

**Spence, A.; Goulden, M.; Leygue, C.; Banks, N.; Bedwell, B.; Jewell, M.; Yang, R.; Ferguson, E. (2017) Digital energy visualizations in the workplace: the e-Genie tool. *Building Research & Information*.**

## **Supplemental data**

### **Appendix 1:**

#### **The e-Genie tool**

##### ***e-Genie version 1: Pilot Study***

The e-Genie system has two main sections: front screens which provide energy information feedback (both electricity and gas) and which scroll periodically, and further screens that users reach by clicking through to discuss and consider changing their behaviour and to report energy related faults (see visualisations within the main text in Figures 1a-1e).

The Temperature Calendar displays temperatures from the workplace illustrated in a format similar to a diary planner. Each column represents one 24-hour day. Columns are divided into 24 cells corresponding to each hour of the day, with time points labelled every four hours on the left, and coloured according to the average temperature for that period. The colour scale moves from white to orange where white indicates cool temperatures and orange indicates the hottest temperatures. Minimum and maximum temperatures for each day are overlaid in numeric text on the relevant cells in each column to provide a reference so that users can interpret the colour gradient more clearly. Users are able to examine current and historical temperatures in different parts of the building by clicking on different pins highlighted on a floor plan in a box on the right hand side of the screen.

The Always-on calendar displays the baseline electricity consumption (i.e. the minimum consumption level, normally the overnight usage) for the past 6 days. Boxes on the displays correspond to different days and illustrate whether the baseline electricity consumption 'went down', 'stayed the same' or 'went up' compared to the previous day; these also provide data describing the actual level of baseline consumption in kilowatts (kW). Positive messages (i.e., 'went down' and 'stayed the same') are illustrated in green to indicate the desirability of these and negative messages (i.e., 'went up') are illustrated in red to indicate they are undesirable.

The Annotation tool displays data from the building's electrical circuit sub-monitoring illustrated in a graph where the vertical axis indicates amount of energy used (in kilowatts)

and the horizontal axis indicates time, labelled at three-hour intervals. The "traces" drawn on the graph - one per electrical circuit - illustrate the peaks and troughs of energy usage, and can be individually hidden or revealed to allow comparison between circuits. The user is also able to click and drag their cursor across different sections of an energy trace and then type in a description of what they thought that energy use corresponded to, e.g. a peak in the morning might correspond to lights being turned on, or cleaners' use of a vacuum cleaner. Similar to the Temperature Calendar, a colour-coded floor plan on the right hand side of the screen illustrates which electrical circuits correspond to which physical parts of the building, and helping the user to hide or reveal traces to match energy use in particular parts of their workplace.

On all front screens that illustrate energy use, there is a button in the middle of the bottom of the screen labelled 'Think about changing your behaviour'. In the pilot study, this button led to three key sections of the tool that support action on energy use. Users could email their local Facilities Manager (FM), they could discuss energy use on the 'Pinboard', or they could make an individual plan to change their behaviour with the Pledge tool.

Building users are able to post photos or comments to the Pinboard and are able to start a new discussion or respond to other people's comments. Posts appear in white boxes in a similar shape to 'Post-it' notes on a background image of a cork board and list the individual's username below it as well as information about how long ago the post was made. The rationale for this discussion space was to support building users to discuss energy use as a means of effecting change in their building, and to support the negotiation of energy use between users who may differ in their demand for energy, for example in situations where people have differing roles or thermal comfort requirements.

The Pledge tool provides ideas of goals for individual and social behaviour change relating to both electricity use and thermal comfort requirements. It also provides a planning tool, which highlights potential 'If...then' statements that building users can consider in supporting their behaviour change intentions (cf. implementation intentions: Gollwitzer & Sheeran, 2006), e.g. 'If I see something that can be turned off, then I will turn it off'. Our ethnographic work, which began prior to the launch of e-Genie, was used to identify behaviour change goals to propose to building users and on which to base implementation intentions. These included goals relating to temperature: 'Turn down the thermostat when it's warmer than it needs to be'; 'Put on another layer when it's cold in the office rather than ask for the temperature to be increase'; and 'talk to environmental champion/colleagues to see if the temperature can be lowered. There were also goals relating to electricity use: 'Turn off my computer when I leave the office'; 'Turn off the printer when I finish using it'; and 'Turn off the lights in the common room when I leave'.

In the pilot study, the Pledge tool proceeded with consecutive screens which asked the participant to read the planned behaviour change, then visualise that change, and finally to print out the plan on a nearby mini-printer, and keep it so that they could remind themselves of the plan. These aspects were designed in order to encourage the individual to repeat and rehearse the plan in order that they would develop mental associations between the environmental cues highlighted in the plan and the behavioural change.

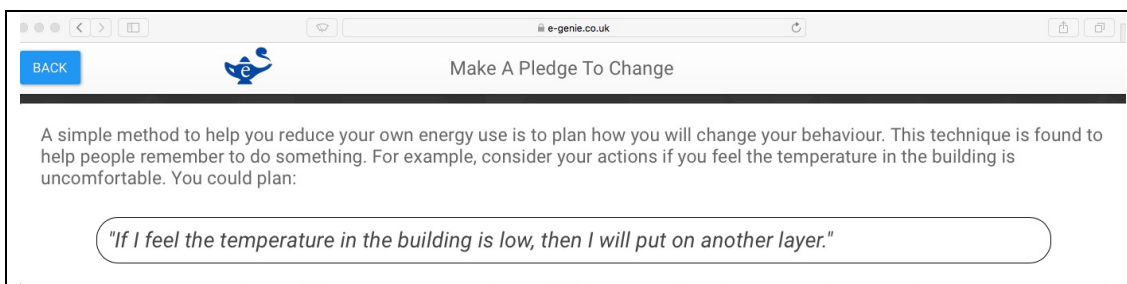
## **e-Genie version 2: Main Study**

e-Genie was further developed prior to the second trial deployment. Specifically the Annotation tool was removed given concerns that it was difficult to understand in its current form. The Pledge tool sequence was also consolidated and shortened, the navigation of the tool was adjusted, the ability to contact the FM and the requirement to log in were removed, and functional adjustments to usability were made.

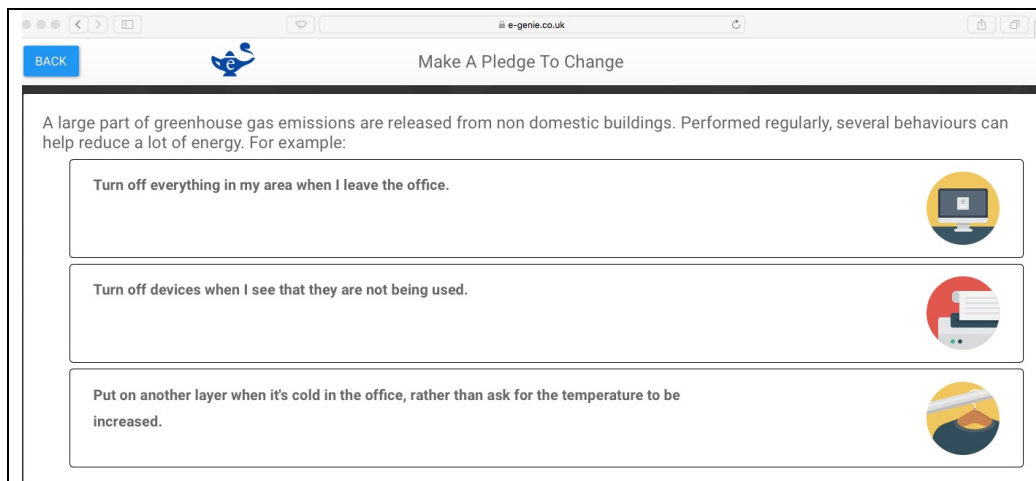
In the main study, workshops were used to generate ideas for behavioural goals for the Pledge tool. These suggested to building users that they: 'Turn off everything in my area when I leave the office'; 'Turn off devices when I see that they are not being used'; and 'Put on another layer when it's cold in the office, rather than ask for the temperature to be increased' (see Figures A1a and A1b - below). Further suggestions for cues to action (e.g. 'If..I leave the office at the end of the day...') and for behaviours (e.g. 'Then I will... turn off everything in my area') were offered within the planning screen of the Pledge tool alongside a drag and drop functionality so that participants could create their own pledges (see Figure A1c).

The Pledge tool was also consolidated by removing the electricity and heating tabs (and displaying these options in the same space), combining and shortening the initial instruction pages. The ability to print the pledge was also removed as this received little use. The navigation of the tool was developed so that the user was able to switch between screens using tabs rather than arrows and added a screen so that when the user clicked on the button labelled 'Think about changing your behaviour', this linked to an overview screen from which the Pinboard, and Pledge tool could be accessed. These changes were intended to give the user a clearer idea of the structure of the system, and their current location within it.

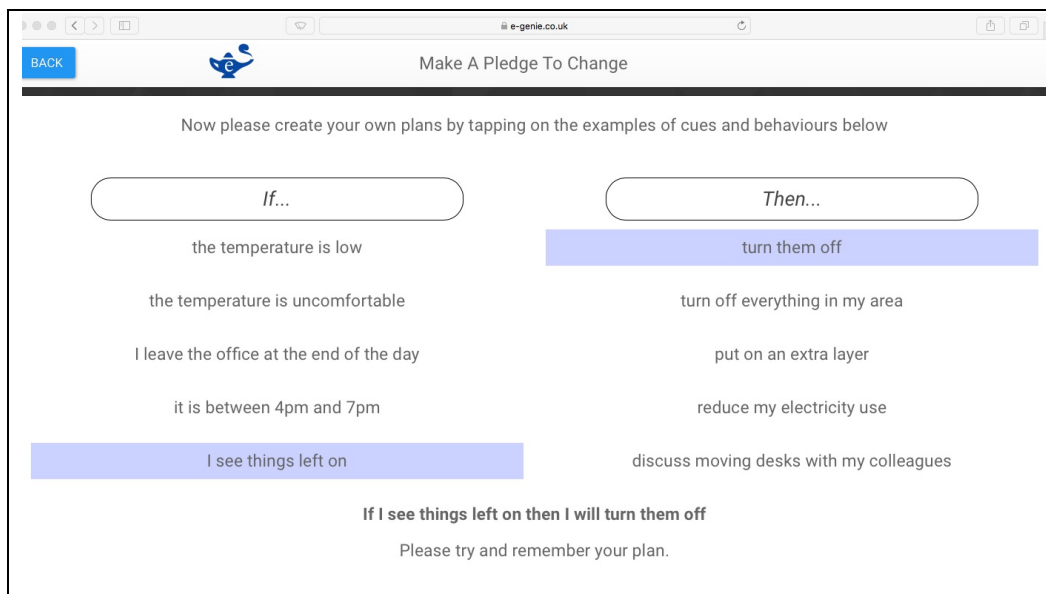
**Figure A1a.** e-Genie tool screen: make a pledge to change



**Figure A1b.** e-Genie tool screen: suggested behaviours



**Figure A1c.** e-Genie tool screen: converting intentions into actions



## Appendix 2:

### Quantitative questionnaire measures

Construct	Question wording	Scale and Cronbach's alpha ( $\alpha$ )
Perceived efficacy	<p>I believe that my energy use has an influence on my organisation's total energy use.</p> <p>I believe that my energy use has an influence on climate change.</p> <p>I believe that my energy use has an influence on my organisation's financial situation.</p>	<p>7-point scale: Completely disagree – Completely agree. Pre intervention scale <math>\alpha</math> = 0.82; Post intervention scale <math>\alpha</math> = 0.88.</p>
Individual energy behaviour	<p>The following is a list of regular actions which you may take at work. Please indicate to what extent you are taking these actions these days (or indicate if not applicable to you):</p> <p>Turn off your computer/monitor when you are away from your desk for a period of time (e.g., lunch)</p> <p>Turn off your printer before leaving for the day</p> <p>Switch appliances off instead of leaving them on standby</p> <p>Put on layers of clothes rather than use additional heating</p> <p>Consider energy efficiency or environmental factors when requesting a new purchase</p> <p>Turn appliances off at the plug socket when not in use</p> <p>Turn down heating (e.g., thermostat, radiator) to a comfortable level</p> <p>Turn off the lights of a communal room before leaving (e.g., after a lunch break, after a meeting)</p> <p>Fill the kettle with the amount you need rather than filling it up</p> <p>Turn off communal office equipment (e.g., printer, copy machine, lab equipment) before leaving for the day</p> <p>Research ways in which your energy consumption at work can be reduced (e.g., online)</p> <p>Turn off the lights before leaving for the day</p> <p>Turn off your computer/monitor before leaving for the day</p> <p>Turn down air conditioning to a comfortable level (so that it doesn't come on at lower temperatures)</p>	<p>6-point scale (Very unlikely – very likely). Not applicable option also provided. Pre intervention scale <math>\alpha</math> = 0.81; Post intervention scale <math>\alpha</math> = 0.71.</p>
Social energy behaviour	<p>Overtly disapprove (e.g., frowning, commenting) of other people wasting electricity</p> <p>Take part in a campaign about an energy issue</p> <p>Report any energy waste (e.g., a hot dripping tap)</p> <p>Discuss energy saving measures with colleagues</p> <p>Remind a colleague to switch something off to save energy</p> <p>Suggest to management that they change procedures, to save energy</p> <p>Speak to key people in charge about energy issues</p>	<p>6-point scale (Very unlikely – very likely). Not applicable option also provided. Pre intervention scale <math>\alpha</math> = 0.86; Post intervention scale <math>\alpha</math> = 0.88.</p>
Concern	<p>How concerned, if at all, are you personally about saving energy at work?</p>	<p>7-point scale: Not at all concerned – Very concerned</p>

## Appendix 3:

### Workshop protocols

	<b>Title</b>	<b>Aims</b>
Workshop 1	Introducing the e-Genie toolkit and mapping the space	<ul style="list-style-type: none"><li>• To introduce e-Genie</li><li>• To map activities in the space</li><li>• To map power consuming devices in the space</li><li>• To map winter and summer comfort in the space</li><li>• To map workplaces practices and technologies needed to be comfortable</li></ul>
Workshop 2	Power and comfort apportionment workshop	<ul style="list-style-type: none"><li>• To think through how energy is used in the office</li><li>• To allocate ownership and control of the energy consuming activity</li></ul>
Workshop 3	Causality and strategy workshop part 1	<ul style="list-style-type: none"><li>• To identify some more energy efficient ways of doing things</li><li>• To think through what is needed to make the energy efficient alternatives happen</li></ul>
Workshop 4	Causality and strategy workshop part 2	<ul style="list-style-type: none"><li>• To identify which behaviours and practices to be focused on in an energy management strategy</li></ul>

## Appendix 4:

### Summary of open-ended responses evaluating e-Genie

**Table 1.** Coded responses on why e-Genie was liked

Code	Fuller Description	Illustrative Quote
Useful	Seeing the energy data is useful	'The information is useful and understandable'
Highlights Wastage	Interesting to see where energy is being wasted	'Clearly shows periods when energy being wasted'
Temperature	Highlights local temperature and variations	'It was interesting to see the temperature fluctuations during the day'
Visuals	Illustrations of energy usage liked	'Clear graphics'
User friendly	Easy to understand and use	'Simple to understand'
Pinboard	Discussion board aspect liked	'The comments board was an interesting way to see other people thoughts'
Encouraged communication	The tool encouraged discussion about energy issues.	'You can get lots of ideas from other people on other floors & getting engagement from lots of people'
Energy importance	Demonstrated the importance of energy issues and showed that management take related issues seriously.	'It is good that energy usage is being taking seriously'
Positive	General positive comments about the tool	'Love the concept'

**Table 2.** Coded responses on why e-Genie was not liked

Code	Fuller Description	Illustrative Quote
More Coverage	Include more sensor measurements across the building	'It wasn't on my floor'
User friendly	Not very user friendly	'I couldn't work out how to get from graphs to pinboard'
Technical issues	Improve the technical performance of the tool	'Wasn't working when attempted to use'
Difficult to act	Difficult to undertake recommended actions	'Shows how hot it is in the office but can do nothing with that information'
Sensor placement	Placement of sensors could be improved	'Placement of the sensors. If the remainder of the building matches my floor, the sensors will have a very good impression of the kitchen area (which no one works in)...'
Not helpful	Did not increase knowledge.	'Didn't really increase my knowledge of energy consumption issues'
Other	Small number of comments that did not fit alternative categories	'Considering the whole point of this is to save energy consumption I was quite dismayed to see that the tablet is on all the time and did not go into hibernation mode to save energy...'

**Table 3.** Coded responses on how e-Genie could be improved

<b>Code</b>	<b>Fuller Description</b>	<b>Illustrative Quote</b>
More coverage	Include more sensor measurements across the building	'Cover all floors of the building'
Sensor placement improved	Sensors should be placed in more useful positions	'Placement of sensors. In our office the sensor is on top of a tall filing cabinet which I think will give a different reading to the environment at 'floor' level.'
User friendly	Make it more user friendly	'Bigger screen and clearer instructions as to how to use it'
Web access	Make it accessible over the internet	'Being able to see data whilst sat at my desk, maybe a web application'
Mobile phone compatibility	Make it easier to use on a smart phone.	'Very difficult to use on an Iphone'
Aims	Make the aims of using the tool more clear.	'Earlier and more thorough explanation of what was trying to be achieved'
Control needed	More control over energy in the workplace environment should be afforded to the user.	'Give us control over our office environment'
Technical issues	Improve the reliability of the tool	'Not 'crash' so easily'
Feedback	More interaction from management desired	'For the relevant people who could act on anything raised in the 'start a conversation' section to reply to conversations so we could see that issues raised were being acted on.'
More information	More information and data desired	'Would have been interesting to see outside temperature data as well and maybe wind-chill to see how it might affect internal temp, as we tend to think building conditions too influenced by weather.'
Other	Small number of comments that did not fit alternative categories	'I haven't used it enough to comment'



**Table 4.** Coded responses on barriers to undertaking behavioural pledges

<b>Code</b>	<b>Fuller Description</b>	<b>Illustrative Quote</b>
Time	Didn't have time to get round to using the tool	'Haven't been in the office a great deal recently, and when have been in just haven't got round to looking at it'
Difficult to act	Found it hard to make behaviour changes. Energy use often not under building users control	'I can't control the heating/lighting at work'
Lack of ideas for action	Participant didn't know what kinds of things they could do.	'I wasn't sure quite what to say'
Not user friendly	The tool wasn't user friendly and navigation was difficult.	'I couldn't work out how to use it!'
Not useful	Did not perceive that the tool would be helpful	'I don't need to make a pledge to reduce my energy use'
Not possible	Not possible to further improve energy efficiency	'I don't believe I could be any more energy efficient with the equipment and office I work in'
Technical difficulties	The tool was not working properly.	'The system froze!'
Lack of coverage	The tool didn't cover the part of the building that they were interested in.	'Because it is not available on floor 9'
Lack of awareness	Was not aware of / had not seen the tool.	'I did not see the option'
Intend to use	Participant intends to use it but has not yet.	'I intend to make a pledge as I care about saving the planet for future generations and energy saving'
Not used	Participant did not use the tool without specifying why not.	'Have not used it fully'
Other	Small number of comments that did not fit alternative categories	'I think it is important to enable self reaffirming'