View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by CURVE/open

Institutional, social and individual behavioural effects of energy feedback in public buildings across eleven European cities

Leticia Ozawa-Meida; Caroline Wilson; Paul Fleming; Graeme Stuart and Carl Holland

Post-print deposited in Coventry University Repository

Original citation:
Ozawa-Meida, L; Wilson, C; Fleming, P; Stuart, G. and Holland, C. (2017) Institutional, social and individual behavioural effects of energy feedback in public buildings across eleven European cities. *Energy Policy* 110, November 2017, 222-233. DOI: 10.1016/j.enpol.2017.08.026

http://dx.doi.org/10.1016/j.enpol.2017.08.026

Elsevier

CC-BY-NC-ND

Copyright © and Moral Rights are retained by the author(s) and/ or other copyright owners. A copy can be downloaded for personal non-commercial research or study, without prior permission or charge. This item cannot be reproduced or quoted extensively from without first obtaining permission in writing from the copyright holder(s). The content must not be changed in any way or sold commercially in any format or medium without the formal permission of the copyright holders.

This is an author-created version of: Ozawa-Meida, L., Wilson, C., Fleming, P., Stuart, G., & Holland, C. (2017) Institutional, social and individual behavioural effects of energy feedback in public buildings across eleven European cities . Energy Policy . https://doi.org/https://doi.org/10.1016/j.enpol.2017.08.026

© 2017. This manuscript version is made available under the CC-BY-NC-ND 4.0 license: https://creativecommons.org/licenses/by-nc-nd/4.0/

Institutional, social and individual behavioural effects of energy feedback in public buildings across eleven European cities

Leticia Ozawa-Meida[1,*], Caroline Wilson[2], Paul Fleming[1], Graeme Stuart[1], Carl Holland[1]

[1] Institute of Energy and Sustainable Development, De Montfort University, The Gateway, Leicester, LE1 9BH, United Kingdom
[2] Research Centre for Global Education, Coventry University, 1 Hill Top, Coventry, CV1 5AB, United Kingdom

Abstract

Better understanding of the factors influencing how people use energy in public buildings can help deliver more effective CO_2 reduction strategies. This paper describes the institutional, social and individual behavioural effects of communication campaigns in over 500 public buildings in 11 European cities. These campaigns involved engaging with staff to reduce energy use through feedback services based on information from sub hourly meter readings.

A summative evaluation was conducted to understand impacts of different information provision in these cities. Qualitative data were gathered through a set of interviews with 40 building professionals at the central or building level. These interviews identified differences in how the energy efficiency communication-based campaigns were implemented at each site and elicited factors to explain how users' perceptions and understanding changed as a result of the interventions. The evaluation framework helped to identify not only improvements in the delivery of communication-based campaigns, but also the communication factors that impacted on individual behaviour change. The research highlighted the influence of institutional and social effects on individual beliefs and norms. To achieve more effective change in attitudes to reduce use, energy feedback needs to be supported with engagement activities, such as energy coaches, campaigns, and interactive online fora.

Keywords:

Public buildings, energy feedback, evaluation, qualitative interviews, behaviour change, engagement

1. Introduction

The building sector accounts for around 40% of the final energy use and about 60% of electricity consumption in Europe, around one third of this consumption is related to non-domestic buildings (Gynther, et al., 2015). Energy use in offices, for instance, contributed approximately 30% of final energy demand in the European service sector over the last decade (Murtagh, et al., 2013) indicating considerable scope for identifying energy savings. Lucon et al. (2014) acknowledge that energy demand can be reduced by up to 20% of present levels through behaviours informed by awareness of energy and climate issues. Therefore, non-domestic buildings represent an opportunity to help meet European Union emission reduction target of improving energy efficiency by 20% within its energy and climate strategy for 2020. This paper examines qualitative data from building professionals involved in the management of more than 500 non-domestic buildings in 11 European cities. Users of these buildings were the subject of a European-funded SmartSpaces project to promote energy efficiency behaviours via communication of energy consumption data.

The design and delivery of behaviour change programmes varies significantly between domestic and non-domestic consumers. The potential for savings are said to be larger in domestic settings due to the direct connection between the energy efficiency behaviour, cost of energy and control over energy consumption. Energy user motivation for efficiency measures in non-domestic settings is typically lower, mainly because there is no link to direct personal cost savings (Carrico and Riemer, 2011; Christina, et al., 2014) and because of the invisibility of energy consumption as long as the space is comfortable and the equipment is working (Stuart, et al., 2013; Goulden and Spence, 2015). Even when individuals are interested in reducing their energy use for non-financial reasons, they have little or no information about how much energy they use, or have used, relative to previous periods (Carrico and Riemer, 2011). Motivation for employees and other non-domestic building users to engage in energy efficiency behaviours therefore usually relies on corporate social responsibility

objectives and the reinforcement of societal norms (Bull, et al., 2015; Scherbaum, et al., 2008; Christina, et al., 2014).

Energy efficiency interventions frequently take two broad forms; efficiency behaviours, which involve one-shot actions such as the purchase of energy efficient equipment or installation of equipment, and curtailment behaviours, which involve forming habits around switching off unused appliances and turning down thermostats (Gardener and Stern, 2002). Communication-based campaigns, as one feature of a many-factor energy efficiency intervention, are well suited to encouraging this latter form of voluntary change (Wilson, 2014). This type of contribution to an energy efficiency intervention is underpinned by the idea that more and better information will encourage consumers to conserve energy use (Delmas, et al., 2013). Communication campaigns tend to be more successful when they are organised by trusted local partners (e.g. the municipality) with messages tailored to the targeted user group and a simple and explicit presentation of the content. This content should be comprehensible for the receivers with interesting and attractive materials and applicable to their situation and their needs (Atkins and Rice, 2013).

Previous research has highlighted the usefulness of energy feedback in changing behaviour by 'making energy visible' (Stuart, et al., 2013; Hargreaves, et al., 2010). However, the majority of this research has been conducted in the domestic context using direct feedback (smart meters, in-home displays) and indirect feedback (enhanced billing, personal goal setting and feedback) (EEA, 2013). The savings achieved by providing real-time and historic energy usage information through in-home domestic displays ranged from 5-15% in a study conducted by Darby (2006) and from 2-4% on average through the combination of smart meters and real-time displays in the large-scale UK-wide Energy Demand Research Project (AECOM Limited, 2011). Less research has been conducted in non-domestic settings. Carrico and Riemer (2011) found that by providing monthly feedback via email of historic energy consumption to employees in a U.S. university in combination with peer education (in the form of 'energy coaches') led into a reduction of 8% in energy use. Dixon et al. (2015) observed a 6.5% reduction in energy use per floor area through the provision of comparative feedback (weekly individualised emails, website updates and posters detailing competition related statistics) during an energy conservation campaign in another university.

In this study of the building performance of over 500 non-domestic public buildings, sub hourly energy and water reading feedback was used to give building users an appropriate frame of reference to determine whether their consumption was excessive and to motivate them to reduce their use without impacting on the service they receive. The pilot project showed savings of up to 5% for those public authorities that were already using sub-hourly data and up to 15% where sub-hourly data was used for the first time (Stuart, et al., 2015).

1.1 Project context

The three-year (2012 to 2014) EU-funded SmartSpaces project (www.smartspaces.eu) aimed to save energy in Europe's public buildings using information and communications technology. Sites in eleven European cities (Belgrade, Birmingham, Bristol, Hagen, Istanbul, Leicester, Lleida, Milan, Moulins, Murcia and Venlo) developed services using information from sub-hourly data gathered from automatic meter reading systems. The services were targeted at building professionals (central and/or local energy/facilities management teams) and building users (staff/visitors). The building professionals used the automated metering to monitor, analyse and control settings of energy and water management systems to keep the buildings at an efficient level with changing conditions. The building users were able to "see" the energy and water consumption in their buildings and receive feedback and communication through energy visualisation tools and 'dashboards' to stimulate dialogue between the buildings users and the building professionals. One-to-many communication messages (Atkins and Rice, 2013) were used to inform, persuade or motivate behavioural change towards more efficient energy and water use in public buildings. This information provided feedback to building users on how much energy and water they used as well as when and how they used it. The information services were applied in each city independently, according to local context. Table 1 provides general information about the participating cities including the number of buildings per site, type of buildings and the availability of energy and water consumption data at the start of the project.

Insert Table 1 (appended below)

Office buildings are anticipated to be the most energy intensive type due to demand for heating, ventilation and air conditioning (HVAC), lighting and appliances (such as IT devices) (Perez-Lombard, et al., 2008). Within the SmartSpaces project, energy use per floor area in offices was

higher compared to leisure centres (around 20%) or nurseries (around 10%) (Stuart, et al., 2015). In addition, other factors that affect consumption include the occupancy patterns associated with schools and libraries, which are medium- to long-term, usually at high density and with an increasing use of computer terminals. This is in contrast, for instance, to leisure centres which have large volume spaces with occasional short-term high density occupancy as well as regular low-density use (CIBSE, 1997). Inter-country factors considered include non-electricity consumption per employee. This was usually higher in countries with larger needs for space heating such as the UK, Germany, and the Netherlands, while the electricity consumption in Southern countries like Spain and Istanbul was higher due to an increasing use of air conditioning (Lapillone, et al., 2014; Stuart, et al., 2015). Within the project's large portfolio of buildings, age, building envelope and energy efficiency features varied widely ranging from heritage listed buildings in Birmingham to recently built efficient buildings in Venlo and Moulins; from locally managed heating systems in schools at Bristol to use of heat pumps in Hagen and Venlo and district heating in Birmingham and Leicester. Installation of energy efficiency equipment was outside the scope of the project. However, automated energy data monitoring systems were implemented in Belgrade and Murcia, while optimised energy management strategies were reported in Hagen and Venlo. Energy savings were predominantly achieved from improved control of settings and schedules; and switching off heating, ventilation and lighting when buildings were not occupied or other equipment when not in use. Overall, the overarching aim of the project was to improve the energy information and communication to building professionals and staff focussing on good housekeeping and early fault detection rather than large scale investment. Messages were developed independently by each site based on local context, via energy visualisation tools. Energy feedback (measured consumption vs. baseline, historic consumption or daily consumption) was presented in a variety of forms across the sites through different views ranging from bar graphs, smiley faces, tachometers (green/amber/red gauge system to indicate high energy consumption), and playful animation for children. Some sites also included information about energy costs (Bristol, Lleida, Murcia, Venlo), energy savings or CO_2 reductions (Venlo), indoor and/or outdoor temperatures (Istanbul, Murcia, Milan, Moulins), a league table comparing energy use across participating buildings (Leicester), indoor air quality (Moulins), thermal comfort (Lleida), more

detailed information about half-hourly consumption profiles on graphs (Leicester) or hourly-slotted coloured matrices to compare energy consumption with occupancy (Bristol).

1.2 Aim of the paper

The aim of the evaluation of the services was to assess the level of the improved energy and water efficiency through the analysis of consumption data and user behaviour at each site before and after the installation of the services. The evaluation combined analysis of metered energy data with human behaviour data aimed to identify factors that influenced energy savings. This paper focusses on detailed interviews with building professionals in an attempt to understand the impacts of the services. While the examination of change at the level of the individual is a commonly assessed factor in the evaluation of many intervention programmes (Brown, et al., 2010; Goldstein, et al., 2008; Whitmarsh, et al., 2011), there is concern that impacts can be missed if changes above the level of the individual are not examined. For instance, Hornik and Yanovitzky (2003, p. 205) argue that the impact of communication campaigns "*may go beyond individual cognitions and behaviours to include effects on communities, institutions, organizations, and social networks*". The argument for energy efficiency interventions which aim to achieve more than individual level change is also found in the energy literature (Shove, 2010; Whitmarsh, et al., 2011; Wilson and Chatterton, 2011). This study explores the views of the building professionals on the effectiveness of the services at the institutional, social and individual level in each city and the factors that drove or hindered these impacts.

This introductory section has explained the focus and context of this paper. Section 2 describes the underpinning theoretical framework used in the evaluation work and how empirical data was gathered to assess the institutional, social and individual impacts of the project. Section 3 contains an analysis of key points observed by building professionals in terms of identified motivating factors or constraints during the implementation and operation of the project. Section 4 discusses the impacts achieved at different levels (i.e. individual, social and institutional). Section 5 draws the conclusions and draws highlights the strengths and limitations of both the interventions and the evaluation framework.

2. Methods and materials

2.1 Theoretical framework

At the level of the individual, the framework to evaluate energy-related behaviour change focused on assessing the extent of cognitive engagement with the SmartSpaces project and its subject matter, as thoughtful behavioural choices are more likely to lead to an enduring change (Bator and Cialdini, 2000). For tracking the impact of the persuasive communication of the project on behaviour change, the theory of change used was based on the Elaboration Likelihood Model (ELM). The ELM helps to understand how communication can prompt cognitive engagement (Petty and Cacioppo, 1986a; Petty and Cacioppo, 1986b) by focussing on the recipient's motivation and ability to process information, and also their evaluation of the source and quality of the message (Wilson and Irvine, 2013). Consequent attitude change was tracked by using the Theory of Planned Behaviour (TPB) - that examines which attitudes, subjective norms and perceived behavioural control are most likely to predict intentions and behaviour (Ajzen, 1991; Ajzen, 2011). Previous studies have discovered that attitude is the predictor variable within the TPB most likely to be impacted by a communication-based programme, because attitudes are individual based, whereas subjective norms and perceived behavioural control comprise some external influence (Stead, et al., 2005; Manstead, 1991; Conner and Sparks, 1995). Further variables are identified as precursors to a change of attitude: awareness and knowledge are initial conditions to engage in energy-saving behaviour (Lo, et al., 2012; Wilson and Stuart, 2014).

This study aimed to demonstrate that change as a result of an intervention is not just seen at the level of the individual, but can be observed at three levels of effects as a result of a communication-based energy efficiency programme. In doing so it adapts a model of communication effects observed in health behaviour change (Hornik and Yanovitzky, 2003). Change might firstly be observed directly as proposed above - in the actions of individuals who are prompted to change personal behaviour. Its effects might also be as a result of diffusion, for example the programme may not influence an energy user directly but the energy user may pick up their cues as a result of interaction with others who *do*

change behaviour (and adapt as a result of the behaviour change of others rather than the programme's communication). Thirdly, institutions might respond at the policy or structural level to the programme and provide additional motivations or reduce barriers to change.

This study aimed to elicit those factors above the level of the individual that are difficult to assess in surveys. The qualitative data gathered allowed exploration of the project's impact at the individual level but also offered insight into how the project operated at the 'social' and 'institutional' levels. Figure 1 illustrates the overall evaluation framework and the central role that qualitative interviews offered in providing insight into these latter factors on individual change that might be discovered in surveys or operational change noted through energy modelling. This theoretical framework is described in more detail in Wilson (2014).

Insert Figure 1 (appended below)

A key part of the evaluation was a series of interviews to capture insights from building managers around month 26 of a 36 month programme. Interviews are regarded as appropriate for research when the information sought is from "key players" who can provide insight into a situation which others cannot (Denscombe and Dawson, 2007, p. 175). These interviews took place at month 26 in order to capture insights before the programme ended and before the capacity to gain insights from the project were lost. These interviews aimed to assess how the energy-efficiency communication-based campaigns were actually implemented and to identify differences at each site as services were implemented in a variety of forms according to the country. Interviews also provided the opportunity to obtain feedback from energy and buildings management personnel about how engaged building users were and on whether attitudes to energy and water consumption were changing. By investigating contextual factors as well as other confounding variables, interviews offered insight into *why* and *how* changes in the energy/water consumption took place (Stuart, et al., 2015), and also offered triangulation of evidence (Atkins and Rice, 2013).

Energy/water savings in the project were estimated as the difference between the measured sub hourly data and the consumption forecast during the reporting period. Baseline data for a one-year period before the intervention was gathered and fitted into a statistical model for each building and used to forecast the consumption for the reporting period. The model estimated the buildings' specific base

temperatures considering how the building responded, in the baseline period, to fluctuations in outside air temperature. In this way, the model was able to account for seasonal temperature changes (Stuart, 2011; Stuart, et al. 2015).

2.2 Communication and Information Materials

Building professionals with facilities and/or energy management responsibilities were selected by representatives of the 11 sites. The role of these professionals in the implementation and communication of the services was essential, as these actors can influence downwards to the building users, upwards to senior managers, and sideways through external organisations, such as energy service providers and professional bodies (Goulden and Spence, 2015).

A total of 40 participants were interviewed face-to-face, by phone or by Skype between March and April 2014. The interviews were carried out in the native language of the interviewee. The interviews took place directly for English and Spanish speaking interviewees and with the assistance of simultaneous translation by representatives of the sites for other languages. Table 2 shows the list of interviews' participants mapped to their roles in their organisations or in the project. To maintain the anonymity of participants, quotes are referred to their respective sites rather than to the positions of the individuals.

Insert Table 2 (appended below)

2.3 Instrument and Procedures

Ethical approval was obtained via De Montfort University's review system, with protocols observed to ensure participation was voluntary and participants were assured of anonymity. After introductions, interviews lasted an average of 60 minutes and were recorded and transcribed verbatim.

The interview format was semi-structured in order to obtain in-depth insights of the participants' thoughts, viewpoints, attitudes and actions (Harris and Brown, 2010) related to the themes identified in the theory of change set out in Figure 1. The main themes were pre-constructed by the researchers based on literature relevant to this study and were used to map experiences of participants and describe whether these align with existing theory (Walker and Myrick, 2006) rather than develop new theory (Willig, 2007). It therefore took a constructivist approach in that the perspective of previous

research directs the attention of the current work (Charmaz, 2008). The sub-themes investigated were related to message, communication channels and branding of the services (Atkins and Rice, 2013); level of alignment of the programme objectives with institutional policies (Andersson, et al., 2005); and about how the services were mobilized and mainstreamed into the institutional culture (Hargrave and Van de Ven, 2002). Questions also sought to understand whether interaction and discussion occurred at the level of the individual and whether the levels of awareness and knowledge of energy use were influenced as a result of viewing or interacting with the services.

The potential for bias from interviewees' responses needs to be acknowledged as participants are more likely to respond in a socially desirable manner within an interview context (Harris and Brown, 2010). Asking for the interviewees' perceptions of users' experiences (proxy reporting) can also pose the potential risk of having fundamental differences between the perspectives of the proxy (interviewee) and the target (user) (Cobb, 2015). Researchers attempted to minimise the bias and risk by asking participants about the headline themes in an open-ended manner, to enable a broad ranging discussion of topics. Through the elaboration on ideas by participants, useful information was elicited to understand the influence of organisational and societal values on the energy-saving behaviour of staff managing and working in non-domestic buildings.

Transcripts were initially examined using template analysis based on the interview questions. Interviews were coded according to the extent to which they aligned with the pre-identified themes of the type of intervention carried out on their site. The experience of its implementation, their impressions of issues which appeared to drive or act as a barrier to change, and their perceptions of impact were also recorded. From this structural coding, common themes emerged within and between sites. Initial findings were discussed with sites' representatives to validate the results or add further information. Subsequently, more detailed analysis of the specific categories within each theme led to the findings presented in this paper.

3. Results

This study set out to elicit evidence of change in factors both at and above the level of the individual as a result of the communication-based programme to encourage energy efficiency. The three levels identified: institutional, social and individual, are addressed in turn.

3.1 Institutional effects

Institutional factors, such as closer supervisor supportive behaviour, can have impacts on individuals' attitudes and performance towards energy savings tasks (Q1 and Q2, Table 3). Building professionals agreed that key actors in the top management of their institutions were committed to and supported the project in Belgrade, Hagen, Istanbul, Lleida, Milan and Murcia. For example, the support of top management, such as the Mayor in Lleida, aimed to gain acceptance at different management levels and departments of the organisation (Q3, Table 3). Specific examples of support provided by the top management, included the provision of economic resources and staff time (Q4and Q5, Table 3), or by removing barriers and creating a gratifying working environment (Q1, Table 3).

Financial considerations at the institutional rather than personal level were the most important factor mentioned to embed the energy and water saving culture in their institutions. Although local authorities are non-profit organisations, there was connection between the corporate cost savings achieved and the eventual benefit that buildings or individuals could receive in terms of budget structure (Q6, Table 3) or job conservation (Q7, Table 3). Due to the close link between energy efficiency improvement and carbon emissions reductions, one building professional considered compliance with environmental regulation as important as cost savings (Q8, Table 3).

Corporate values, particularly a visible corporate commitment to sustainability, can also have a strong influence on individual behaviour in organisations. While at least one participant in each site agreed that the project was consistent with the sustainability culture of their organisations, two interviewees pointed out the contribution of the project towards energy and environmental commitments at the local, national or European level (Q9 and Q10, Table 3).

Aligning with their corporate sustainability values and cost reduction, interviewees considered that technological change and innovation are important strategies to achieve their environmental goals

(Q11, Table 3). Reputation was a motivating factor in sites like Birmingham. Similar to a competitive advantage, one interviewee highlighted that the dissemination of these projects increases the attractiveness and interaction with potential business partners and investors (government funding) for further projects (Q12, Table 4).

Despite the perceived support and commitment from senior management, the issue of competing workplace priorities was also raised by the interviewees. Two building professionals perceived that managers in their organisations did not see energy management as *'part of their jobs'* (Q13, Table 3) or that it had a lower priority compared to other tasks (Q14, Table 3). In times of economic recession, budget cuts and increased workloads in the public sector, it seems that the pressure to perform the work well reduces the importance of energy management tasks in supervisors' minds (Q15, Table 3). This, in turn, makes this only *'one small task additional'* to the daily activities of general employees (Q16, Table 3).

Having multiple organisational goals may not reduce the performance on energy management tasks, but it may be a problem when tasks are conflicting or contradictory. For example, in libraries where the availability of computer services should be provided as advertised (Q17, Table 3) or in schools where the main priority is educating the children and keep them in a comfortable environment (Q18, Table 3). Even when energy saving measures were perceived incompatible to the quality and efficiency of the service required, the interviewee considered that energy usage of other appliances should be addressed (Q17, Table 3).

With competing and conflicting goals, such as meeting occupants' comfort demands as well as achieving energy reduction targets, two building professionals pointed that the senior level commitment needed to be better permeated into lower management levels in *'a top-down approach mainly at the intermediate level'* (Murcia interviewee) and supported with a more consistent internal policy guidance (Q19, Table 3).

Insert Table 3 (appended below)

3.2 Social effects

Building professionals explained how internal and external networks were strengthened through the implementation of the project. In Leicester, environmental champions (an existing social network)

supported the training and dissemination activities of the project. One interviewee perceived that environmental champions found the information service useful to communicate with their colleagues and with students (Q1, Table 4). Another key feature for the communication between staff and the energy management teams in Leicester was the online interactive discussion forum. Users of this forum could report anomalies to the energy management team, such as problems with thermal comfort, water taps left open and lights left on (Q2, Table 4). Energy managers not only responded to the posts, but also made the necessary adjustments in the controls. In particular, one interviewee referred to the online discussion forum as a powerful communication tool that has enabled *'careful thinking and discussion'* about energy topics among building users (Q3, Table 4). In Murcia, the visualisation of energy data also improved the communication of building users with their central or local energy management teams, which in turn facilitated further dissemination of information among colleagues (Q4, Table 4).

In Bristol, Lleida and Venlo, communication and training in energy efficiency was supported by energy coaches who operated as a point of contact between the building users (staff and visitors) and the building professionals (Energy and facilities management staff). As part of their duties, energy coaches aimed to answer users' queries about energy and water use in their buildings and guided them to implement actions to reduce consumption (Q5, Table 4). Interviewees in Bristol highlighted that the communication with the energy coach played an essential role not only in their learning processes, but also in enhancing the credibility of the whole process since the access to information improved and response times from the Central Energy Management Unit were quicker. As well as increasing their technical knowledge and the credibility of the energy information received (Q6 and Q7, Table 4), interviewees considered that this communication brought legitimacy to the innovation process of the project.

In Lleida, three intensive "energy savings campaigns" were conducted in its Sant Francesc office building related to heating (winter 2013), minimisation of electricity use (spring 2014) and air conditioning (summer 2014). All staff members were trained on different energy efficiency measures they could act upon in each campaign and how they could visualise the results of their efforts in terms of energy reductions through the visualisation tool. Information about each respective campaign was

displayed in screens and posters. Frequent emails were also sent to remind staff to access the tool, consult the information and notify if there were incidents of abnormal energy consumption. Users also expressed their viewpoints of *'what is working and what is not'* within the campaigns. Interviewees considered that factors that strengthened the collaboration among building users were the visibility and acknowledgement of actual energy and cost savings as well as the recognition of employees' efforts for achieving those savings (Q8, Table 4).

It was also acknowledged that the services also aimed to increase cooperation, or at least responsiveness, among departments and staff from other disciplines that were not previously interested in energy and water use in the buildings (Q9, Table 4). This interdepartmental collaboration was particularly relevant in Birmingham, which was developing a comprehensive Energy Strategy for the council at the time of interviews. Birmingham's site representatives also highlighted that the experience gained in the project regarding the acquisition of data and knowledge as well as the management of resources were essential in the development of this strategy, which was approved by Birmingham's council leaders by the end of the programme. This provides an example where cumulative interaction among actors and organisational units offered the opportunity to recognise areas where cooperative relationships could be established and complementary benefits be achieved. Beyond internal networks, interviewees commented that strong networks with the municipal bodies or community housing associations were developed in Istanbul (Q10, Table 4), whereas existing networks with governmental institutions were strengthened in Belgrade (Q11, Table 4).

Insert Table 4 (appended below)

3.3 Individual effects

This section presents perceptions at the individual level on the information provider *(who)*, the message of the communication tool *(what)* and the engagement tools of the services delivered in the project *(how)*. As detailed in section 2, the source and quality of the message are communication features that can impact on individuals' attitude towards what is communicated, and reviewed ahead of discussing attitude directly.

3.3.1 Attitudes

As described in section 1.1, messages were developed by each site according to local context, via energy visualisation tools. Feedback was presented via bar graphs, smiley faces, tachometers and playful animation.

Interviewees' perception of the message of their services was similar in different sites. *Ease of processing* was acknowledged in Bristol, where participants found use of hourly-slotted coloured matrices to be a "*very visual and user friendly tool*" that helped to locate high energy use at particular times. In Moulins, a more playful message with animations was regarded as attractive and easy to understand for their intended audience (young children and their families) to encourage them to save energy and money not only in the building, but also in their homes. Interviewees in Murcia considered that the graphs and data were presented in *"an effective and intuitive manner"*.

The *persuasiveness* of the message was recognised in Belgrade, where the interviewees' perception of the message of their services was regarded as "*short, clear, explicit and convincing*". While in Birmingham, use of smiley faces and tips of the week were depicted as a *"straightforward message to increase awareness and a prompt for local action"*.

Although two thirds of participants in Leicester considered that smiley faces were simple, easy to understand, and a clear way to inform energy users about the performance of the buildings, three interviewees suggested that alternative indicators should also be considered, particularly when the face expressions stayed the same despite changes in space use, increased occupancy or equipment (Q8, Q9 and Q10, Table 5). These interviewees felt that despite their constant efforts to keep low levels of energy consumption, a yellow neutral face indicator risked discouraging staff or providing an erroneous message to senior management or to the public.

The *credibility* of the institutions providing the information in the project was investigated by asking interviewees about the branding of the services in their cities. All sites, except for Leicester, used the logos of the SmartSpaces project and their partner institutions in the services. Building professionals considered that use of a logo for branding was important to provide credibility of the information (Bristol, Leicester, Milan, Murcia, Venlo), recognition of the council services (Leicester, Lleida, Murcia) and to increase the feeling of ownership amongst users.

Energy coaches performed a key role in increasing the technical knowledge of building users and the credibility of the information received in the energy visualisation tools (see section 3.2). In Istanbul and Milan, interviewees also perceived that the implementation of the services increased the *technical knowledge* on how the energy systems work within their buildings, not only within their technical staff (Q1, Table 5), but also amongst personnel without energy responsibilities (Q2, Table 5). In all sites, interviewees agreed that the services raised *awareness* in building users through training activities and through the visibility of the feedback mechanism (Q3, Q4 and Q5, Table 5).

3.3.2 Subjective norms

Interviewees referred to the influence of the information and communication services in their social norms in terms of what most people would approve or disapprove or what most people would normally do.

In Leicester, an energy performance league table of the participating buildings was provided in the visualisation tool. For each building, daily or weekly metered consumption was compared against that predicted by a baseline consumption model (see section 2.1). One interviewee considered that staff commitment and competition between buildings can increase when reflecting about *'how people are doing in their building and with other buildings'* before and after a 'switch off' campaign, for example (Q6, Table 5). In Murcia, one building professional also agreed on an increased competitiveness and commitment when staff can view the performance of other buildings (Q7, Table 5).

A negative feature of league tables was identified by three interviewees who considered that the ranking and smiley faces may not be well understood by senior management or the public. These staff felt the rankings used did not reward buildings where staff were highly energy aware and conducting procedures to keep energy consumption low and constant (Q8, Q9 and Q10, Table 5). Instead of recognising these efforts, senior management may expect actions to improve this ranking (Q9, Table 5).

3.3.3 Perceived control behaviour

Building professionals referred to having enhanced control of the building energy management systems (BEMS) as a result of SmartSpaces services. The visualisation of data prompted them to take more control of settings and schedules to reduce energy consumption (Q11, Table 5).

In contrast, general staff interviewees perceived that they had minimal or a lack of control over the heating and cooling services (Q12, Table 5). Nevertheless, these staff members followed *'good standard procedures'* to ensure that electrical equipment and water taps were turned off when they were not in use. This perceived lack of control could be attributed to the fact that heating and cooling services are mainly managed centrally for the entire building or a set of buildings in sites like Leicester (where four out of the twenty participating buildings used district heating). Only in Venlo, staff could change the local settings for their heating and cooling in their offices.

3.4 Behaviour

As illustrated in Figure 1, and based on the TPB, individual attitudes, subjective norms and perceived control behaviour are antecedent factors for changed behaviour. However, this study also recognises the influence of institutional and social context on individual behaviour in organisational settings. Observed outcomes as a result of the energy-efficiency communication-based campaigns are presented considering factors internal to the individual (section 3.4.1) as well as external contextual factors that influence behaviour (section 3.4.2).

3.4.1 Individual behaviour

Thermal comfort of building users was a salient theme across all sites as the main priority in schools and nurseries, and as a relevant issue for staff to have a comfortable physical environment to work. Building professionals considered that their energy management strategies can be regarded as successful when energy savings were achieved without compromising the thermal comfort of the building users (Q1, Table 6).

As a result of increased knowledge and awareness, participants considered that the information and communication services stimulated thoughtful consideration among staff about what they can do to improve energy efficiency in their buildings and detected changes in attitudes and behaviour of building users. For example, one building professional in Hagen commented that when employees

detected high energy consumption in the feedback mechanism they contacted the energy team and asked reasons behind the consumption and if they can turn off certain appliances or services (Q2, Table 6). After being able to visualise the energy data and training on energy savings, interviewees in Istanbul noticed that staff and visitors were more careful to turn off lights or appliances when not in use or to not open windows when heating or air conditioning were operating (Q3, Table 6).

3.4.2 Behaviour in the institutional and social context

Personal behaviours can be enhanced or hindered by positive motivators and negative barriers in the institutional and social context. Individuals' attitudes and performance towards energy saving tasks can be enhanced with support of top management and supervisors (see section 3.1).

In Lleida, the energy saving campaigns concentrated on reduction targets. One interviewee noted that communicating the energy savings achieved to their staff and recognising their efforts provided them not only an encouraging environment to increase awareness amongst employees (Q5, Table 5), but also with satisfaction resulting in further motivation and engagement (Q4, Table 6). Positive feedback enhanced employees' belief that they can attain organisational goals (self-efficacy), which in turn strengthened their motivation for action.

In contrast, gain-oriented motivations to save energy were low in buildings where energy bills are paid centrally or where teams from different departments share these buildings due to the lack of ownership perceived by the occupants (Q5, Table 6).

Despite the differences between building professionals and building users on what they can or cannot control (see section 3.3.3), the communication between users and the energy teams increased in most sites (see section 3.2), which in turn enhanced the control of energy use. Furthermore, one interviewee noted that an increased cooperation among building users reduced excessive energy consumption due to extreme temperature settings (Q6, Table 6).

4. Discussion

The following sections discuss the influence of institutional and social effects on individual's energy saving behaviour in non-domestic buildings as well as the impact on individuals directly.

4.1 Institutional effects

As described in sections 3.1 and 3.4.2, organisational commitment in the form of trust in top management or supervisors' supportive behaviour can have a positive influence in individual employees' attitudes towards energy-saving behaviour particularly in a multiple-goal situation (Andersson, et al., 2005; Pellegrini-Masini and Leishman, 2011). Trust in the organisation's commitment was recognised when senior management provided specific resources and support to the project in the form of dissemination of the campaigns at different levels, additional economic resources or staff time. However, this support was not perceived equally in all sites, where staff struggled to prioritise energy management amongst their multiple tasks or act upon energy saving opportunities that could conflict with the quality of their services (e.g. schools and libraries). Studies on organisational settings have also found that competing, conflicting or incompatible business priorities may reduce the performance on energy management tasks (Lo, et al., 2012; Christina, et al., 2014; Bull, et al., 2015; Andrews and Johnson, 2016; Zierler, et al., 2017).

Institutional drivers and strategies found in this research are consistent with results of studies examining corporate responses to address climate change in terms of corporate sustainability values, compliance with environmental regulation, technological change and innovation (Kolk and Levy, 2001; Okerke, 2007; Ozawa-Meida, et al., 2008; Sullivan and Gouldson, 2013; Okerke and Russel, 2010). Reputation also appeared as a driver in the uptake of energy and water efficiency in buildings that brings external benefits, such as competitive advantage through the dissemination of the project to potential business partners and investors, as well as internal benefits, such as increased employees' commitment (Pellegrini-Masini and Leishman, 2011).

Although employees are not typically motivated to save energy when they do not have to pay the energy bills (Carrico and Riemer, 2011; Christina, et al., 2014), building professionals in this study considered that financial factors at the institutional, rather than at the personal, level may have an influence on staff's energy behaviour. However, this financial motivation was limited in centrally managed buildings where staff had little or no control of their building's energy use or little engagement and ownership of the energy savings as the bills were paid centrally. In these cases, senior managers need to become more engaged with the organisation's energy reduction strategies

through consistent internal policy guidance and potentially supported with financial incentives schemes.

4.2 Social effects

Among the most important aspects of engaging people in collective action are formal and informal networks that introduce and diffuse new models, concepts and practices, so these can become part of the organisation's culture (Hargrave and Van de Ven, 2002). The mobilisation of the services in the project relied on existing and newly identified networks of like-minded individuals with specific interest on energy issues (environmental champions) in Belgrade, Birmingham, Milan and Leicester (see section 3.2). These networks of highly engaged individuals acted as peer educators, disseminating their knowledge on to colleagues and coordinating collective action (Stuart, et al., 2013).

There was clear evidence that direct communication with local or central energy management teams (through energy coaches or an online forum) were highly appreciated. When energy managers engaged with building users to discuss the energy use in their buildings and considered their feedback, this factor appeared to legitimise the change process more than the support of senior management. An increased cooperation among building users can reduce excessive energy consumption due to extreme temperature settings. As Goulden and Spence (2015) point out, occupants who have a sense of control of their local environment are more satisfied with thermal conditions generally and tend to be more accepting of wider temperature bands.

Interdepartmental collaboration was particularly relevant in Birmingham, which was developing a comprehensive Energy Strategy for the council at the time of interviews. Birmingham's site representatives also highlighted that the experience gained in the project regarding the acquisition of data and knowledge as well as the management of resources were essential in the development of this strategy, which was approved by Birmingham's council leaders by the end of the project.

4.3 Individual effects

Facility and energy managers are usually seen as the key actors responsible for energy use (Lo, et al., 2012; Goulden and Spence, 2015). Building professionals showed a positive attitude to energy

savings as a result of more accessible and meaningful data. The sub-hourly energy and water data helped them to identify high energy or water usage at a particular time, which enabled the building controls to be corrected. Despite this enhanced control and engagement with some staff, other employees perceived a lack of control of energy reductions, particularly in buildings where the heating and air conditioning services were centralised. In the latter case, self-efficacy beliefs could be strengthened by communicating to staff when energy savings have been achieved following an information campaign to recognise their efforts like in Lleida (see section 3.4.2). Positive feedback on the progress in relation to established goals can strengthen the employees' belief that they can attain the goal (self-efficacy), encouraging them '*to adjust their level of effort to match what the goal requires*' and providing further motivation to act (Locke and Latham, 2002, p. 708).

Social norms were enhanced in those sites where users perceived competition of energy performance improvement between buildings (e.g. league tables in Leicester or peer conversations in Murcia). In addition to positive feedback, it may be worth exploring competitive approaches (energy reduction competitions) and incentivation models (gamification) in future projects to intensify knowledge exchange and participation among the users as well as promoting cooperative behaviour (Vine and Jones, 2016).

5. Conclusions and Policy Implications

The overarching aim of the SmartSpaces project was to improve the energy information and communication to building professionals and staff with particular focus on good housekeeping and early fault detection rather than large scale investment. Near up-to-date feedback and visualisation from sub hourly meters can be effective in reducing energy and water consumption in public buildings. For sites that already had sub hourly metering, savings of up to 5% in average were achieved, while for those pilots new to sub hourly metering, savings increased to up to 15% (Stuart, et al., 2015).

Technical recommendations that can be made as a result of this project are around availability and use of energy data, as the properties of buildings and energy efficient equipment were beyond the scope of this project. These recommendations include solving problems around the quality and timeliness of

energy data available from utilities. A key factor in dealing with public buildings is their change of use. For example, around 25 buildings in the project were demolished, sold, had data centres installed or significantly increased or decreased the number of staff working in them. This will always be an issue when measuring long term energy performance of buildings.

As well as recommendations about the quality of information, this project learned about the quality of communication with building users. Visualisation of energy trends or "dashboards" over time facilitates engagement with buildings users who can identify and solve energy performance problems effectively and efficiently (Stuart et al. 2016). Engaged users return to the data visualisation to check their building performance, however, on-line activity by itself is not enough. There is still a need to arrange campaigns and to engage face to face with energy managers, energy champions and building users, for example, through monthly training meetings to explain users on how to interpret data and provide advice on actions that can reduce energy consumption in non-domestic buildings or specific energy saving campaigns related to heating, minimisation of electricity use and air conditioning, at critical points in the year. Clearly these campaigns can be more effectively supported by the information from the analysis of data and the peer to peer education.

The learning from the SmartSpaces project is now influencing a further European project. Continuous monitoring of energy data, collection of information about energy efficiency measures in participating buildings, analysing the data and developing training material are all features being made available for some European local authorities via a Coordination and Support Action of Horizon 2020 called EDI-Net (www.edi-net.eu)[1] which aims to help institutions use more effectively smart metering and related building use data to reduce electricity, gas and water consumption in their buildings.

An institutional policy action that should be considered, based on the findings from this study, is to create localised ownership of energy resources. As discussed in section 4.1, centrally-paid energy bills, or shared occupancy buildings which nurture a lack of connection between the energy user and energy cost, act as a disincentive for individuals to engage in energy efficiency activity. Another institutional effect noted in this project was the support the services offered in assisting organisations

[1] EDI-NET – The Energy Data Innovation Network; using smart meter data, campaigns and networking to increase the capacity of public authorities to implement sustainable energy policy. Grant Agreement: 695916

to meet environmental targets, such as pledges made in the Covenant of Mayors, a European coalition of cities and local governments dedicated to combating climate change via efficient use of energy. Signatories of this initiative are committed to reduce their CO_2 emissions by at least 40% by 2030 through actions specified in their Sustainable Energy and Climate Action Plans (SECAP) (CoM, 2015). Services provided in SmartSpaces and EDI-Net can assist institutions to implement interventions as described in this paper, provide data easily about savings from buildings and report progress towards meeting their targets in the SECAP.

The framework used to evaluate the project was an effective tool for planning and assessing different stages of communication-based interventions. It offered a useful structure to elicit factors to explain how users' perceptions and understanding changed as a result of the interventions and in what conditions their behaviour was likely to change. It helped to investigate the effectiveness of the programme from the lens of staff responsible for the energy management of the building or for training colleagues during the operation of the programme.

The evaluation, with its focus on investigating change at the institutional, social and individual level, provides evidence for the argument that too much energy efficiency guidance has been directed on change at the level of the individual (see section 1.2). Frequently individuals feel powerless to make effective change, whereas change at the social level creates a sense of agency. A major impact of the SmartSpaces project was in the increased institutional focus on energy efficiency. The project's positive influence on the development of Birmingham's whole authority energy strategy provides an example of institutional change likely to have far more impact on ongoing energy consumption than the most concerted efforts of a group of individual building users.

Due to the effectiveness of the evaluation framework of the SmartSpaces project, a similar framework, incorporating institutional, social and individual behavioural effects, is being used in the evaluation of the EDI-Net project. The SmartSpaces evaluation has provided evidence of the importance of change taking place beyond the level of the individual. External influences play a key role in determining energy-saving behaviours in organisations. The theoretical behavioural framework for EDI-Net has been modified to explore further the influence of personal and social norms operating in non-domestic buildings as well as the organisational energy-saving 'climate' based on the Norm

Activation Theory (Schwartz, 1977; Zhang, et al., 2013) in the attempt of better understand the individual and organisational drivers for energy efficiency. The EDI-Net project is also collecting additional information about installed or planned energy efficiency measures in a better attempt to determine to what extent the actual energy savings can be attributed to upgrades in equipment and infrastructure, to the better control and energy management conducted by building professionals and to the behavioural change of staff.

Acknowledgements

The data referred to in this paper were collected in the project titled "SmartSpaces: Saving Energy in Europe's Public Buildings using ICT" by the European Commission within the ICT Policy Support Programme Grant Agreement 297273. The funding source had no influence on the findings. We would like to acknowledge and thank the support of all partners in the SmartSpaces project.

References

AECOM Limited, 2011. Energy Demand Research Project, Final Analysis, AECOM and Ofgem, St Albans.

Ajzen, I., 1991. The Theory of Planned Behavior. Organ. Behav. Hum. Decis. Processes 50, pp. 179-211.

Ajzen, I., 2011. Behavioral Interventions: Design and Evaluation Guided by the Theory of Planned Behavior. In: Mark, D. S., Campbell, B. (Eds.), Social psychology for program and policy evaluation, Guildford, New York, pp. 74-100.

Andersson, L., Shivarajan, S., Blau, G., 2005. Enacting ecological sustainability in the MNC: A test of an adapted value-belief-norm framework, J. Bus. Ethics 59(3), pp. 295-305.

Andrews, R., Johnson, E., 2016. Energy use, behavioural change, and business organisations: Reviewing recent findings and proposing a future research agenda. *Energy Res. Soc. Sci.*, 11, pp. 195-208.

Atkins, C., Rice, R., 2013. Public Communication Campaigns, SAGE publications.

Bator, R. J., Cialdini, R. B., 2000. The application of persuasion theory to the development of effective proenvironmental public service announcements. J. Soc. Issues 56(3), pp. 527-541.

Brown, T., Ham, S., Hughes, M., 2010. Picking up litter: an application of theory-based communication to influence tourist behaviour in protected areas. J. Sustainable Tourism, 18(7), pp. 879-900.

Bull, R., Lemon, M., Everitt, D., Stuart, G., 2015. Moving beyond feedback: Energy behavhiour and local engagement in the United Kingdom. Energy Res. Soc. Sci. 8, pp. 32-40.

Carrico, A., Riemer, M., 2011. Motivating energy conservation in the workplace: An evaluation of the use of group-level feedback and peer education. J. Environ. Psychol. 31(1), pp. 1-13.

Charmaz, K., 2008. Grounded Theory as and Emergent Method. In: S. Hesse-Biber, P. Leavy, eds. Handbook of Emergent Methods. Guildford Press, New York, pp. 155-172.

Christina, S., Dainty, A., Daniels, K., Waterson, P., 2014. How organisational behaviour and attitudes can impact building energy use in the UK retail environment: a theoretical framework. Architectural Engineering and Design Management, 10(1-2), pp. 164-179.

CIBSE, 1997. Energy efficiency in further and higher education - cost effective low energy buildings, Watford: CIBSE.

Cobb, C., 2015. Proxy Reporting. In: Krosnick, J.A., Presser, S., Husbands Fealing, K. Ruggles, S. Vannette, D. (Eds.) The Future of Survey Research: Challenges and Opportunities, A Report to the National Science Foundation. [Online] Available at: http://www.nsf.gov/sbe/AC_Materials/The_Future_of_Survey_Research.pdf [Accessed 12 August 2016].

Conner, M., Sparks, P., 1995. The Theory of Planned Behaviour and health behaviours. In: M. Conner, P. Norman (Eds.) Predicting Health Behaviour: Research and Practice with Social Cognition Models, Open University Press, Buckingham.

Covenant of Mayors, 2015. The Covenant of Mayors for Climate and Energy, Brussels [Online]. Available at: http://www.covenantofmayors.eu/IMG/pdf/covenantofmayors_text_en.pdf [Accessed 10 July 2017]

Darby, S., 2006. The effectiveness of feedback on energy consumption. A review for DEFRA of the Literature on Metering, Billing and Direct Displays, Oxford: Environmental Change Institute, University of Oxford.

Delmas, M.A., Fischlein, M., Asensio, O. I., 2013. Information strategies and energy conservation behavior: A meta-analysis of experimental studies from 1975 to 2012. Energy Policy, 61, pp. 729-739.

Denscombe, M., Dawson, B., 2007. The good research guide for small scale social research projects. 3rd ed., Open University Press, Maidenhead.

Dixon, G., Deline, M.B., McComas, K., Chambliss, L., Hoffmann, M., 2015. Using Comparative Feedback to Influence Workplace Energy Conservation: A Case Study of a University Campaign. Environ. Behav. 47(6), pp. 667-693.

European Environmental Agency (EEA), 2013. Achieving Energy Efficiency through behavioural change: what does it take. Issue EEA Technical report no. 5/2013.

Gardener, G.T., Stern, P., 2002. Environmental Problems and Human Behaviour, Pearson, Boston.

Goldstein, N., Cialdini, R., Griskevicius, V., 2008. A room with a viewpoint: Using social norms to motivate environmental conservation in hotels. J. Consumer Res. 35(3), pp. 472-482.

Goulden, M., Spence, A., 2015. Caught in the middle: The role of the Facilities Manager in organisational energy use. Energy Policy 85, pp. 280-287.

Gynther, L., Lapillonne, B., Pollier, K., 2015. Energy efficiency Trends and Policies in the Household and Tertiary Sectors, An Analysis based on the ODYSSEE and MURE Databases, Report for the Intelligent Energy Europe Programme of the European Union [Online] Available at: http://www.odyssee-mure.eu/publications/br/energy-efficiency-trends-policies-buildings.pdf [Accessed 28 February 2017]

Hargrave, T., Van de Ven, A., 2002. A Collective Action Model of Institutional Innovation. Academy of Management Rev. 31(4), pp. 864-888.

Hargreaves, T., Nye, M., Burgess, J., 2010. Making energy visible: A qualitative field study of how householders interact with feedback from smart energy monitors. Energy policy, 38(10), pp. 6111-6119.

Harris, L. R., Brown, G. T., 2010. Mixing interview and questionnaire methods: Practical problems in aligning data. Practical Assess. Res. and Evaluation 15(1), pp. 1-19.

Hornik, R., Yanovitzky, I., 2003. Using Theory to Design Evaluations of Communication Campaigns: The Case of the National Youth Anti-Drug Media Campaign. Commun. Theory, pp. 204-224.

Kolk, A., Levy, D., 2001. Winds of Change: Corporate Strategy, Climate Change and Oil Multinationals. European Management J. 19(5), pp. 501-509.

Lapillone, B., Pollier, K., Mairet, N., 2014. Energy Efficiency Trends in Tertiary in EU, Enerdata [Online] Available at: http://www.odyssee-mure.eu/publications/efficiency-by-sector/services/Services-profile.pdf [Accessed 28 February 2017]

Locke, E.A., Latham, G.P., 2002. Building a practically useful theory of goal setting and task motivation, A 35-year odyssey. American Psychologist 57(9), pp. 705-717.

Lo, S.H., Peters, G.J., Kok, G., 2012. Energy-Related Behaviors in Office Buildings: A Qualitative Study on Individual and Organisational Determinants. App. Pyschol. 61(2), pp. 227-249.

Lucon, O., Ürge-Vorsatz, D., Zain Ahmed, A., Akbari, H., Bertoldi, P., Cabeza, L.F., Eyre, N., Gadgil, A., Harvey, L.D.D., Jiang, Y., Liphoto, E., Mirasgedis S., Murakami, S., Parikh, J., Pyke, C., Vilariño, M.V.., 2014. Buildings. In: Edenhofer, O., Pichs-Madruga R., Sokona, Y., Farahani, E, Kadner, S., Seyboth, K., Adler, A, Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlömer, S., von Stechow, C., Zwickel, T.; Minx, J.C. (Eds.), Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge and New York, pp. 671-738.

Manstead, A., 1991. Social psychological aspects of driver behaviour. Invited paper presented at the meeting New Insights into Driver Behaviour, organised by the Parliamentary Advisory Council for Transport Safety, University of Manchester, Manchester.

Murtagh, N., Nati, M., Headly, W.R., Gatersleben, B., Gluhak, A., Ali Imran, M., Uzzell, D., 2013. Individual energy use and feedback in an office setting: A field trial. Energy Policy 62, pp. 717-728.

Okerke, C., 2007. An Exploration of Motivations, Drivers and Barriers to Carbon Management: The UK FTSE 100. European Management J. 25(6), pp. 475-486.

Okerke, C., Russel, D., 2010. Regulatory Pressure and Competitive Dynamics: carbon management strategies of UK energy intensive companies. California Management Rev. 52(4), pp. 100-124.

Ozawa-Meida, L., Fransen, T., Jimenez-Ambriz, R.M., 2008. The Mexico GHG Programme corporate responses to climate change in a 'Non-Annex I' country. In: R. Sullivan (Ed.) Corporate responses to Climate Change: Achieving Emissions Reductions through Regulation, Self-regulation and Economic Incentives. Greenleaf Publishing, Sheffield, pp. 117-137.

Pellegrini-Masini, G., Leishman, C., 2011. The role of corporate reputation and employees' values in the uptake of energy efficiency in office buildings. Energy Policy 39, pp. 123-205.

Perez-Lombard, L., Ortiz, J., Pout, C., 2008. A review on buildings energy consumption information. Energy and Buildings, 40, pp. 394-398.

Petty, R., Cacioppo, J., 1986a. The Elaboration Likelihood Model of Persuasion. Adv. Exp. Soc. Psychol. 19, pp. 123-205.

Petty, R., Cacioppo, J., 1986b. Communication and persuasion : central and peripheral routes to attitude change. Springer series in social psychology ed., Springer-Verlag, New York.

Scherbaum, C., Popovich, P., Finlinson, S., 2008. Exploring individual-level factors related to employee energy-conservation behaviours at work. J. Appl. Soc. Psychol. 38(3), pp. 818-835.

Schwartz, S., 1977. Normative influences on altruism. In: L. Berkowitz, (Ed.) Advances in experimental social psychology. Academic Press, New York.

Shove, E., 2010. Beyond the ABC: climate change policy and theories. Environ. Plan. 42, pp. 1273-1285.

Stead, M., Tagg, S., MacKintosh, A., Eadie, D., 2005. Development and evaluation of a mass media Theory of Planned Behaviour intervention to reduce speeding. Health Education Res. 20(1), pp. 36-50.

Stuart, G., 2011. Monitoring Energy Performance in Local Authority Buildings, PhD thesis, De Montfort University, Leicester.

Stuart, G., Wilson, C., Irvine, K., Bull, R., 2013. Designing live energy performance feedback for public buildings in Leicester. ECEEE Summer study proceedings, France.

Stuart, G., Ozawa-Meida, L., Holland, C., Fleming, P., Vogt, G., Dashja, E., 2015. Deliverable 7.2 SMARTSPACES Pilot Outcomes. [Online] Available at: http://www.smartspaces.eu/fileadmin/smartspaces/download/documents/outputs/deliverables/smartspaces_d7.2_final.pdf [Accessed 11 July 2016].

Stuart, G., Snape, R., Fleming, P., 2016. Closing the Feedback Loop: A Systems Approach to Supporting Community-wide Behaviour Change in Non-domestic Buildings. Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, California.

Sullivan, R., Gouldson, A., 2013. Ten years of corporate action on climate change: What do we have to show for it? Energy Policy 60, pp. 733-740.

Vine, E.L., Jones, C.M., 2016. Competition, carbon, and conservation: Assessing the energy savings potential of energy efficiency competitions. Energy Res. Soc. Sci. 19, pp. 158-176.

Walker, D., Myrick, F., 2006. Grounded Theory: An Exploration of Process and Procedure. Qualitative Health Res. 16(4), pp. 547-559.

Whitmarsh, L., O'Neill, S., Lorenzoni, I., 2011. Engaging the public with climate change: behaviour change and communication, Earthscan, London.

Willig, C., 2007. Reflections on the Use of a Phenomenological Method. Qualitative Res. Psychol. 4(3), pp. 209-225.

Wilson, C., 2014. Evaluating communication to optimise consumer-directed energy efficiency interventions. Energy Policy 74, pp. 300-310.

Wilson, C., Chatterton, T., 2011. Multiple Models to Inform Climate Change Policy: A Pragmatic Response to the 'Beyond the ABC' Debate. Environ. and Plan. A, 43(12), pp. 2781-2787.

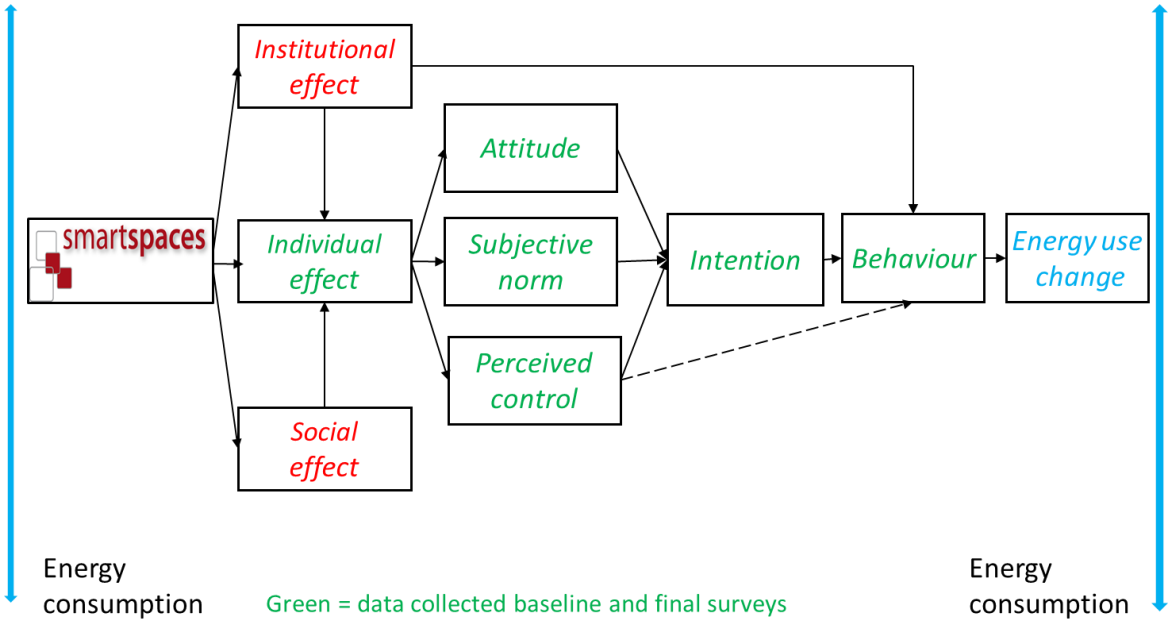
Wilson, C., Irvine, K. (2013). Bottom-up communication: Identifying opportunities and limitations through an exploratory field-based evaluation. Energy Efficiency 6(1), 91–104. https://doi.org/DOI: 10.1007/s12053-012-9161-y

Wilson, C., Stuart, G., 2014. A Persuasive Case for Ex Ante Evaluation of Energy Savings Campaigns? 2014 International Energy Program Evaluation Conference, Berlin, pp. 1-11.

Zhang, Y., Wang, Z., Zhou, G., 2013. Antecedents of employee electricity saving behavior in organizations: An empirical study based on norm activation model. Energy Policy 62, pp. 1120-1127.

Zierler, R., Wehrmeyer, W., Murphy, R., 2017. The energy efficiency behaviour of individuals in large organisations: A case study of a major UK infrastructure operator. Energy Policy 104, pp. 38-49.

Figure 1



Green = data collected baseline and final surveys
Red = data collected mid-term interviews
Blue = Metered energy data collected baseline and final evaluation

Based on Hornik & Yanovitzky (2003)

Tables

Table 1: Summary of sites and participating buildings

Site	Number of participating buildings	Buildings' types	Data availability at the start of the project
Belgrade (Serbia)	2	Administration offices	Monthly
Birmingham (UK)	3	Council House, Offices, Museum	Monthly
Bristol (UK)	450	Schools, nurseries, children's homes, depots, libraries, museums, youth centres, community centres, etc.	Monthly / Sub-hourly
Hagen (Germany)	2	City Hall, Museum	Monthly
Istanbul (Turkey)	1	Sports Facility	Monthly
Leicester (UK)	20	Offices, libraries, schools, leisure centres, community centres, museum	Sub-hourly
Lleida (Spain)	22	Offices, sport halls, schools, cultural centres, and a nursing home	Monthly
Milan (Italy)	3	Police Station, museum, and nursery school	Monthly
Moulins (France)	1	Nursery	Monthly
Murcia (Spain)	6	Administration offices, public security complex	Monthly
Venlo (Netherlands)	1	Offices / Exhibition space	Monthly

Table 2: Interviews' participants

Site	Senior manager	Central energy / facilities manager	Local energy manager / technician	Staff [1]	Other
Belgrade [2]	3		2		
Birmingham [3]	1	2			2
Bristol		3		1	
Hagen		1			
Istanbul [4]			3		
Leicester		3	2	1	
Lleida		1	1		
Milan		1			
Moulins [4, 5]	1		3		1
Murcia		1	1	1	
Venlo [4]			3		

[1] General staff, such as office workers, school teachers, librarians, etc. identified as "energy champions" by sites' representatives.
[2] Written responses to the interview guide due to rules of the Belgrade's City Council. All external communication should be provided in written and approved by the Communications Department.
[3] 'Other' refers to one external consultant responsible for the monitoring of energy data and one for recruiting participants for the surveys.
[4] Conducted as group interviews (Istanbul, Moulins, and Venlo). The group interview in Moulins involved 1 senior manager, 1 facility manager, 1 local energy manager and 1 local energy officer.
[5] 'Other' refers to energy utility staff responsible for the monitoring of energy data

Table 3: Perceptions on institutional effects

Factors	Sample quotes
Organisation commitment	Q1: *"Top management has supported the project since the beginning. They have made great efforts to overcome the problems concerning the project. They have delegated the authority to the project team and offered a very comfortable work environment"* (Istanbul)
	Q2: *"Activities have been supported directly from the political management of the municipality. In our internal procedures, senior management did all the action that we need, so it has had a good support from the municipality."* (Milan)
	Q3: *"The Mayor is interested and supports this topic. Therefore, it has been well accepted at different levels"* (Lleida)
	Q4: *"The support to this project is also through the provision of economic resources and the means to be able to carry it out. There are also messages to all staff to support it* [project]." (Murcia)
	Q5: *"From the city, they also allow us time to work with this program."* (Hagen)
Energy cost savings	Q6: *"Yes, cost savings, indeed. Although the way that council's budgets has been structured this year, it means that we do not necessarily see the benefit about this. That would be a corporate saving rather than a building saving."* (Bristol)
	Q7: *"For example, if I know that the people are not turning the computers off or things like that… you can also tell them 'this is how much it is costing us'. It is particularly important now in the light of people's jobs being lost, because that is a very big thing at the moment."* (Leicester)
Compliance with regulation	Q8: *"That they perceive the cost and energy savings is fundamental in the time we are in, this is of great value. Doing it in order to comply with norms is other factor to take into account, so doing things in compliance with the law."* (Murcia)
Organisational values	Q9: *"Our organisation has signed an official Act called 20/20/20. This Act is related to reducing energy consumption and reducing environmental pollution… We have the responsibility to make the municipality environment cleaner. So, SMARTSPACES focuses in a right way in our culture and in our mission."* (Milan)
	Q10: *"It goes in the same direction at the European and local level. Locally, there are several policies that are in line with this. Therefore, SMARTSPACES suits perfectly with the environmental and energy saving policies."* (Lleida)
Technological change and innovation	Q11: *"Moulins is an old medieval city, we would like to combine innovative projects with the history of the city, it is very important for us to show that we are sensitive to new technology and energy savings, but we want to preserve the historical aspects."* (Moulins)
Reputation	Q12: *"The main impact of disseminating SMARTSPACES is international and probably to some extent recognition and reputation. … This is something we have to do because eventually it will give us possibly extra funds, more finance from Government, other project partners inviting us – it is that type of virtual circle, by disseminating one project you then get interest from others.*" (Birmingham)
Low or competing priorities in the workplace	Q13: *"There's been some changes at the higher director level so I still have hope that this will change, but at the moment they don't seem to see that as part of their job"* (Bristol)
	Q14: *"We do have limited time and our priority is to promote our services to our customers, not so much the energy usage of the building."* (Leicester)
	Q15: *"There are other priorities, it is difficult particularly now in the situation that we are at, in crisis* [recession], *it is complicated that the institutional responsible people give to these projects all the real value they have...* (Murcia)
	Q16: *"Nobody has assigned these tasks or this goal as their main activity. For everybody, this task of energy efficiency and behaviour related to their consumption is one small task additional of their usual activities."* (Lleida)

Table 3: Perceptions on institutional effects (Continued)

Factors	Sample quotes
Conflicting work priorities	Q17: *"The difficulty that we have is that because we are a public service, we advertise that we have services available to the public within given hours, we can't switch things off within that period of time… it is not reasonable for us to do that, but there are other things, such as fans, electric heaters and other bits and bops that people use… It is always good to remind people 'if you are not using it, switch it off, if you are the last person leaving the office, switch the lights off, open the windows, radiators on, radiators off, there is a lot of things that you can do that can regulate the amount of energy that you use' and that is the sort of constant interaction"* (Bristol) Q18: *"The only thing they care about is that the school is warm and that we have hot water and that the kids are happy. The main priority here is educating the kids and make sure that they are comfortable."* (Leicester) Q19: *"We cannot heat just bits of the building, so if we have a few staff working on the top corner, we still have to heat 16,000 square meters of the building… [we] need some guidance on how we need to respond to the out of hours, so if someone is working on one room of that building and just get a fan heater for that room and so on. So, in that sense, we need to get a policy response in order to deal with this type of things."* (Leicester)

Table 4: Perceptions on social effects

Factors	Sample quotes
Internal social networks	Q1: "*I think that environmental champions have found it as a useful and easy way to communicate things to their colleagues… Yes, in some way the work of the environmental champions and their communication with colleagues has made it stronger. I think there has been also a good reaction amongst the Students Union…"* (Leicester)
Communication with energy management teams	Q2: *"Yes, the forum is in the SmartSpaces web portal. Building users can discuss issues with the energy management team, they can also report anomalies or energy saving opportunities within the buildings, ranging from problems with thermal comfort, water taps or lights left opened or turned on to discussion about the use of renewable energy within the buildings."* (Leicester)
	Q3:*"I think that through the forum, people say what they do really care. For example, this is bothering me and that means that someone cares. So that is a powerful thing… Yes, we have had discussions of some interesting things in the forum that encourage more care thinking and discussion."* (Leicester)
	Q4*: "Between the Energy Agency and us, we communicate frequently through email… We have the web application to visualize and obtain the information. Once we have this information, we can take action or communicate it through email…"* (Murcia)
Energy coaches	Q5: *"Every month we have some activities, where we give information about our techniques, [the energy coach] also gives some presentations for all employees or users of the office about what is coming up and how we can deal with it."* (Venlo)
	Q6: *"I think another thing that's really helped the council through the SmartSpaces project is that [Project Energy Manager] and [Energy Coach] have been very good at listening to how people want to use it and help them get what they need from it."* (Bristol)
	Q7: *"It was through Smartspaces that we started the communication with the energy coach, there was nothing like that before… we have a much better understanding on how our energy systems work now that we did before… So, that is what established the credibility, knowing that there was somebody there who was interested to make this thing accurate and useful."* (Bristol)
Collaboration among building users	Q8: *"The factors that have strengthened the cooperation among users are that* [the service] *has provided benefits to the responsible people in terms of energy consumption reductions, and this has been transferred to the users and the employees of the facilities..."* (Lleida)
	Q9: *"You have to involve many different teams who sometimes compete with each other… this project has given us a chance to at least open conversations with many people... it is far from perfect but it certainly has opened up conversation and dialogue with people that before were not really willing to talk to us. They are talking to us; they are more responsive."* (Birmingham)
External networks	Q10: *"We contacted a lot of municipal bodies and shared our project experience with them. We created strong networks among the municipal bodies and the project team… Staff working in the project are also telling to their neighbourhood. Lots of people got interested in the project and approach us to learn more about the project."* (Istanbul)
	Q11: *"We have now stronger networks with governmental institutions: Department of Energy, Department for Environmental Protection, Secretariat for Utilities and Housing Services"* (Belgrade)

Table 5: Perceptions on individual effects

Factors	Sample quotes
Knowledge	Q1: *"Our technical staff knowledge and experience level as well as environmental awareness are increasing thanks to the project"* (Istanbul)
	Q2: *"The Smartspaces services is a useful project is to reduce energy in buildings, surely it increases knowledge and skills among people that are not involved every day with the energy problems and energy savings."* (Milan)
Awareness	Q3: *"Before the Smartspaces project, users were aware and willing to save energy, but it was not visible. There was no monitoring mechanism where you can see what is happening. With this project, we can see it now, we can take measures and it can be documented."* (Murcia)
	Q4: *"On one side with the program, we are able to see more. On the other side, we talk with staff and the awareness of staff is higher than before since we have the program."* (Hagen)
	Q5: *"There was not high awareness, the monitoring and the fact of being able to see the evolution, and the emails telling us 'we are doing well or we are not doing well'. This create a good environment and creates a good awareness amongst the employees."* (Lleida)
Subjective norms	Q6: *"For example, let's have a switch off campaign again, and then, you will be able to see the benefits of how people can use the software to see how they rank alongside their own performance before and after the campaign, and then, it would be good if they could see how much money they have saved"* (Leicester)
	Q7: "It is clear because there is more competitiveness and more commitment regarding energy savings. In several cases, you can see it between buildings, between staff, 'how can you get such a high consumption? How can you get this temperature in this date?' and they are comments as a result of an increased awareness regarding energy savings." (Murcia)
	Q8: *"…if you are presenting to customers and they saw that we were never good or bad but stable [in the league table], I think that they would assume that we are not particularly good. If they see the very green faces with the big smiles, they will assume that they are great, if they see the red faces, they will assume that they are poor, but if they see a standard face, a sort of not committed face, they may think that it is not particularly good…we are trying really hard to keep the same consumption, but when you see the league table and you see the green smiley faces, you feel that you will never get there"* (Leicester)
	Q9: *"I think that the people that would really look at it are my boss, the Head Master of the school, the Board of Governors, and the people that have an input in the school and what they would be looking at in the case that they* [faces] *are not smiling… If the faces are neutral, they are in yellow without expression, they will not see that as 'good' that means that you are maintaining the same, they would ask 'why are they not smiling?'*" (Leicester)
	Q10: "*The table league is a little bit peculiar, because the ones with the Smiley faces means that their energy consumption has changed dramatically… Because ours does not change, because we are pretty energy conscious anyway, we make sure that things are turned off. So, I do not think that we will ever be in the top of the table..."* (Leicester)
Perceived control	Q11: *"The main features for me are having access to all these data and detect when there is energy consumption when there is no need. For example, we have detected at nights that users left PC monitors in standby or even the PC or the lights. Then, we can take some measures, so this does not happen"* (Murcia)
	Q12: *"The only control we have here is in some of individual radiators that we have radiators all around the building. We can turn them up or down to a certain extent, but we cannot completely turn them off. So the main heating in the building, which is district heating, we have a lack of local control. This is our issue… we have good standard procedures to make sure that equipment is turned off."* (Leicester)

Table 6: Perceptions of changes in behaviour

Factors	Sample quotes
Individual behaviour	Q1: *"We have this thing in our buildings of switching off the heating an hour earlier because there is residual heat… so what we decided to do is to bring the heating on one hour earlier in Monday morning, but every other day we turn the heating off one hour early, so we have five days of turning off the heating early against one extra hour on Monday, so you are still make four hours of net gain. And very few people complain about that."* (Leicester) Q2: *"Staff, who have worked for many years in these buildings, can see if there is a high energy consumption. For example, if the lights or other equipment are on. They ask us 'what is the reason for this? Can we turn this off or should it be left on?'"* (Hagen) Q3: *"The project awareness is increasing among building users because we share with them the values of reducing energy consumption, and they are more careful using the energy… when the heating or cooling systems are in operation, building users and visitors are more careful to not open the windows, not using extra heating, turning off the lights, etc."* (Istanbul)
Behaviour in the institutional context	Q4: *"Once we have talked with the staff, the next month we can see reflected in a document the savings that we have had in case that we have achieved it. This provides some satisfaction to the employee, to see that the means or tools that have been utilised are rewarded… Then, when things are working well, they engage a little bit more, and the results motivate them"* (Lleida) Q5: *"I think the biggest barrier that I've come across is the fact that a lot of building users don't pay the energy bills, they're paid centrally and recharged… quite a few of our big buildings are used by teams from different departments and so in a way nobody in that building feels any ownership of it, they don't have any control over the heating or of the lighting."* (Bristol)
Behaviour in the social context	Q6: *"I think that cooperation has improved, because it has shown excessive consumption and it has detected situations that now can be corrected… we have detected excessive high temperature in winter or very low temperature in the summer or excessive consumption in festive holidays. It has allowed correcting all these issues..."* (Murcia)