The smart way to display

A summary report on consumer preferences for energy display designs

energy saving trust®

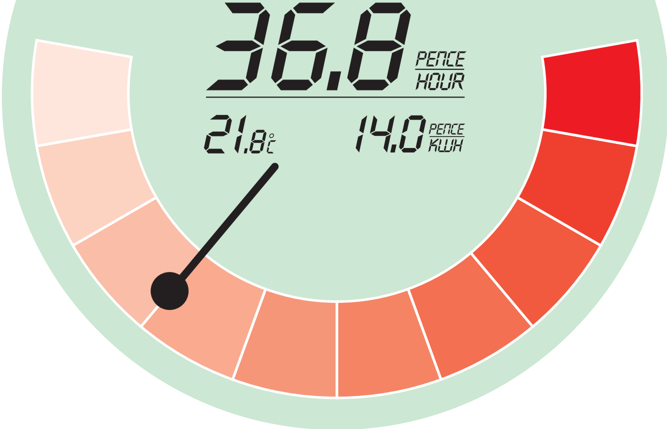
About The Energy Saving Trust

The Energy Saving Trust is the UK's leading organisation set up to address the damaging effects of climate change by helping everybody to cut carbon dioxide emissions – the main greenhouse gas causing climate change – from their homes. We promote the efficient use of energy and a more low carbon lifestyle.

The Energy Saving Trust, through its network of "one-stop-shop" advice centres, provides free and impartial advice to consumers on saving energy, domestic renewables and greener transport, and is beginning to include water saving and waste reduction advice in its remit.

The Energy Saving Trust also works with retailers, builders and industry to make sure that energy efficient products are available for people to choose as well as advising government on policies that are needed to cut greenhouse gases.

For more information visit energysavingtrust.org.uk.



Introduction

This report offers a summary overview of research undertaken for the Energy Saving Trust by the Centre for Sustainable Energy. The full project report is available at: www.energysavingtrust.org.uk/corporate in the library section.

Displays

In-home energy displays present information on electricity and gas consumption, enabling consumers to monitor and control their energy usage. By making consumers more conscious of their day to day energy consumption, such displays can help change behaviour and promote energy saving habits. National and international experience suggests that such feedback leads to between 5 and 15 per cent energy savings[1].

National context

In-home displays are already fairly common, with a number of manufacturers and retailers of clip-on electricity display products operating in the UK. Such displays look set to become increasingly common. Recent amendments to the Carbon Emissions Reduction Target (CERT) allow energy suppliers to meet a portion of their carbon saving targets through distribution of clip-on electricity displays to households. The UK Government has also committed to rolling out smart meters to every home by 2020, with an in-home display potentially accompanying each meter. At the time of writing the Government's stated preference was for displays to be the standard way of communicating feedback on consumption to households[2].

Focus of report

The impact of displays on consumer behaviour will be determined by the extent to which the display engages the consumer and how understandable and meaningful the information displayed is. While displays have the potential to engage consumers and influence their behaviour, poorly designed displays are likely to confuse, mislead or turn consumers off using them.

It is possible for a display to present information on energy consumption in a multitude of different ways. The units of measurement could be power (in watts), spend (in pounds) or resulting CO_2 emissions. Equally, this information could be expressed as a cumulative amount or as a rate of use, for each hour, each day, over a week or longer. All of this information could then be presented in a number of different ways: in text, numerically, graphically, through movement or change in colour.

While it is generally accepted that displays can help change behaviour and save energy, little is known about the relative strengths or otherwise, of different display design options. Most large scale trials, such as the ongoing Ofgem-run Energy Demand Research Project[3], do not distinguish between the impact of different display types. What little research that has been done by display designers and manufacturers tends to be considered commercially sensitive and not publicly available.

This project aims to help fill this gap in our understanding of displays. We hope the results outlined in this report will help inform policy decisions relating to smart meter roll out and use of displays. We also hope the results will be useful to other stakeholders including display designers and manufacturers. Although not the focus of this project, the findings are potentially also of relevance to designers of other types of energy consumption feedback such as internet-based services. Some principles will also be applicable to designers of other displays such as those which present details of water consumption.

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1. Darby S (2006) The effectiveness of feedback on energy consumption. A review for Defra of the literature on metering, billing and direct displays. Environmental Change Institute, University of Oxford www.eci.ox.ac.uk/research/energy/electric-metering.php
2. DECC (2009) A consultation on smart metering for electricity and gas www.decc.gov.uk/en/content/cms/consultations/smart_metering/smart_metering.aspx
3. See www.ofgem.gov.uk/Markets/RetMkts/Metrng/Smart/Pages/SmartMeter.aspx

Research approach

This project used the following research techniques:

Literature reviews. Two expert literature reviews were undertaken. One focussed on the existing literature on displays. This was undertaken by Sarah Darby of the Environmental Change Institute, Oxford University. The other assessed the psychology of human interaction with displays and was undertaken by Clive Frankish of the Department of Experimental Psychology, University of Bristol.

Interviews with individuals from companies selling displays.

Focus groups. Five focus groups were recruited. The focus group work formed the core part of the study. Each group contained seven or eight individuals who were recruited to represent the following social groups:

- Prepayment meter users
- Under 30 years old
- 60-69 years old
- 30-59 years old, socio-economic group A/B/C
- 30-59 years old, socio-economic group D

Each group met twice. At the first meeting the groups collectively designed a real-time energy feedback display. At the end of the first meeting, participants were given a real-time electricity display to take home and use. Each member of a group received a different display. Participants were also given a diary which they were asked to complete and bring back to the follow-up group. The devices used are shown below.

The second meeting was held eight days later. Participants described their experiences of using their display and were encouraged to discuss the strengths and weaknesses of each of the seven different display designs. They then reviewed their initial designs and prepared new ones.

Photographs of the display designs produced by the groups, the participant diaries, notes on the focus groups and responses to questionnaires completed by the participants were used to record outcomes and inform analysis.

Figure 1: Real-time electricity display devices used in the focus groups - (clockwise from top left) the Wattson, Current Cost CC128 ENVI, Owl, Eco-eye, GEO minim, Efergy lite and (centre) Owl Micro.

Findings

Evidence of behaviour change
The study revealed numerous examples of behavioural change as a result of participants using the display and learning about differences in the electricity consumption of the lights and appliances in their homes. It is important to note that the study did not attempt to measure the extent of behaviour change resulting from the use of displays. This would require a far larger sample size, more control over variables and the study to have been run over a far longer time to test the longevity of behavioural changes. Additionally, participants were incentivised to take part in the project and to keep a diary of their experiences and responses to using the display. They were therefore motivated to interact with the displays more than would be the case in real life. Nevertheless, the range and type of impacts were striking and illustrate the potential effect on behaviour of feedback provided through in-home displays. Reported impacts on behaviours can be grouped as follows:

Turn it off

“I used it to find out stuff at first – now I turn everything off and know it costs nothing at night and when I’m out.”

“I learnt how lazy I am with lights – I’m always leaving them on. I used to leave a light on at night, because I didn’t like the house to be in darkness, but now I turn them off as it’s just not necessary”

Use it less

“I had the cooker and washing machine on at the same time – I was so shocked at the amount of kilowatts I was using! I am only going to wash when I have a full load”

Use it more carefully

“We used to charge things through the night – but realise this is unnecessary, as it only takes a couple of hours to charge, but the charger uses electricity even when it’s finished charging. So now I don’t leave it to charge overnight”

Improve its performance

“When using my vacuum to clean my car it got very hot. It seemed to be using a lot of electricity. I cleaned out all the filters and the monitor went down.”

Improve its performance

“I made a mental note to question all white goods [sic] on energy used in the future.”

Display design

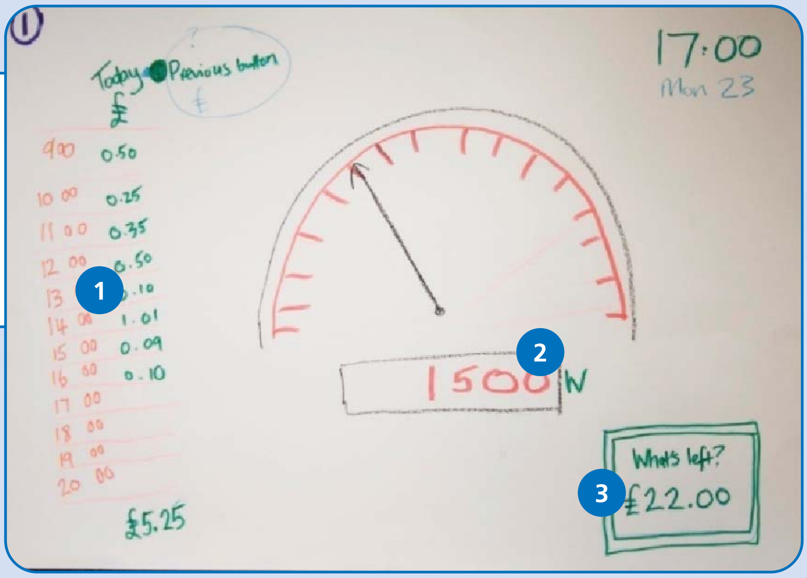
Although participants were generally able to use the displays they were given, and many changed their behaviour as a result, their experiences were mixed. Impacts were inhibited where the display was considered unreliable, difficult to read, difficult to comprehend or where it did not provide appropriate information.

This practical experience of using displays, and the focus group process, teased out differences between what people initially thought they would like on a display and what they actually ended up wanting. The experience therefore helped to clarify what was genuinely informative and useful and what was superfluous.

Example group 1: Prepayment meter users

First design

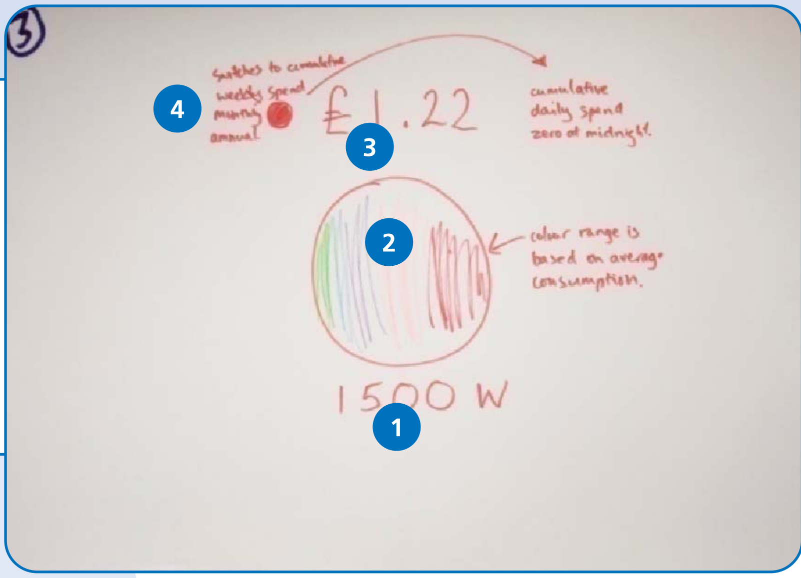
1. Detailed data on spend throughout the day
2. Rate presented in watts
3. Figure of remaining funds (like prepay meter data)



Example group 2: 60-69 year olds

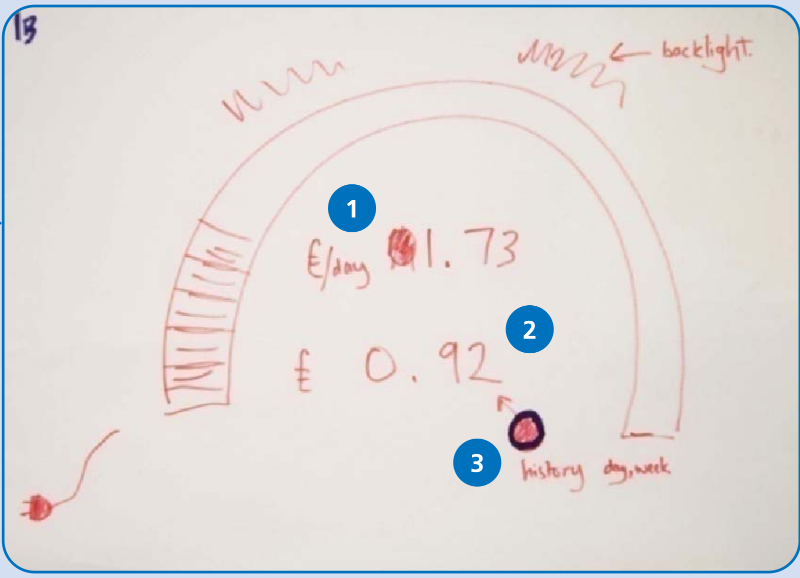
First design

1. Rate is presented in watts
2. Light in middle changes colour depending on rate of consumption (green through amber to red)
3. Cumulative daily spend
4. Button to access cumulative spend weekly, monthly and annual spend



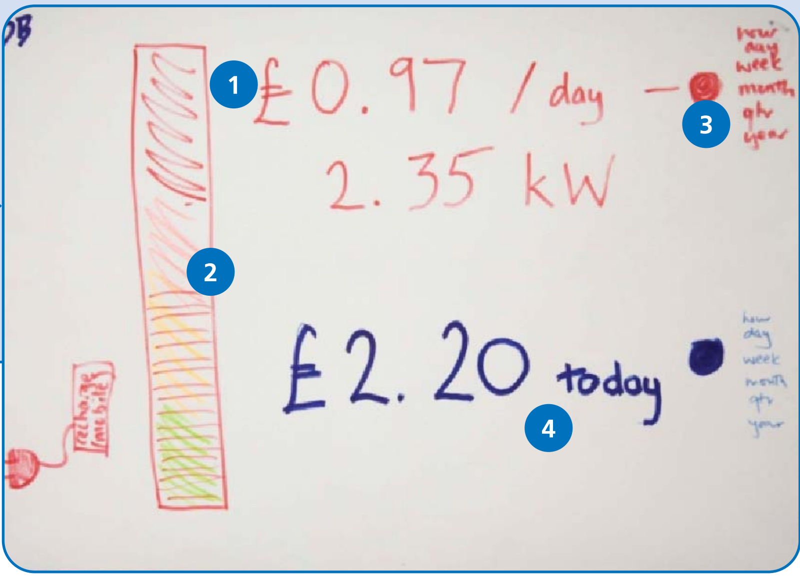
The outputs from the exercise demonstrate a remarkable degree of convergence across the different groups. The photos of designs below illustrate the changes made by two of the five groups as they revised their diagrams to produce their final design:

Second design



1. Rate presented as £/day
2. Cumulative daily spend
3. Button to access cumulative spend for previous day and week

Second design



1. Rate presented as £/day and as kilowatts per day
2. Moving bar to reflect rate of consumption
3. Buttons to access historical data
4. Cumulative daily spend

No two final designs from all five groups were identical. Each group added their own unique features and subtle preferences. However, there were some clear common themes as demonstrated by the outputs of the two groups above.

The power of visual displays

It is notable in example group 2, that the visual display changes from a light with varying colour in design 1, to a moving bar in design 2 (similar to the design produced by example group 1). This preference was also found amongst the other three groups. One group which initially favoured just a digital display abandoned it in favour of a similar moving 'speedometer' design. Although the groups valued the accuracy provided by digital figures, every one of the final designs included a graphic indicator of the current rate of electricity consumption. The group designs were undoubtedly influenced by the visual design of the GEO display, which was universally liked by participants. Participants pointed to the fact that moving visual displays allow readers to get an immediate impression of current rate and allow relative scales of change in consumption to be shown quickly without the need for calculations. A moving display can also help catch the eye. It is worth noting that these points correspond strongly with the theory on display design and ergonomics, as identified in the literature reviews (see box below).

Presentation of rate

All five groups wanted to see real-time rate of consumption but they struggled in deciding how this should be presented. Both example groups began by presenting rate of consumption in watts. Both groups initially considered expressing rate (especially in financial terms) to be too difficult as it had the potential to confuse or mislead. This initial preference for watts is also likely to be partially the result of focus group discussions where the idea of watts was introduced by researchers. However, by the second design stage both groups opted for a rate of spend in pounds per day which they considered to be perfectly understandable. This trend was also visible in the other three groups. Although it was recognised that watts reflected rate and the meaning of this was understood in relative terms, watts were very poorly understood. Far more meaningful was use of pounds per day which was understood once participants had direct experience of using, or viewing, a display with this functionality. Most groups also wanted to be able to see rate expressed in watts or kilowatts per day, either on the same screen or through pressing a button.

Overall spend

Without exception all five groups decided they wanted cumulative daily spend presented. This, combined with information on current rate of spend, was typically considered sufficient to enable users to track consumption and pinpoint areas of high usage in their home. This was even the case for the prepayment users in example group 1, who had initially wanted a detailed breakdown of costs hour by hour throughout the day to help them identify high cost activities.

Historic data

All final designs included the ability to access historical data on spend and to compare it to current levels. Although not placed on the main default screen this information could be accessed through further investigation by pressing a button.

Simplicity

There was a strong desire to keep the display screen simple. This was the single most common recommendation made by participants, especially the older members of example group 2. In all groups there was a tension between keeping it simple and satisfying multiple needs. While the final design utilised buttons to be able to switch units or to access historical information, the more 'technophobe' users are unlikely to want to physically interact with their display to access different data.

Key findings from literature reviews

Ideally, a real-time energy display will provide information that is accessible, engaging and that can benefit almost everyone to some extent. By combining understanding from ergonomic display design theory, historically focussed on avionics and cockpit design, with the experiences of energy displays to date, it is possible to identify design principles to inform the development of effective energy displays:

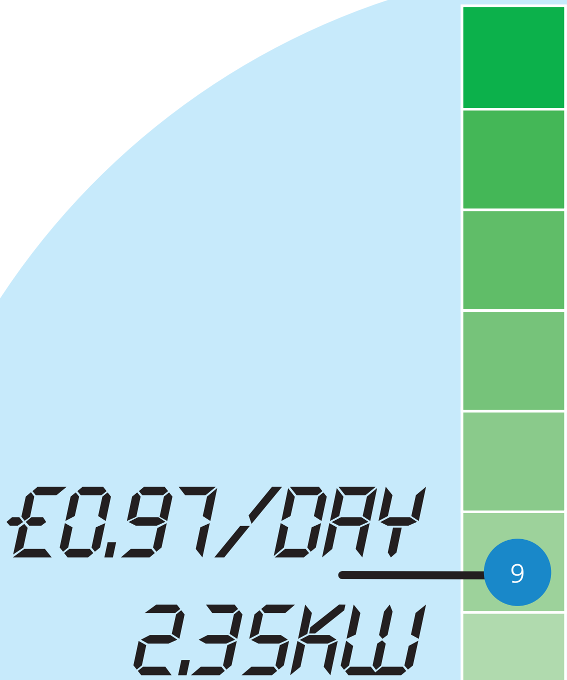
- Displays need to be consistent with user intuitions. Engineers and energy specialists may forget that the average householder is not familiar with energy units and not very interested in energy for its own sake.

- Displays should provide clear action-specific information. In the absence of detailed appliance by appliance data breakdown, genuine real-time data (with a short delay between measurement and presentation of data) can allow users to link usage levels with specific actions or uses.

- Digital displays facilitate quicker reading times and fewer errors in readings. However, analogue displays[4] can enable the user to make a quick qualitative assessment. It may be harder to read the exact value represented by an analogue display, but it can directly convey the difference between current and desirable values in a direct and readily interpretable manner. Research to date, including early findings from the UK Energy Demand Research Project, suggests that the importance of very basic 'ambient' signals has been underestimated. Including both analogue and digital approaches to communicating information on a home energy display could provide an optimal combination.

- There are trade-offs to be made between enabling users to navigate to new screens to access comprehensive information, versus maintaining simplicity in design and avoiding the risk of deterring users who lack the confidence to interrogate the device. Either way, it is essential that the default screen provides the information required for consumers to act.

4 Here 'analogue' refers to a display feature which presents information by means of a dial or another visual representation e.g. an analogue speedometer.



Conclusions

- A minimum specification for energy displays is required to ensure that they hold the functionality that consumers identify, in practice, as being critical to display design. Despite a relatively well developed in-home electricity display industry in the UK, the majority of displays do not currently exhibit this functionality.

- There was a remarkable convergence in the final designs produced by the five focus groups, despite the significant differences between and within the groups. This demonstrates that it is possible to identify a minimum specification which meets the core needs of the majority of consumers.

- Based on this research we recommend the below functionality should form the basis of a minimum specification for displays. This should be viewed as a minimum requirement which does not restrict display design to only these features nor stifle further innovation.

Minimum specification

1. The default display should include:
    - A clear analogue indicator of current rate of consumption
    - Current rate of consumption as a rate of spend in pounds per day (numeric)
    - Cumulative daily spend in pounds (numeric)

2. The display should offer the following options through interaction (by pressing a single button):
    - Spend in last seven days, day by day
    - Spend in last complete week
    - Spend in last complete month
    - Spend in last complete quarter

    The historic periods should match the utility's billing periods in order that the display is consistent with household bills.

3. The display should offer the option (by pressing a single button) of switching units from money to power, i.e. from pounds per day and pounds to kilowatts and kilowatt-hours. If interaction is not possible, current rate of consumption in kilowatts should form part of the default display.

4. The display should be mains-powered but have an internal battery to enable mobility in the home.

    Although the study focused on electricity use as these are currently the most widely available displays, the same design principles should apply to gas. If a display is to show both fuels, exactly the same means should be used for gas as for electricity. These options could either be presented side by side or the user could switch between them with a dedicated button.

Other possible requirements:

- The groups were not asked to consider variable time of use tariffs but the emphasis placed on cost suggests the value of the current tariff ought to be included on the default display.

- To ensure that displays are capable of supporting the introduction of the feed-in-tariff from 2010, the requirements of households generating their own power will need to be considered. More complex information will be needed by these users including rates of electricity generation and exportation, as well as consumption.

- Three of the groups included a target-setting option in their final display design. This should be considered as part of a minimum specification but more evidence is needed to establish whether this extra functionality justifies the increase in complexity.

- Some study participants wanted to be able to see information on associated carbon dioxide emissions. Such a function would help those consumers to understand the relative environmental impacts of their electricity and gas use and could help improve 'carbon literacy' levels. However, for the majority of consumers carbon dioxide emissions data would not be meaningful, suggesting this function is best offered to certain customer groups, rather than it being a vital part of a minimum specification.

- While the basis of a minimum specification is likely to remain the same, it should be viewed as dynamic and revisited and updated as technology and consumer understanding develops. In the short to medium term, the integration of displays with new heating control devices and automated 'smart' controls offers huge potential to help people better manage their energy use.

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