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

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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.

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;

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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

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% to 15% in a study conducted by Darby (2006) and from 2% to 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 (2012–2014) 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.

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