to reducing energy use in the workplace and actual energy consumption. Qualitative data provided a plethora of reasons for not switching off desk equipment, a 'syndrome of reasons' which may be explained by a lack of positive goal or motive to drive energy reduction behaviour.

A reduction of energy use was found for Months 3 and 4 but not Months 1 and 2 of the study. Most longitudinal studies have found that energy conservation reduces over time (Ueno et al., 2006; van Dam et al., 2010): we would have expected that a feedback effect was more likely in the earlier part of the study and we caution that other factors could have influenced energy use in the later months. We considered whether the lower energy usage in August and September could relate to a seasonal effect, such as holiday leave. However, the sample was predominantly post-graduate researchers: few had teaching duties or school-age children so work deadlines, and therefore holiday leave, were not likely to have aligned with academic terms. If the lecturers within the sample (that is, 10%) had taken holiday leave in August, the effect would be expected to diminish in September (term began on 1st October) whereas energy use in September was lower than August. Two alternative explanations for the pattern of change can be suggested: that the feedback had an effect which developed slowly or that an unidentified aspect of working practice led to reduced energy consumption in August and September. The data collected cannot determine the answer so caution is advised in considering the significant reductions found.

The relationship between feedback and behaviour may be complex. It may be that introduction of feedback raises awareness and that awareness is a mediating construct between feedback and behaviour. Existing research suggests a role for awareness (cf. Kim et al., 2010; Shiraishi et al., 2009): future studies should examine awareness of energy consumption quantitatively and explore the relationship of feedback to awareness over time. Measures of engagement did not correlate with behaviour and engagement was found to reduce over time, adding support to domestic studies which suggested temporally decreasing engagement (Hargreaves et al., 2010; Ueno et al., 2006; van Dam et al., 2010). If engagement with feedback diminishes over time, the challenge remains of how feedback could facilitate continuation of changed behaviour.

In the current study, a sizeable (41%) minority of participants did not access their individualised feedback even once. The proportion is slightly higher than in the AECOM/Ofgem (2011) study described in Section 1, in which over half did not access their data more than twice. Access to the data was more direct in our study, and we were measuring the first step of engagement, which may explain the slight difference. This is an important point in any universal provision of feedback, such as the rollout of in-home displays with smart meters, planned for the UK from 2015 and already underway in a number of European countries: a substantial minority may not engage with it. Additional measures will be necessary to address the energy consumption of this group.

The current study is amongst the few which have measured both self-reported pro-environmental behaviour and actual behaviour. Reliance on self-reported, rather than actual, measures of pro-environmental behaviour is a well-rehearsed weakness of the discipline of environmental psychology (cf Olson, 1981). The methodological, ethical and practical challenges of measuring actual behaviour mean that self-reports are frequently the only means to make progress. It remains critically important however to maintain awareness of actual behaviour. One way of achieving this aim is to attempt objective measurement of behaviour in the field when circumstances permit and to compare such measurement with self-report, and the present research achieved this aim. In this study, self-reported pro-environmental behaviour did not relate to actual energy behaviour: what participants said they did was not matched by what they did. Why might this be so? McDougall et al. (1981, p. 350) spoke of "considerable exaggeration" in consumer opinion responses on energy conservation though psychological explanations may provide more insight. Olson (1981) argued that self-reported measures may relate more to participants' perceptions and beliefs than to their actual behaviour. A desire to present oneself in a manner considered socially acceptable, or 'social desirability', may play a role and this may link to an opt-in bias: people who complete questionnaires may have higher pro-social tendency than those who do not. Identity theories propose a need for consistency and coherence in presentation of the self (Swann et al., 2003), thus individuals who demonstrate pro-social behaviour by responding to a questionnaire may also report more environmentally-friendly behaviour, a form of pro-social behaviour, than those who do not respond.

An alternative explanation lies in the influence of situational factors on behaviour. The comprehensive action determinant model of ecological behaviour (CADM; Klöckner and Blöbaum, 2010) posits situational context as a direct determinant of environmental behaviour. Situational processes include both objective and subjective constraints. In the present study, objective constraints are likely to have been relatively constant: participants had similar energy consumption needs (based on the energy consumption of work-related appliances and working hours) and similar levels of control at their workdesks. However, subjective constraints may have differed, for example, perception of workload may have varied between individuals.

Measurement factors may offer a further explanation. Although Kaiser and Wilson (2000) argued for a uni-dimensional measure of pro-environmental behaviour, such a measure is, by definition, general: its scope must include a range of behaviours. However, Bamberg (2003) argued that environmental concern, measured as a general construct, is a distal factor influencing action, and its effects are mediated by more proximal – and specific – constructs, such as specific attitudes. The findings here support Bamberg′s proposition: the measure of general pro-environmental behaviour did not correlate with actual energy behaviour in the office, despite inclusion of items on energy use at work; specific attitudes however did relate to aspects of energy behaviour. For the current study, three possible explanations have been proposed for differences between self-reported and actual energy behaviours: a possible pro-social, pro-environmental bias in self-report, situational influences on actual consumption and measurement differences in level of generality versus specificity. More studies are required to gather data on both self-report and actual behaviours, to examine these and other possible reasons for discrepancy, and thus to strengthen the methods available to environmental psychology.

There have been strong calls for assessment of environmental impact of behaviours (Gatersleben et al., 2002; Matthies et al., 2011), and the approach taken in the study, of objective and detailed measures of electricity consumption over time, answers this call. From their models, Matthies et al. (2011) suggested a theoretical potential saving of 14% on computer devices in university offices. From the empirical data above, maximal PC usage compared to mean energy use in the baseline period would suggest that electricity consumption of workdesk devices in universities may potentially be reduced by 32%. If our 'typical' user is in fact typical, savings of up to 73% could be targeted.

Age was found to correlate negatively with total energy use for all 4-week periods and this relationship is intriguing. Perhaps younger office workers, who have grown up with electrical and electronic appliances becoming increasing embedded in all areas of life, are more dependent on electrical devices, or more likely to leave devices 'always on', leading to increased consumption.

Based on the psychological literature, the study hypothesised that three individual factors (attitudes towards energy reduction, a 'green' self-identity and biospheric values) would have a significant relationship with energy use, engagement with feedback and energy reduction, but of these, only attitudes contributed to energy use. The discussion above of the potential for non-alignment of self-reported and actual behaviour could offer possible explanation. The importance of context too suggests an explanation. Situational context offers opportunities to act or constrains action in particular ways. Social norms (Cialdini et al., 1990), organisational socialisation (Kramer, 2010) and organisational culture (Schein, 1990) are amongst the mechanisms which encourage particular behaviours in the workplace. Response to individual feedback is likely to be embedded within these, and other, influences. Future studies on feedback should ideally take a broader perspective on the potential factors of influence, considering physical and social context, in the workplace and beyond.

The design of the current study offered the rare opportunity to conduct a focus group with unengaged participants—normally a difficult group to access. A 'syndrome of reasons' was noted in the analysis and an interpretation proposed that participants lacked a desired outcome or motive to undertake energy conservation. This interpretation drew on a perspective of the individual as autonomous, proactive and goal-oriented: a perspective of a person whose behaviour is motivated. Although models of environmental behaviour have identified a number of critical motivators which guide action towards the environmentally beneficial, including personal and social norms, identity and values (e.g. de Groot and Steg's, 2008; Klöckner and Blöbaum, 2010; Murtagh et al., 2012; Whitmarsh and O'Neill, 2010), it may be necessary to consider a wider range of motivators to explain more variance in environmental behaviours. For example, de Groot and Steg's (2008) have shown how egoistic values negatively influence pro-environmental intention: further work is needed to investigate how other motivations – interacting with situational factors – positively and/or negatively affect environmental behaviours. Understanding other motivations of action may offer opportunities to encourage pro-environmental behaviour.

In considering broader motivations, the overall context of the study should be considered. The study's focus on plug load only may have contributed to a limited response. Heating and lighting in offices consume the majority of energy (DECC, 2012) but were not included in the study (due to technical challenges in measurement and in providing individualised feedback on shared usage), and this may have undermined individual motivation. Further, in order to focus specifically on feedback, the intervention was designed as feedback only, in contrast to other studies in offices which provided information as part of a wider programme. Programmes which include individual commitment and managerial support (e.g. Matthies et al., 2011), posters and communal feedback (e.g. Staats et al., 2000) or social comparison (e.g. Siero et al., 1996) are likely to engender additional motivations such as enhanced meaning, communal goals and social identification, and potentially enable higher levels of behaviour change.

A number of limitations in the current study should be acknowledged. First, although the work setting for office-based researchers in a university, that is, PC-based work at individual desks in shared offices, is highly similar to other office settings, there may also be differences (e.g. hours of attendance) and further evidence is needed to generalise from this study to other office settings. Second, the sample was more culturally diverse than a nationally representative sample, which may have introduced differences. Third, the relatively small sample size limited the statistical testing to simple linear regressions. Ideally, future studies should explore individual feedback in an office setting representative of office buildings in their national context, and should plan for the costs and time needed to conduct a large scale field trial. In tracking energy use over 16 weeks, the study was longer than most in the published literature, with the exception of van Dam et al., 2010. The findings here indicated a significant saving in the third and fourth months, aligning with the findings from the domestic study of van Dam. A longer-term follow-up would have been necessary to test van Dam's additional finding that the initial savings were not maintained at 11 months, but practical barriers emerged to a valid follow-up. A number of factors may influence office energy use, such as weather and work demands, and a longer measurement period would have been desirable to explore longer patterns over time of energy use. However, a disadvantage of a longer measurement period is the increased incidence of change, particularly the rate of change of desk occupancy if individual energy use is being measured. Here an unanticipated level of change, with occupants joining, leaving and changing desks, reduced the number of participants in the research, and the rate of change prevented valid data collection at 11 months, as van Dam had done. Future research would need to consider the optimal balance between the length of the energy data collection period and the rate of change of occupancy at desks.

Notwithstanding these considerations, some implications may be drawn from the findings for energy reduction in offices. The results imply that individual feedback on energy use at work may aid energy conservation. However, the effect may be limited overall and in the number of individuals who engage. The lack of motivation noted in the focus groups is likely to affect additionally more energy-intensive office behaviours such as lighting and heating, as well as plug load. Seeking positive outcome goals may facilitate change over and above provision of feedback and so too will reducing barriers to energy reduction such as technical problems. The current study did not address social norms, and group norms intrinsic to an organisational culture may offer stronger motivation. A basic requirement will be providing information on the size of potential for impact of actions as simple as switching off a PC. For example, in the university in which the field trial was conducted, we estimated that approximately £60,000[3] (€70,500) – the salaries of two researchers – could be saved annually if all office PCs were switched off at the end of each day. There are implications too for domestic energy feedback. The findings on engagement may help to explain the wide variation in outcomes of domestic trials. It has been noted that a universal rollout of a display may not engage a substantial minority and that additional approaches may be necessary. Earlier studies have noted that monetary savings are not sufficient to motivate change (AECOM/Ofgem, 2011; Hargreaves et al., 2010) so more innovative approaches will be needed. The smart grid infrastructure will provide potential for dynamic and interactive communication between utility and householder, and innovation on this infrastructure may open up further possibilities (Thomas, 2012).

So, in summary, how much electricity do people use in their workdesks? Much more than they need. And how prepared are they to change their energy use behaviour? Not very. Although individual feedback may have some benefit, motivations beyond energy reduction will need to be harnessed to engage people in changing their energy behaviour.

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Appendix A

See Table A1.

[3] Plug load measured in the trial was 5.5% of total building electricity consumption. Assuming savings of 52.5% (average of lower bound of 32% and upper bound of 73%), £3026 could have been saved annually in this building. Over the approximately 10 buildings on campus of twice the size of the trial building, savings could be £60k.

Table A1
Mean, standard deviations and correlations of main variables.

		N	Mean (SD)	1	2	3	4	5	6	7	8	9	10	11
1	GEB	35–56	4.87 (.83)											
2	Intention to use MEF	30–46	4.64 (1.53)	.32*										
3	Attitude to MEF	30–46	5.38 (1.14)	.22	.73**									
4	Attitude to energy reduction	35–56	5.67 (1.28)	.34*	.44**	.66**								
5	Values—biospheric	35–56	5.36 (1.10)	.67**	.43**	.35*	.35**							
6	Identity—environmental	35–56	5.47 (1.13)	.49**	.17	.21	.33*	.64**						
7	Number of MEF accesses	35–76	2.55 (4.56)	.25	.33	.43*	.27	.14	.03					
8	Total duration of access	35–76	10.07 (26.11)	−.17	.29	.36*	.21	.02	−.06	.97**				
9	Energy baseline	33–72	29.39 (17.21)	−.13	−.15	−.27	−.46**	−.14	.01	−.15	−.15			
10	Energy Month 1	31–72	27.77 (14.77)	−.12	−.20	−.16	−.34*	−.05	.09	−.31**	−.30*	.73**		
11	Reduction Month 1	31–72	4.24 (1.04)	.05	.11	−.05	.01	−.04	−.06	.18	.16	.32**	−.33**	
12	Reduction Month 4	30–69	4.39 (1.52)	−.33*	−.05	−.18	−.01	−.29	−.11	.15	.15	.25*	−.12	.41**

Note: Significance testing is dependent on number of cases and hence varies by correlation.

* $p < .05$.

** $p < .01$.

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