# Enhance

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# Enhance: The Assembly Rooms Energy Living Lab

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**Abstract:** Enhance is a digital innovation project aimed at understanding and reducing energy demand in public sector buildings. The Assembly Rooms, an iconic events space in the centre of Edinburgh, is one of many public buildings in the UK with ongoing pressures to reduce energy use. Better awareness of energy and the ability to manage its use in the building has been achieved since the installation of an Energy Management System. However, large amounts the building's energy use are associated with 'unregulated' energy, often aligned to individuals and groups of building users. Involving building users in the management of energy use creates opportunities to link between 'hard' technical systems and the 'soft' social structures that exist in the public realm and design for the cultures and practices that lead to better ways of using energy. A Living Lab approach is being used to explore the energy demand in the Assembly Rooms relating to its day-to-day operations. Working with the venue team, the Enhance project is identifying opportunities for reducing energy demand via behaviour change. Designed interventions will connect people with digital artefacts and sensors to help create engaging and responsive interactions with energy use.

**Keywords**: Energy, Behaviour Change, Public Sector

## Introduction

The Assembly Rooms, originally opened in 1787, is a multi-purpose events space housed in a historic building in the centre of Edinburgh. Along with many public buildings in the UK there are ongoing pressures to reduce energy use. Enhance is a digital innovation project which is taking the form of a Living Lab in the Assembly Rooms aimed at raising awareness of and reducing energy demand. Building users are involved in understanding energy use relating to everyday activities in the building, developing ways of seeing energy use in an accessible digital form and designing approaches using the digital data to avoid wasteful energy practices.

The wider context of the project is threefold: as a public building it is required to contribute to reduce carbon emissions of 80% by 2050 (DECC 2014); as a historic building it has constraints that impact on energy use; and as a cultural venue it has a varied client body with distinct energy requirements. Each of these contexts influences energy use in the Assembly Rooms, which is owned and operated by the city council. As part of a public sector estate, it is governed by the policies and regulatory framework of the wider organisation, while simultaneously operating as business in its own right. The historic status of the building limits the fabric interventions that can be done to improve energy efficiency. For example,

the historically important chandeliers, each comprising hundreds of bulbs, currently have standard fittings to meet the requirements for aesthetics and warmth of light. The Assembly Rooms was designed for public assemblies, dances and concerts and this use continues to today. The building has two main assembly spaces and associated circulation, and ancillary spaces, providing facilities for varied events throughout the year. There is complexity in the relationship of energy use, the diverse range of events held, and the priorities of the client.

The inception of the Living Lab was through a series of interactions with the city council to explore the idea of energy use for large organisations. It became evident that both explicit and tacit knowledge of energy use was used across the organisation, much of this with individuals and groups of people within individual buildings. This resulted in the selection of the Assembly Rooms as the location for researching energy use within the wider context of the city council. The Living Lab is unfolding through a year in the life of the building, and has three evolutionary phases – contextualisation and insight research; co-design and implementation; and evaluation. Throughout each of these phases individuals and groups of building users inform and shape the course of the research.

## Energy Use in 'Smart' Public Buildings

The increasingly popular concept of 'Smart Buildings' is synonymous with an energy management system designed to optimise energy use. This fascination with automated energy systems has resulted in the installation of energy management systems to control devices and systems as and when they are needed. Evidence from EU pilot projects shows the positive impact of this on energy reduction (Janez Moran et al. 2016). Many of the systems installed through these projects required expert knowledge to operate. This then leads to buildings where the energy system is separated from the people using the building, which in turn leads to a diminished sense of responsibility for energy use. As a result, systems are often configured to provide thermal or lighting conditions that are inappropriate for the activities taking place. This centralisation of energy control to complex and sophisticated management systems has been shown to undermine their effectiveness (Goulden & Spence 2015). Better integration between the energy systems and the activities taking place within a building can be used to negotiate the energy domain that is vital for a comfortable, pleasant, enjoyable environment.

### *Energy Use and Building Users*

Janda (2011) reinforces the connection between building users and energy use. The relationship between people and energy in public buildings presents specific challenges. Public buildings have a wide range of user groups, from long term regular workers occupying the building on a daily basis; to business clients; to regular visitors; to fleeting users visiting the building only once. With this range comes a quickly diminishing familiarity with, and responsibility for energy use. This suggests that building users cannot be defined with a set of homogenous characteristics - a factor that is not accounted for by existing building management systems. Janez Moran et al. (2016) reinforced the need for creating different approaches for energy management depending on the typology of the building user, to both raise awareness and engage with behaviour change.

In events buildings, energy use varies considerably with the type of event. While always affected by seasonal and daily outside conditions it is also influenced by client specific requirements: audio-visual needs; the energy efficiency and the type of equipment used; thethermal and lighting conditions required by the client; and the characteristics, activity-

level, and dress code of the clients. This demonstrates the complexity in the parameters for creating the right environmental conditions for a particular event.

### *Involvement of Building Users*

People within a building have direct and indirect influence and control over energy used. The Living Lab taking place in the Assembly Rooms is providing opportunities for the different group of people who work in and use the building to consider modes of use that lead to energy demand. Gaetani et al. (2016) refers to using a fit-for-purpose model for building energy that reflects the typology of the people and building. Interactions between people and the energy system are considered important for validating the setting, but also to harness the psychological effect of retaining a perception of an element of control over ones' environment.

## Methodology

Living lab research engages people within their everyday settings to identify opportunities and solutions through processes of exploration and co-design. The approach encompasses five key principles:

1. **Continuity**: conducting the research over a continuous and lengthy period enables close and trustworthy partnerships to be established.
2. **Openness**: incorporating different viewpoints and contributions from various stakeholders leads to an inclusive and open-minded approach.
3. **Realism**: the research takes place in real-world settings, facilitating close collaboration, in-depth understanding, and ecological validity.
4. **Empowerment**: stakeholders are given active roles in shaping the course of the research and defining its outcomes.
5. **Spontaneity**: the approach affords the flexibility to respond and adjust to unforeseen changes in circumstances.

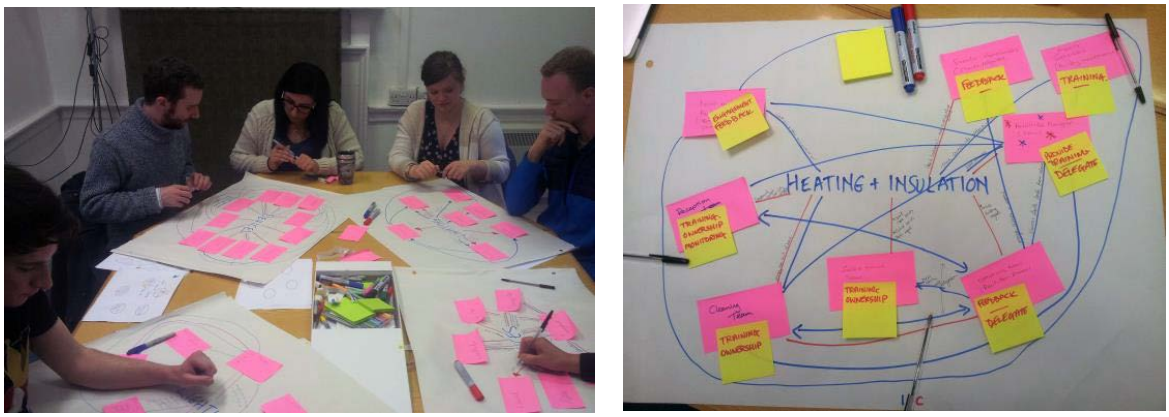
These principles are essential in building trust with the participants. Based of work by Pierson & Lievens (2005), Kareborn & Stahlbrost (2009) and Baedeker et al. (2014), three phases of the Living Lab are used to provide a framework for an extended period of engaging with the building users. Each phase is designed to contribute to the overall aim of the evolutionary nature of the research. The first phase lays the foundations for the living lab, establishing its context and conducting insight research to build relationships and investigate the existing status-quo with respect to the topic of interest. The second phase involves the co-design and deployment of an intervention (technology or service), based upon the challenges and opportunities identified in phase one. During the third phase, feedback and data are collected and analysed to assess the adoption and impacts of the intervention. The latter two phases of this framework can be iterated to provide an ongoing process of evaluation and re-design. The Enhance Living Lab is currently entering its second phase. The following paragraphs provide details on some of the exiting methods that have been employed, as well as plans for the co-design and deployment phase.

### *Phase 1: Contextualisation and Insight Research*

The selection of the Assembly Rooms as a site for the Enhance Living Lab was the result of early meetings with senior managers in the city council and a consideration of the project from the context of a large organisation. Over a period of three months the concept of

engaging building users in a Living Lab was used to explore the building typologies that present interesting challenges for the council in its aim to reduce energy demand across its stock. Site visits and staff interviews were conducted to evaluate the suitability of each potential building. The Assembly Rooms was chosen due to the high levels of control and influence over energy use available to building users, as well as the diverse and complex challenges associated with its function as an event venue for external clients.

Introducing the project to the people working within the Assembly Rooms was facilitated through a series of workshops conducted with all the permanent staff in the building and some of the regular staff from outsourced contractors. These workshops were also designed to investigate energy narratives around the building in the context of everyday activities. In particular, the intention was to explore the behavioural pathways that link people to the building fabric and systems that ultimately determine energy consumption. Workshop participants were first asked to individually identify material aspects of the Assembly Rooms that they felt presented good opportunities for energy saving. These were then shared amongst the group, and the two most prominent opportunities were taken forward for further consideration. In groups of two, participants were then asked to identify people (groups or individuals) who have influence or control over these factors, and to arrange them with the energy saving opportunity at the centre (see Figure 1). Participants then annotated pathways of influence or control between people and the energy use, and between different types of people. The workshop participants identified potential interventions that could influence the different energy pathways.



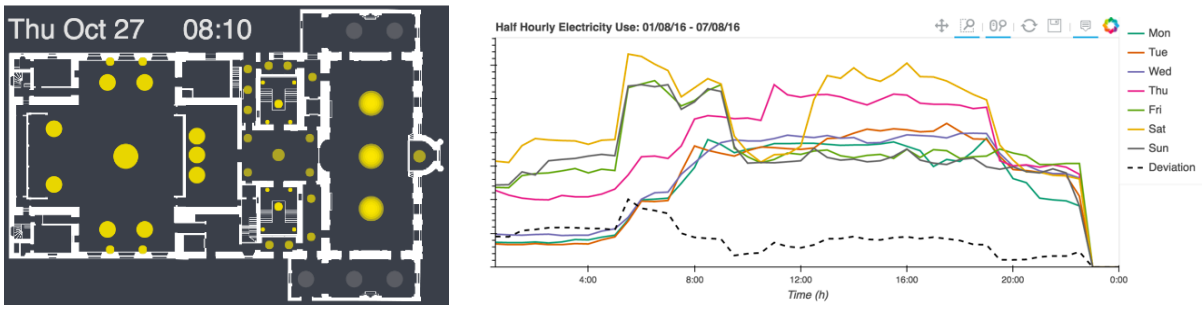

(a) (b)

Figure 1. a) Staff the Assembly Rooms attend an initial workshop. b) A map of pathways of influence and control between people and heating/insulation.

These workshops succeeded in revealing inter-related threads that create a holistic view of the complexities of building users' relationships to energy use. To supplement the predominantly qualitative nature of the workshops, quantitative data relating to energy use in the Assembly Rooms were captured. Existing data on electricity and gas metering for the whole building was provided by the council. In addition custom data was recorded from the existing control systems to accurately monitor lighting and building management system (BMS) parameters for the purpose of the project. This data collection serves several functions: a) it allows baseline energy usage to be captured prior to the deployment of an intervention; b) it provides a potential source of raw data to feed into an energy feedback intervention; c) when visualised, it can be used to stimulate discussion and realisations about energy use. Regarding the latter point, visualisations of lighting and electricity use were created and

presented in the workshops and early meetings with staff (see Figure 2 for examples). These prompted staff members to provide a qualitative and descriptive layer to the visualisations, based upon their knowledge of the building's use. This led to the identification of specific issues and opportunities surrounding energy use in the Assembly Rooms.

In summary, the first phase of the Assembly Rooms living lab explored the context in which the research is being conducted, developing a rich qualitative understanding of energy use from the building users' perspectives, whilst also ensuring that valuable quantitative data are captured from the building's energy systems. Working closely with diverse teams of staff has provided them with a sense of ownership in the process, and enabled the development of trust and understanding between the stakeholders and researchers. Furthermore, by providing a platform to all who had an interest in the project, the potential for building users to engage in energy use was incorporated. Emerging findings from this work are discussed later in this paper. These findings will inform and shape the second and third phases of the project, which are outlined briefly below.




(a) (b)

Figure 2. Data visualisations of a) lighting use according to time and location; and b) hourly electricity use.

### *Phases 2 and 3: Co-design and Evaluation*

The goal of the second phase of the project, which is currently in its early stages, is to design and develop a digital innovation that will facilitate behaviour-based energy savings at the Assembly Rooms. Building upon work carried out during phase 1, and especially the interactions and relationships developed with staff, an 'innovation team' has been established. The aim is to design, develop and prototype an initial innovation incorporating digital data to respond to the energy pathways plotted in phase 1. This team will participate in co-design workshops with designers and researchers on the Enhance project to develop and prototype an initial innovation. Following the deployment of this innovation, the third phase will involve evaluating its usage and impact within the building. Again, this will involve a mixed approach employing qualitative methods, such as interviews and focus groups, alongside quantitative analyses of data relating to energy use and interactions with the innovation; the results from which will contribute to further development and iterations of the innovation. The reflective and responsive approach is strengthened by involving building users fully in the design and utilisation phase.

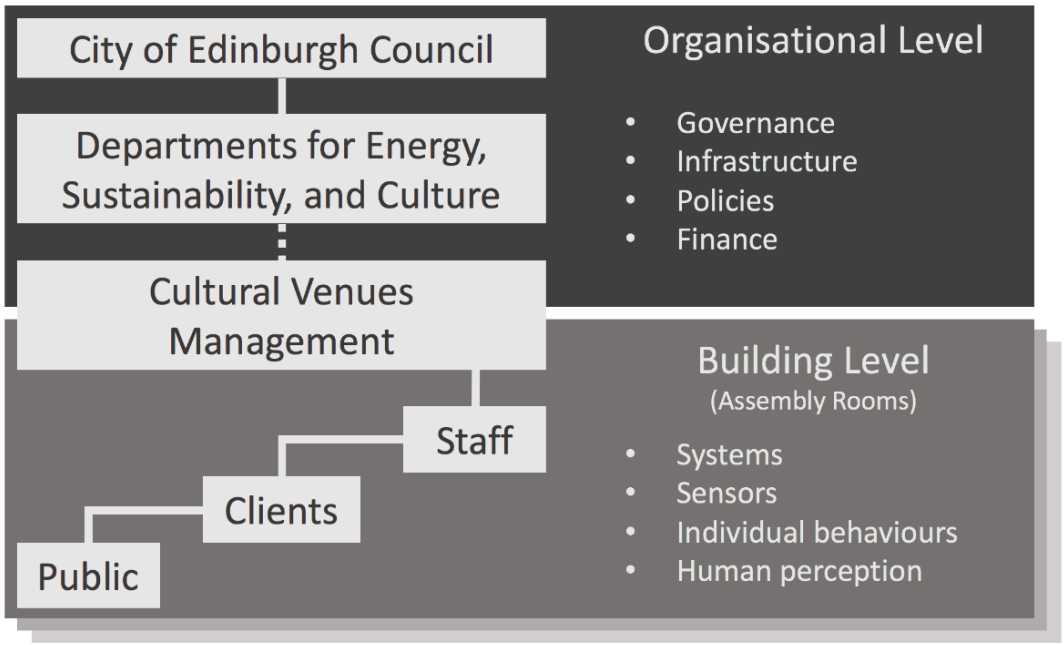



Figure 3. A representation of the organisational structure and factors that frame the Assembly Rooms within the wider City of Edinburgh Council.

**Emerging Findings**

***The Building within the Public Sector Estate***

Figure 3 shows the position of the building organisation relative to the broad organisational structure of the council. The Assembly Rooms, while operating as an independent venue, has formal and informal influence on energy use and sustainability from the wider council agenda, policies and systems. The opening phase of the Living Lab, working with the senior managers in the council, provided the dual purpose of both identifying the building to work in and understanding the wider organisation, from management to building users. Although the council has a commitment to reduce carbon emissions in its building stock by 80% of the 1990 rate by 2050, this specific responsibility is not associated with any senior role within the council, or within the individual building level organisation.

From an organisational level, targets to reduce energy use translated into 'hard' infrastructure changes. The Energy department worked closely with the building management to install appropriate energy control systems (lighting and heating/ventilation) where technologies and venue requirements permitted. Therefore, at senior management level it was perceived that they had a large influence on energy use in the buildings. Across many council buildings EMS installation facilitates control of energy systems, however these systems were not found to be used for energy monitoring and feedback purposes to any great extent or granularity. Thus, full advantage was not taken of these tools for data monitoring and identification of possible opportunities to further reduce energy demand in buildings. The lack of utilisation and cohesive storing of energy data also posed a difficulty for senior management in the ability to clearly assess and evaluate gains and improvements in energy use across the estate. Installation of the 'hard' EMS systems (lighting and heating/ventilation) in the Assembly Rooms were not designed to have a reciprocal relationship with the 'soft' social structures and the complex relationships between people and energy. This has been shown to have an impact on the gap between expected energy use and actual building performance occur (Gaetani 2016).

It was apparent that from building users' perspectives they felt the council organisation had little influence and impact on daily energy use in the Assembly Rooms. It was the initiatives and personal drive of building managers and staff which led them to target energy reduction through behavioural actions and to strive for external acknowledgements on their performance (eg Green Tourism Awards). The staff of the building take pride and are motivated in achieving these awards, using them in the promotion of the venue. This has been shown to be an important influence on employees' environmental perspectives (Onkila 2015).

***The Building as an Energy System***

The Assembly Rooms has a relatively modern EMS, which facilitates thermal control over individual spaces and is configured on a per-event basis by the events and facilities managers. The system can also provide graphs of energy usage data over previous weeks, however, this functionality is rarely used. The lighting in the building is controlled via a network-based iLight system, with control panels situated in each room to enable building users to make localised lighting adjustments. These panels are configured by the production manager, who has fine grained control over parameters such the maximum brightness and dimming behaviour of individual lights. In this case, specific adjustments have been made to the lighting system to reduce energy use and prolong the life of light bulbs.

Looking beyond the EMS and lighting systems, the workshops and data visualisation described in the previous section paint a more holistic view of the Assembly Rooms as an energy system incorporating not just materials and systems, but people - their behaviours, responsibilities, interactions, and relationships. Analyses of the workshops have revealed findings and insights at both a generalised building level, and at lower, person/group-specific levels. When considering material aspects of the building, workshop participants most frequently identified lighting, heating, and equipment use as opportunities for behaviour-based energy savings. Of the people identified as having control or influence over these forms of energy use, clients emerged as the most prominent, whilst the council were rarely discussed (fig 4). This is an important finding, since it suggests that staff do not recognise the council as having significant control or influence over energy use. As such, they may be less likely to respond to, or feel any ownership of, energy saving projects which are set by corporate services.

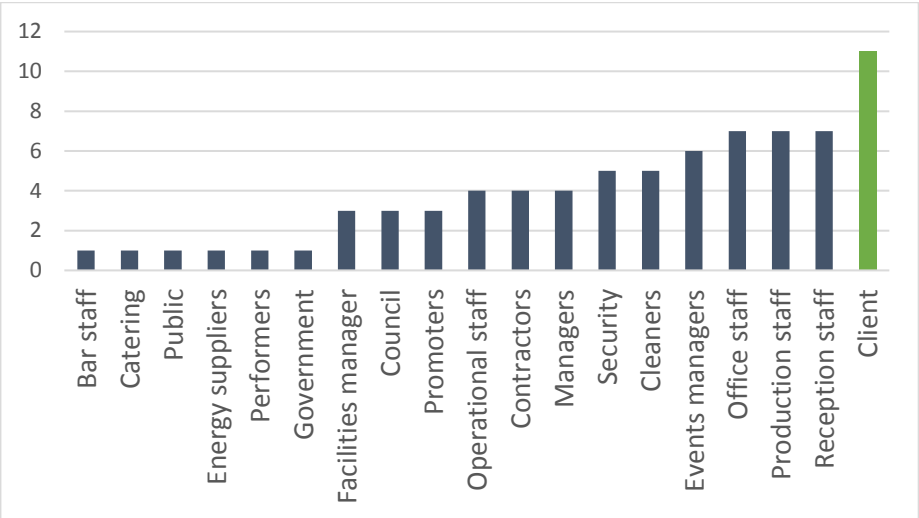



Figure 4. People perceived to have control or influence over energy use

The three most commonly identified forms of behavioural influence or control over energy use were direct lighting adjustments, requested changes, and event requirements. Again, this indicates a focus on the client as having a dominant influence on factors relating to energy use. With respect to potential interventions, training, information, and feedback were the three most frequently proposed ideas. This finding supports existing studies that have cited lack of feedback on personal actions as an important barrier to energy saving behaviours in large organisations (Carrico & Riemer 2011)

At a lower level of analysis, the workshops revealed particular interactions between individuals or groups of people, which have a subsequent impact upon energy use. For example, in the lead up to an event, discussions between the sales team and client will determine how the event space and facilities are used. During an event, attendees will often make requests for changes to heating, either directly to the events staff, or via the client. As the research progresses into the second, co-design phase, these insights will be used to channel attention towards specific interactions that could be the target of a digital intervention.

## Conclusions

Energy use is correlated closely to the activities taking place in the building. Large events can be mapped against big increases in energy use. While this can be expected, the challenge for the Assembly Room teams is to manage the need for energy use for the core business activity of the venue, while working within a public organisation with a commitment to reducing energy. Finding ways of providing a socio-technical system that is responsive to energy demand in harmony comfort and enjoyment for the activities taking place is vital for a successful integration of energy use into the everyday life of the building.

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