Energy Visualisations

An overview of the energy visualisation tools developed and tested as part of **the eViz project** to encourage energy conservation behaviours.

www.eViz.org.uk

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Energy Visualisation - Lessons learned from the eViz project

What can visuals offer?

Energy use in homes is typically invisible, abstract and intangible. It is thought that 'making the invisible energy visible' will help reduce energy demand. This is part of the rationale for the UK government plans to roll-out smart meters and in-home displays to all households by 2020, similar to many other countries. Technological advances have made it possible to move beyond the rather factual numbers and graphs commonly used to represent energy use. There are many advantages to using visual imagery: it is closely linked to emotions, has qualities to condense complex information, and can quickly convey strong easily remembered messages. Also, compared to text, images can be interpreted without relying heavily on knowledge of technical terms.

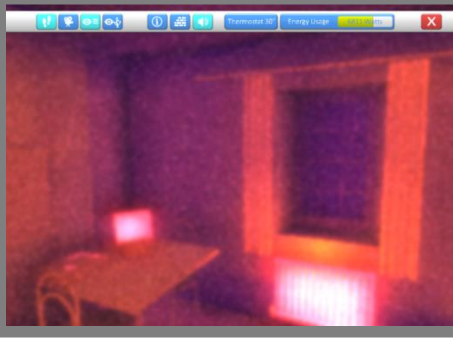
As part of the **Energy Visualisation for Carbon Reduction** (eViz) research project, a range of energy visualisation tools have been tested and developed. These tools use visuals in different ways ranging from visualising energy use directly with a feedback display, to visualising heat flows in the home (in real life or virtually), to using people's visual representation of their values to understand how these relate to energy use.

Thermal Images

Our research examines **thermography** as a tool to visualise energy and heat. Thermography visualises temperature differences, so it is possible to 'see' or infer where a building is losing heat or where cold air is entering a building. Thermal images can increase the visibility of the normally invisible heat flows in and around the home. A series of studies has provided evidence that seeing thermal images increases energy efficiency actions. Compared to a control and audit-only group, a group of householders that received a carbon footprint audit and thermal images of their home reported an increased number of energy saving actions at a 1-year follow-up (Study 1). Also, compared to an audit-only group, householders that received an energy saving audit with thermal images were nearly five times as likely to install draught proofing measures (Study 2). In addition, personalised thermal images, compared to images of other peoples' homes, encouraged stronger energy related intentions in householders along with a stronger belief that they would benefit from taking draught proofing measures in their home (Study 3).

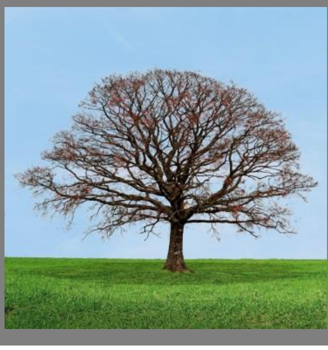
Virtual Reality Home





The **eViz Virtual Reality Home** was designed to provide an interactive energy tool. It allows users to switch appliances on or off, open and close windows/doors, change thermostat, TRV and fridge settings, and change the fabric of the house (i.e. insulation and widows/door types) while receiving feedback on energy use. Simple occupant avatars provide another method of engaging end users. Also, "particle streamer" modes visualise air flows around the rooms when the windows are open, and a virtual thermal view can identify areas of heat loss. The eViz VR Home was developed using the 3D modelling tool 3ds max and imported into the Unity3D real-time virtual environment development software toolkit. Movement around and within the apartment is achieved using a mouse and standard keyboard but options for head-mounted display and gamepad interaction using, for example, the *Oculus Rift* or *Xbox* controller, are also available. Feasibility studies show that the eViz VR Home can be used to 1) study people's responses to energy scenarios in a (virtual) home setting 2) educate people about energy use and motivate conservation behaviours 3) provide a 'virtual lab' where users responses to feedback and visualisation technologies (i.e. in-home displays) can be recorded.

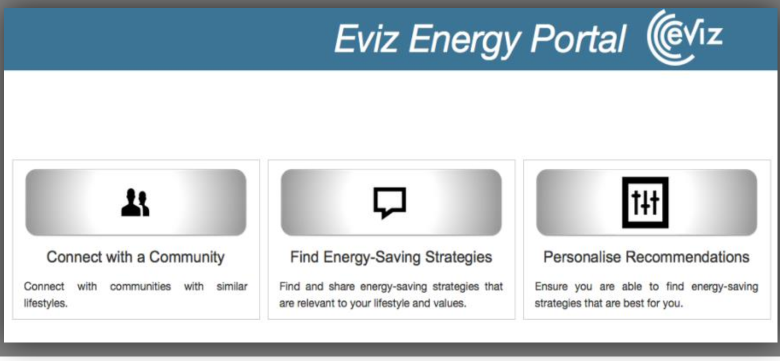
Real-Time Energy Display

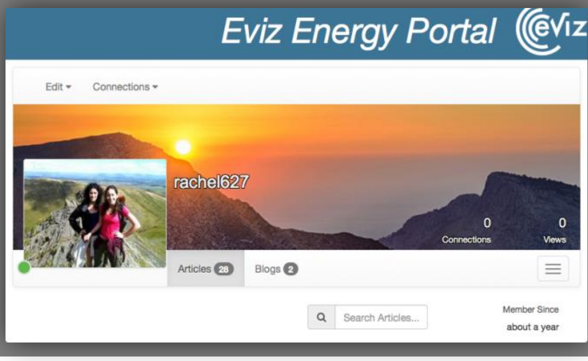



Near **real-time feedback** has been identified as a successful approach in the domestic setting by improving householders' knowledge on energy consumption, enabling householders to see the outcomes of their efforts, and providing social encouragement and support for further savings. A field study at a UK council office (housing social services employees) provided an opportunity to test the feasibility of implementing a near real-time feedback display into a workplace setting with timepressured staff keenly aware of their primary job roles. As part of the study a web-based display was developed where current electricity usage was compared to average electricity usage and translated into a visual. As current use reduced compared to average use a tree would gain leaves and flowers. As current use increased compared to average use the tree would lose its leaves. By providing a visually-interesting, meaningful display linked to one of the motivations identified in the staff sample for conserving energy (i.e. preserving the environment) energy use could be made more tangible.

The use of visuals in real-time energy displays was further investigated in a lab study. A range of mock-up visual feedback displays was developed, using for example weather, local landmarks, emotions, money and nature imagery to represent energy use. Amongst others, this study examined preferences based on individual differences, as well as energy understanding and intentions in response to the various energy displays.

Social Media

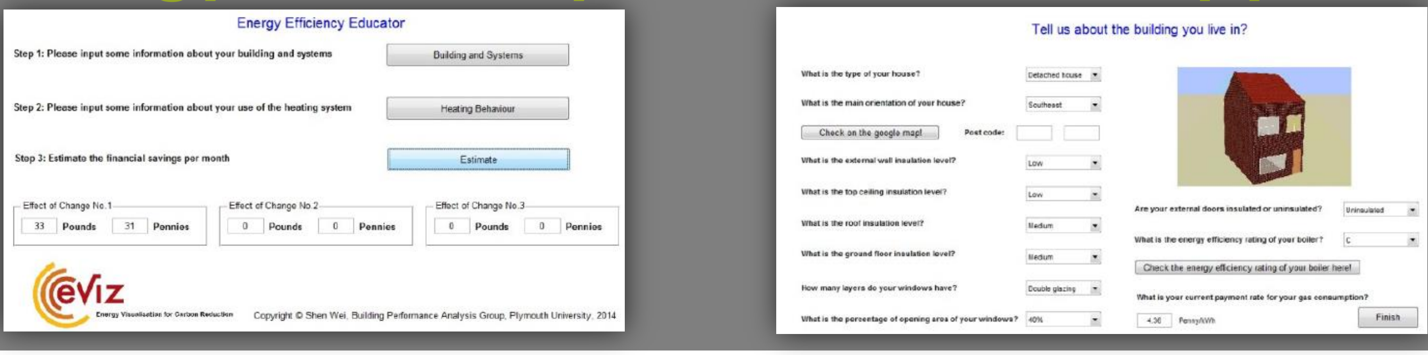




The **eViz Energy Portal** is a social media website designed to allow users to search, find and contribute energy-saving strategies. The goal is to influence their choices through their values and in doing so to stimulate sustainable changes in their behaviour. This particular design allows communities to be in control of the website content. They are able to create, share and interact with energy-saving strategies that are relevant and personalised to their own values and lifestyle.

The website was developed together with end users in a series of 5 participatory design studies and utilised value sensitive design methodology. These studies included a photo diary study to identify their values as a precursor to understanding how these were related to their energy use (study 1); an investigation of their different values and the implications upon their lifestyles where energy-use is a constrained resource (study 2); the construction of a user model to understand how to associate particular energy-saving strategies to individual's and community's values (study 3); the design of web-based interactions and representations as a medium for creating, storing, searching, finding and sharing energy-saving strategies (study 4); and the evaluation of software design features with respect to user engagement and behaviour change (study 5). Results from the studies informed the software architecture, which subsequently contains components responsible for decision-making within the application. This allows for the functionality and content recommendations of the system to be personalised for individual users based on their individual values and lifestyle information and those of their community.

Energy Efficiency Educator and App



The **Energy Efficiency Educator** (EEE) combines dynamic building simulation with a user-friendly interface to allow exploration of tailored options that can help householders to make energy-related decisions in their home. The EEE offers a menu of energy-efficiency parameters to be input and changed by the householder so that they can model the effect of changing building operations, e.g. turning down the thermostat or reducing the boiler running time. The energy saving potential of adopting these energy-efficient behaviours is estimated using dynamic building performance simulation in EnergyPlus, based on typical UK housing types. Building performance simulation software is already professionally available to 'model' a range of building parameters and predict the effect of changes to a building in terms of its energy efficiency. Using an adapted interface, this software can be used to allow householders to 'model' their own buildings and predict the effect of changes to their model. The EEE can demonstrate the impact of changes in the building fabric or behaviour on building energy demand to users, tailored to their own building and environment. The EEE has been ported to an Android app that we plan to make available free to the public via the Google Play store. The app models the results from lengthy building simulations using artificial neural networks. Thus the public can get the benefit of hours of building simulations in a matter of seconds on their phone.

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Reference: eViz Project (August 2015). Energy Visualisation: Lessons learned from the eViz project. Available at http://www.eviz.org.uk