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# CoDesign With Data

## Volume II Appendices

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Presented for the degree of Doctor of Philosophy

# Table of Contents

# Table of Figures

# Appendix A: Publications

The following publications were written during this research and are included in this appendix:

Dove, G., & Jones, S. (2014, June). Using data to stimulate creative thinking in the design of new products and services. In *Proceedings of the 2014 Conference on Designing Interactive Systems* (pp. 443-452). ACM.

Dove, G., & Jones, S. (2014, April). Using Information Visualization to Support Creativity in Service Design Workshops. In *ServDes.2014 Service Future, Proceedings of the fourth Service Design and Service Innovation Conference*, (pp. 281-290), Linköping University Electronic Press.

Goodwin, S., Dykes, J., Jones, S., Dillingham, I., Dove, G., Duffy, A., Kachkaev, A., Slingsby, A., & Wood, J. (2013). Creative user-centered visualization design for energy analysts and modelers. *Visualization and Computer Graphics, IEEE Transactions on*, *19*(12), 2516-2525.

Dove, G., Jones, S., Dykes, J., Brown, A., & Duffy, A. (2013, June). Using data visualization in creativity workshops: a new tool in the designer's kit. In *Proceedings of the 9th ACM Conference on Creativity & Cognition* (pp. 304-307). ACM.

Dove, G. (2013, May). Inspired by information: combining data visualization and generative techniques in early stage design research. *Paper Presented at Graduate Symposium Creativity & Cognition '13*. ACM

Dove, G. & Jones, S. (2013, May). Evaluating creativity support in co-design workshops. *Paper presented at the CHI 2013 Workshop: Evaluation Methods for Creativity Support Environments*. ACM.

Dove, G. and Jones, S. (2012, July). Narrative Visualization: Sharing Insights into Complex Data. In *Proceedings IADIS International Conference Interfaces and Human Computer Interaction (IHCI 2012), (pp299-302),* IADIS digital library.

Dove, G. (2012, June). Visualizing Perspectives for Creative Collaboration. *Paper presented at Doctoral Consortium, DIS 2012*, ACM

# Using Data to Stimulate Creative Thinking in the Design of New Products and Services

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## ABSTRACT

Exploring interactive visualizations of data generated within the domain for which new products and services are to be designed can play a useful role in stimulating ideas that are considered highly appropriate to that domain. We describe a study in which participants in four collaborative design workshops used information visualizations representing electricity consumption data to help generate ideas for new products and services that could utilise the data generated by a smart home. Participants in the workshops appeared to use sensemaking behaviour to develop insights about the domain, which were later used in generating new ideas. Ideas arising from workshops where the stimulus was data visualized with less ambiguity in the visual encoding were judged to be significantly more appropriate than those from workshops where ambiguity in the visual encoding of the data used as stimulus was intentionally increased. We discuss the implications of this with regards to designing future workshop activities.

## Author Keywords

Information visualization; creativity support; collaborative workshop technique.

## ACM Classification Keywords

H.5.2. [Information interfaces and presentation]: User Interfaces, User-centered design, Theory and methods

## INTRODUCTION

It has been argued in previous work that domain relevant data can have a useful role to play in stimulating stakeholder creativity in early stage design workshops, and that visualizations of such data can play an important part in this [10, 9, 11]. In this paper, we begin by presenting a brief review of the theoretical underpinnings for work in this field by considering literature in three related areas. We then report an initial study, involving four collaborative design workshops, which aimed to investigate a key issue in

relation to the style of information visualization that might most effectively be used in implementing such an approach. The results from this study, including an analysis of both the activity during the workshops and the outputs they generated, provide some support for our conjectures regarding the processes likely to be involved in what is a valuable new technique designers can employ to research future users' requirements and desires.

## BACKGROUND AND MOTIVATION

### Stakeholder creativity in early stage design workshops

Design is an inherently creative process, but without deliberate attempts to stimulate creative thinking, current approaches to user-centred design may inadvertently focus on refinement of existing concepts, rather than developing more radical ideas. In our work, we aim to address Norman's criticism that current user-centred methods do not lead to major design enhancements [27] by introducing deliberate creativity techniques to stimulate creative thinking when eliciting ideas for design from stakeholder representatives.

According to one well-accepted definition, 'Creativity is the ability to produce work that is both novel (i.e. original, unexpected) and appropriate (i.e. useful, adaptive concerning task constraints)' [36]. Maiden et al [24] have discussed how creativity workshops in which a range of stakeholder representatives undertake activities using techniques such as constraint removal, brainstorming with creativity triggers and analogical reasoning can prompt participants to generate important ideas for requirements that are considered both novel and appropriate, and that may otherwise remain unexpressed. Jones et al [21] report on a workshop in a similar style that encouraged participants to brainstorm with creativity triggers, generate new ideas by removing constraints, and combine ideas about problems or requirements with other ideas about the application of new technologies; and Sustar et al [37] used similar techniques in workshops involving designers and older people in the design of digital devices.

These approaches to the use of deliberate creativity in early stage design have based their work on various models of the creative process. For example, Maiden et al [24] used methods derived from, and structured according to, models proposed by Osborn [20], Wallas [42] and Boden [2]. There are many such models, a summary of which can be found in [23]. Perhaps the most frequently referred to is the four

stage model arising from work such as that of Wallas [42], which identifies the stages of *preparation*, including preliminary problem analysis and definition; *incubation*, in which associations are unconsciously developed in the mind of the problem solver(s); *illumination*, or idea generation; and *verification*, or conscious evaluation and refinement of ideas. All models of the creative process include one or more stages in which ideas are generated, and it is at these stages that most effort on creativity support has so far been concentrated. Most models also include reference to one or more preparatory stages. For example, Lubart [23] characterizes the preparatory phase as one in which "relevant information is gathered and preliminary ideas are advanced" while Treffinger [38] describes processes of mess finding, data finding (through information search), and problem finding. Here we focus on the way in which support can be provided during these preparatory stages, in order to effectively stimulate the generation of new ideas later in the creative process.

**Using data to stimulate creative thinking**

The amount of data we generate annually has grown exponentially, from 150 exabytes in 2005 to 1200 exabytes in 2010 [18]. This suggests that important opportunities may be available if these data sources can be exploited effectively. One way of capitalizing on this increased availability is by visualizing these data and utilising human perceptual capabilities and visual cognition skills to understand, explore and gain insights into that data. Cybulski et al [7] provide an overview of previous work describing how interactive visual analytics is a process of digital creativity that utilizes data for problem solving and decision-making amongst expert data analysts.

In our work, we look to explore data with stakeholders who are not necessarily expert analysts, helping both them and us to develop a better understanding of the context for which new systems are to be designed. We do this within workshop activities as part of the preparation stage of the creative process, described above, and with the aim of generating insight that can later be used to inspire new ideas for products and services. Interactive information visualization has been shown to be an effective method of making data more accessible and engaging to a public audience [44]. It is also one of the transformational tools and technologies identified by Shneiderman as being generators of excellence suitable for supporting creativity and innovation [34]. In particular he highlights the opportunities that information visualization provides for comparing alternatives thoroughly and rapidly by coding with visual variables such as colour and size; using computational power to filter or refine dynamically; and then utilising human perceptual skills to identify patterns, trends or outliers and gain insight.

Many approaches to information visualization design view it as an exercise in using graphical representations to amplify analytical cognition. Kosara [22] has used the term

*pragmatic visualization* to describe this style of design. Here the work of Tufte [39] has been influential with his call for "clarity, precision and efficiency" to "avoid distorting what the data have to say" and his statement that "[c]lear, detailed and thorough labeling should be used to defeat graphical distortion and ambiguity". Similarly, Few [14] places an emphasis on clearly communicating precisely the data that is represented. In recent years, however, both the computational power available and the number of different ways in which researchers have used this in supporting information visualization have grown rapidly. There are now many possible ways of representing the same sets of data.

As the range of activities information visualization is employed to support has expanded, new styles of visualisation design have emerged. Pousman et al [31] describe a class of *casual information visualization* characterised as being non-work related, with a user base not necessarily expert in analytical thinking. Here they describe visualizations that support peripheral or ambient information seeking, social data analysis and data art. Both Viégas and Wattenberg [41] and Kosara [22] use *artistic visualization* as a classifier, describing the use of visualization techniques to express a particular, contextualized viewpoint or evoke deep emotional or intellectual responses. Finally, Manovich [25] notes that any mapping between data and representation is potentially arbitrary, arguing therefore that information visualization techniques might be employed to display the ambiguity inherent in experience.

**The role of ambiguity in creative thinking**

For us, the notion of ambiguity in visual representation is of particular interest, due to frequent associations between the concepts of ambiguity and creativity. There are several lines of work that suggest the use of ambiguous stimuli may in some way be associated with high degrees of creativity.

A high tolerance of ambiguity is a trait that has been shown to be associated with creative personalities, being recognized as such in Guilford's [16] foundational research. Vernon [40] considered it to be a necessary condition for creative personalities because it permits individuals to be satisfied with partial or sub-optimal solutions to complex problems. Sternberg & Lubart [35] suggest that a tolerance of ambiguity enables people to remain open and continue working through complex situations longer, thereby increasing the probability that they will discover a novel solution, and Zenasni et al [47] have demonstrated the relationship empirically.

In the field of design, Sanders [33] has encouraged participants to explore experience and desire through generative design activities in which they are provided with ambiguous stimuli that encourage experimentation and surprise. This has been shown to be particularly effective in helping participants generate new ideas. Similarly Gaver and Dunne [15] employed ambiguity in their design of

cultural probes used to capture creative feedback from stakeholders during design research. Cruz and Gaudron [6] also employ ambiguity in their Open-ended objects, which, in a similar fashion to our use of information visualization, they employ as a preparatory tool in design workshops. In addition to this, many practitioner-oriented and commercial approaches to applied creativity, especially those used in design, urge followers to be comfortable with ambiguity in their own creative thinking, and to experiment playfully with the many possibilities it can present [13,3,19].

Therefore, as part of our investigation into the role of information visualization in stimulating creative thinking, we were interested to know whether it would be more productive to employ visualizations, which aim to clearly communicate precisely the data that is represented and are designed with a less ambiguous visual encoding, or whether the use of more ambiguous stimuli, where one representation could have several possible interpretations, would support greater creativity in the ideas our workshops' participants generated.

**STUDY DESIGN**

To investigate the way in which visualizing domain relevant data supports creative thinking, and whether the degree of ambiguity in the visualizations of data that we provide as stimuli in workshops has an effect on our participants' ability to gain insight from these data and then generate creative ideas, we designed a simple study. This study consisted of four workshops, each with three participants, where the objective was to generate ideas for new products or services that could utilise the energy data generated by a smart home to benefit its occupants in a future scenario where variable electricity pricing has been introduced. In each workshop participants undertook two rounds of identical idea generation activities, each round using a different style of information visualization as stimulus. We therefore had two conditions under investigation:

- Idea generation with stimulation provided by an information visualization designed with a less ambiguous visual encoding (IV1).
- Idea generation with stimulation provided by an information visualization in which ambiguity in the visual encoding is intentionally increased (IV2).

**Participants**

Twelve participants were recruited from City University London's School of Informatics and School of Engineering and Mathematical Sciences. Seven participants were female and five male. Ten were in the age range 25-34 and two were in the age range 45-54. Participants of different ages, gender and experience were evenly distributed across each workshop.

**Information visualization design**

Both styles of information visualization used in this study were custom designed for the purpose. The data visualized

was randomly selected from a set of anonymised electricity consumption data generated by the smart plugs and smart meters deployed in a test-bed of one hundred and thirty households that make up a long-term technology trial in Milton Keynes, UK. These represent consumption records for selected appliances named by the household (e.g. refrigerator or T.V.), and for total electricity consumption, all generated at three-minute intervals. The same data are represented in both visualizations.
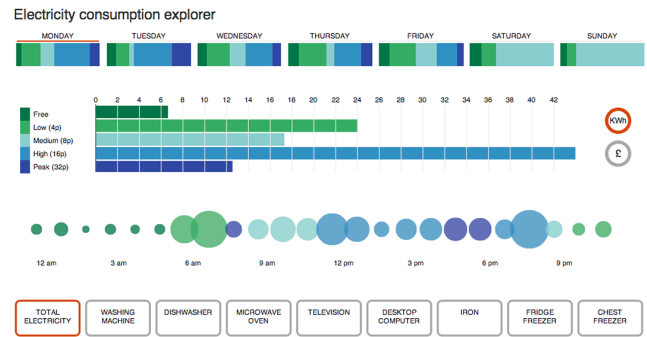


**Figure 1: Screenshot of IV1 showing total electricity consumption in kWh for Monday**
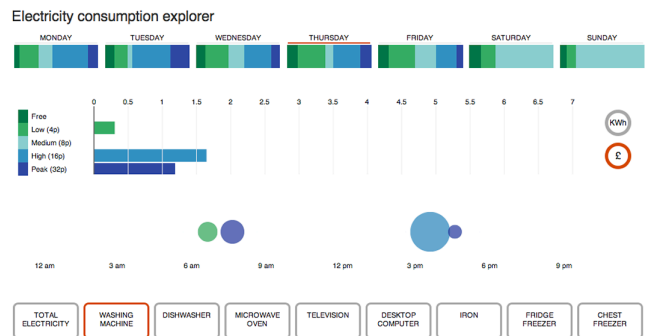


**Figure 2: Screenshot of IV1 showing the cost of the household's washing machine use on Thursday**

IV1 (Figure 1) was designed with a less ambiguous visual encoding. It is based on a familiar dashboard style of interface that utilizes features including a bar chart to show consumption within price bands; a linear timeline and bubble chart to show consumption through 24 hours; and area charts to show percentage of consumption in price bands. Each of these elements is commonplace within information visualization design. With this design, we followed guidelines found in Few [14] and Tufte [39], in particular the use of labeling to defeat graphical distortion and ambiguity [39:56]. The days, appliances and units of measure (cost and kilowatt hours) are clearly labeled and easily identifiable scales are used to help fix the values of data items in users' minds. IV1 can be viewed online at www.dadc.co.uk/eon/infovis1.html. The information visualization interface is interactive. Selecting any of the interface elements representing the day, appliance type or unit of measure updates the whole visualization to reflect new data values. For example selecting the washing

machine from the appliances list towards the bottom, Thursday from the days towards the top and the cost as a unit of measure (see Figure 2) will update each element of the visualization to reflect the corresponding data values.

IV2 (Figure 3) was designed so that ambiguity in the visual encoding, that is the mapping between data and representation, was intentionally increased. We aimed to introduce a level of abstraction that provided a class of possible interpretations and gave participants multiple options for exploration. In IV2 we replaced the familiar linear timeline with a grid-based representation of the 24 hours in a day but retained the use of a bubble chart representation of energy consumption. This hinted at consumption within a given period of time but was equally open to alternative interpretations.
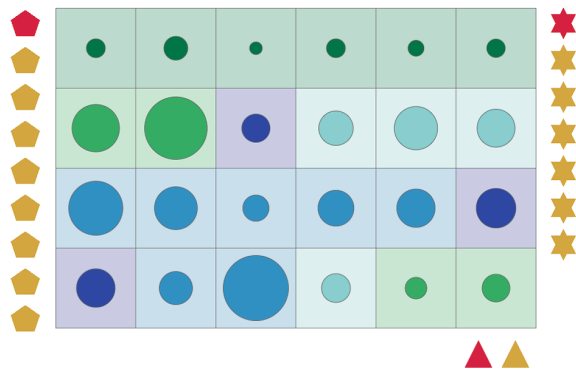


**Figure 3: Screenshot of IV2 showing total electricity consumption for Monday in kWh**
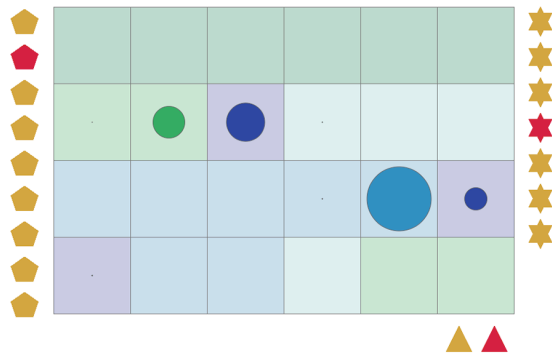


**Figure 4: Screenshot of IV2 showing the cost of the household's washing machine use on Thursday**

With IV2 we avoided using textual or numerical labels that would define visual items and used abstract symbols to represent the interactive features that control how the data are filtered. Here the pentagons represent different appliances, the stars days and the triangles are used to switch between units of measure. We used abstract symbols because they retain the ability to suggest similarity groupings without using textual labeling or explanation. This follows our understanding of visual variables [1] and

Gestalt principles of visual perception [45]. IV2 can be viewed online at www.dadc.co.uk/eon/infovis2.html. Again the information visualization interface is interactive. Selecting the abstract interface elements representing the day, appliance type and unit of measure updates the whole visualization to reflect new data values (Figure 4).

**Workshop activities**

*Activity 1: Initial inspirations*
The concept of *control* had been identified in earlier project research as being important in engaging customers with smart home energy technologies. As an initial preparatory activity, lasting approximately 25 minutes, participants were presented with a number of definitions of and synonyms for control and then asked to brainstorm ideas for people or things that exert control. We gave two examples to illustrate what was required:

- A conductor controls an orchestra
- Traffic lights control the flow of vehicles

*Activity 2: Generating insights about the domain*
In a second activity, also part of the preparation stage, participants collaboratively explored one information visualization interface. They were asked to capture any insights, observations or aspects they thought important or found interesting on individual post-it notes. This activity typically lasted approximately 25 minutes. To encourage participants' insight seeking during this activity, they were asked to consider the following five questions:

- 'What do you see?'
- 'What do you think it is for?'
- 'What are you thinking whilst you explore?'
- 'What do you notice in the visualization?'
- 'What story does it tell?'

*Activity 3: Generating ideas for new products and services*
For the idea generation stage in our workshop, we employed a combinational creativity technique, derived from Boden's [2] theory of creative processes which describes how new ideas can be formed from the combination of existing concepts. This type of technique has been effective in workshops held during the requirements gathering for major socio-technical projects [24]. Participants were asked to select one of the outputs from Activity 1, and one of the outputs from Activity 2, and combine them to create an idea for a new product or service that would utilise smart home energy data to benefit the occupants of that home. Each idea was recorded on a separate post-it note. Participants were asked to repeat this process as often as they could, re-using ideas from Activity 1 and Activity 2 as often as they liked and in any combination they chose. This activity typically lasted 25 minutes. At the end of Activity 3 participants briefly explained their ideas to camera. These we transcribed and gave to the domain experts helping our evaluation.

**Figure 5: Participants interacting with the information visualization during Activity 2**

After a short break and refreshments, participants were asked to repeat Activity 2 using the second information visualization interface, and then to repeat Activity 3, combining the outputs of Activity 1 with those generated in the second instantiation of Activity 2. An example workshop structure was therefore as follows:

1. Activity 1

2. Activity 2: using IV1

3. Activity 3: outputs from Activity 1 combined with insights gained from IV1

4. Break and refreshments

5. Activity 2: using IV2

6. Activity 3: outputs from Activity 1 combined with insights gained from IV2

The order in which the information visualizations were used was counterbalanced, so that in two of the four workshops participants explored IV2 first and IV1 second.

## EVALUATION AND DATA ANALYSIS

### Effectiveness of support for creative thinking

To evaluate the effectiveness of our approach to stimulating creative thinking under each condition of interest, we analyzed the ideas generated during each instance of Activity 3 in two ways. First, we counted the number of ideas generated to give a measure of fluency, an important attribute of creative thinking [17]. Second, these ideas were transcribed, collated and their order randomized. They were then presented to three separate domain experts who were asked to rate each idea from 0 to 5 for novelty, based on their understanding of how new the idea was to the domain of smart home energy. The same domain experts were also asked to rate each idea from 0 to 5 for appropriateness, based on the their view of the idea's usefulness within this domain and it's fit to the workshops' objective. This evaluation follows Sternberg and Lubart's [36] definition of creativity in terms of novelty and appropriateness, described earlier, and an approach to evaluation outlined in Dean et al [8] and previously used in Jones et al [21].

### Stakeholder perceptions of support for creative thinking

We were also interested in the extent to which participants felt their creative thinking was supported during the workshop by our use of information visualization and other techniques. We therefore asked participants to complete a short questionnaire at the end of each idea generation activity (Activity 3). The questionnaire included 7 questions. Four of these were derived from the Creativity Support Index [5], and concerned the extent to which the visualization and other aspects of the workshop supported various aspects of the creative process. The remaining three were concerned with the extent to which the visualizations supported insight seeking during the second workshop activity, and were derived from work describing how users gain insight from information visualization by Yi et al [46] and North [28]. Responses to all questions were collected using a Likert scale rating from 1 strongly agree to 5 strongly disagree. The questions were as follows:

- **Q1:** I was very engaged and absorbed using the visualization. I enjoyed it and would do it again.

- **Q2:** I was prompted to generate ideas that were new and varied.

- **Q3:** I was able to work together with others easily.

- **Q4:** I felt able to explore many different options, ideas or outcomes.

- **Q5:** I could easily identify relationships and patterns in the data that contributed to new ideas.

- **Q6:** It was easy for me to gain an overview of the data using the visualization.

- **Q7:** I was able to combine my existing knowledge with insights from exploring the visualization to generate ideas that I had not previously considered.

### Generation of insights into the domain

To help us better understand the ways in which the different styles of visualization were used in generating insights about the domain of interest, the insights and observations that participants had generated on post-it notes during each round of Activity 2 were collated, clustered and categorized using models of sensemaking behaviour. Yi et al [46] have suggested using models of sensemaking such as those proposed by Pirolli and Card [30] and Russell et al [32], to help understand the process through which users gain insight from information visualization. These models describe how people iteratively search the available information in order to create useful mental representations; instantiate and manipulate these representations to create possible schema that describe the subject currently of interest; investigate these schema to develop new insight on the subject; and then use these insights to generate new knowledge products. With respect to better understanding our participants' performance in Activity 2 we focused on the first three stages of these models, resulting in

participants' new insights. On this basis, we identified four distinct categories of insights and observations:

- **Data Insight (DI):** An insight gained into the underlying data. In sensemaking this would be the point where investigating a schema produced new insight.

- **Data Hypothesis or Question (DQ):** An hypothesis or question about what the data being visualized represent. In sensemaking this is where schema are being instantiated, manipulated and investigated.

- **Observation About Use (OU):** A suggestion for a context in which the visualization would be useful or an observation about its purpose. In sensemaking this is the initial search for useful mental representations.

- **Observation About the Interface (OI):** A statement, comment, question or criticism of some part of the visualization's interface or interactions. In sensemaking this is the initial search for useful mental representations.

Finally, video data was used to identify how participants' sensemaking activities progressed using each visualization. In each workshop, we analyzed the conversation and activity surrounding periods where participants were interacting with the information visualizations during each round of Activity 2. Here we used a thematic analysis technique [4], based on the coding scheme described above.

## RESULTS

### Effectiveness of support for creative thinking

When comparing quantitative results from the different conditions of interest, we adopted the following approach. First we used Levene's test of equality of variance, followed by the relevant Student's or Welch's t-test and finally Cohen's d measure of effect size for those results that were significant. We can see that participants were able to generate design ideas in both conditions (see Table 1), and that there was no significant difference in the number of ideas generated ($p = 0.697$). There was also no significant difference ($p = 0.525$) between the two conditions in the novelty of ideas generated (see Table 2 for mean and standard deviation).

| Workshop | IV1 | IV2 |
|----------|-----|-----|
| WS1 | 16 | 14 |
| WS2 | 23 | 24 |
| WS3 | 14 | 12 |
| WS4 | 14 | 11 |
| Combined | 67 | 61 |

**Table 1: Number of Ideas Generated**

| Workshop | IV1 | IV2 |
|----------|-----|-----|
| WS1 | M=2.98, SD=0.70 | M=3.00, SD=1.17 |
| WS2 | M=2.68, SD=1.10 | M=3.24, SD=0.90 |
| WS3 | M=2.71, SD=0.43 | M=1.83, SD=0.75 |
| WS4 | M=2.19, SD=1.17 | M=1.79, SD=1.20 |
| Combined | M=2.66, SD=0.94 | M=2.64, SD=1.18 |

**Table 2: Average Novelty Rating for Ideas Generated**

| Workshop | IV1 | IV2 |
|----------|-----|-----|
| WS1 | M=3.48, SD= 0.94 | M=2.98, SD=1.10 |
| WS2 | M=2.20, SD=1.15 | M=2.53, SD=1.02 |
| WS3 | M=3.52, SD: 0.84 | M=1.92, SD=1.44 |
| WS4 | M=2.31, SD=1.42 | M=1.76, SD=1.35 |
| Combined | M=2.81, SD=1.26 | M=2.37, SD=1.24 |

**Table 3: Average Appropriateness Rating for Ideas Generated**

However, there was a significant difference in the appropriateness of ideas generated (see Table 3 for mean and standard deviation), with ideas generated following preparation using the more ambiguous information visualization being judged significantly less appropriate for use in the energy domain than those generated using the less ambiguous design ($p = 0.026$, effect size = 0.347). To investigate this effect further, we turned to the data from our questionnaire.

### Stakeholder perceptions of support for creative thinking

Perceptions of the general level of support for idea generation appear to be unaffected by the difference in the two conditions. There was no significant difference in responses to questions 2 - *'I was prompted to generate ideas that were new and varied'* - ($p = 0.193$) or 4 – *'I felt able to explore many different options, ideas or outcomes'* - ($p = 0.244$). In answers to question 3 - *'I was able to work together with others easily'* - there was no evidence that the difference in visualization style affected participants' perceptions of the support for collaboration ($p = 0.25$).

However, all questions relating specifically to the data or visualization were answered significantly differently for the two different conditions. Increasing the ambiguity in the visual encoding in the information visualization used to stimulate creative thinking had a negative impact on participants' engagement (Q1, $p = 0.044$, effect size = 0.73); on their ability to spot patterns and relationships that contributed to new ideas (Q5, $p = 0.022$, effect size = 0.886); on their ability to gain an overview of the data (Q6, $p = 0.001$, effect size = 1.4); and on their ability to combine existing knowledge with new insights to generate ideas (Q7, $p = 0.016$, effect size = 0.932).

**Generation of insights into the domain**

The differences identified above can be further understood by considering the numbers of outputs of different types that were generated in the insight seeking activity (Activity 2) using the two different information visualizations (see Table 4). We found that increasing the ambiguity of the visual encoding had a negative impact on the number of observations generated during Activity 2 that were subsequently categorized as **DI** *Data Insight* (p = 0.019, effect size = 1.884). There was no significant difference in the number of outputs categorized as **DQ** *Data Hypothesis or Question* (p = 0.723), **OU** *Observation About Use* (p = 0.426) and **OI** *Observation About the Interface* (p = 0.113).

| Observation Type | IV1 | IV2 |
|---|---|---|
| DI | 21 | 6 |
| DQ | 6 | 9 |
| OU | 7 | 3 |
| OI | 32 | 58 |

**Table 4: Number of Categorized Outputs from Activity 2**

Analysis of the video data further shows that participants discuss *Data Insight* (DI) more frequently whilst using the less ambiguous visualization (IV1). This indicates that their sensemaking is more successful in this condition. Conversely, when using the visualization in which ambiguity was intentionally increased (IV2), participants spent the largest proportion of their conversation on *Observation About the Interface* (OI). In sensemaking terms, they were focused on searching for useful mental representations of the available information and not creating and manipulating the schema that might lead to their gaining insight.

A conversation from WS4 (Table 5) demonstrates the difficulties participants encountered using IV2. Their concerns remain concentrated on a series of *Observation About the Interface* (OI) comments with a single instance of *Miscellaneous Comment* (MC), a category introduced during analysis to denote general comments that continue the conversation without applying directly to participants insight seeking or sensemaking processes. In this instance the sensemaking process does not reach a conclusion as participants struggle to turn the visualized information into useful mental representations of the underlying data.

By contrast, in Table 6 we see a conversation taking place when the same participants were using IV1. This demonstrates how the sensemaking process can reach a successful conclusion with participants sharing a new insight relating to the context of the energy use the data represent. In this conversation, we see a series of *Data Hypothesis or Question* (DQ) comments interspersed with *Miscellaneous Comments* (MC). This indicates that participants have formed mental representations and created

schema relating to the information in the data underlying the visualization and that these schema are being investigated, re-framed and manipulated as they search for a *Data Insight* (DI). This we see at the end when they confirm that the data relates to a single household.

| P3: | What happens when you try that? You were going up that one? You were just going up like this… | OI |
|---|---|---|
| P3: | So how many? | OI |
| P1: | It's not really clear | MC |
| P3: | It's 5 across here, 4 up and down | OI |
| P2: | These or these? | OI |
| P1: | Shall I see what this one? | OI |
| P3: | That is… What does it do? | OI |
| P1: | More circles and less circles… | OI |

**Table 5: Transcript of Sensemaking Using IV2 in WS4**

| P2: | And this is washing machine. What does it look like? And there is nothing... | DQ |
|---|---|---|
| P3: | Oh but that's on a Monday | DQ |
| P1: | If it's on Tuesday... | DQ |
| P1: | Yeah so people doing their... | MC |
| P3: | So who is doing their washing when? | DQ |
| P1: | On Thursday people are washing their... | DQ |
| P2: | And on Sunday. | DQ |
| P1: | Thursday and Sunday | DQ |
| P3: | Oh! You never do washing on a Sunday | MC |
| P2: | And dishwasher... on Saturday only in the morning ... on Friday.... Thursday no dishwashers… and on Wednesday… | DQ |
| P1: | It's at midnight. | DQ |
| P3: | Oh. Is this one persons consumption? Do you think? Because they didn't do anything on those days. What about fridge-freezer? That one's continually on... So does that one have something on every day? Yes. | DQ |
| P3: | So something like that that's constantly plugged in is running throughout. | DQ |
| P1: | Yes and if we see the fridge... the circles are almost the same | DQ |
| P3: | So this is one person's consumption for a week and that's what the circle stands for. | DI |

**Table 6: Transcript of Sensemaking Process Using IV1 in WS4**

Our final investigation into the role of visualized data in supporting insight-seeking that can lead to creative ideas for new products and services involved attempting to trace the origins of some of the most appropriate ideas that emerged from each of the workshops. The idea that was scored most highly for appropriateness, with a score of 4.66 out of 5, was a suggestion to install a microcontroller into fridges so that their energy consumption could be regulated away from peak hours. This was recorded with the post-it headline "Microcontroller to Fridge Energy Consumption".

When we look at the outputs from Activity 1 in this workshop we see that a microcontroller is listed as a thing that exerts control. The observations included in the outputs from Activity 2, when using IV1 in this workshop, include the *Data Insight* "Fridge Is Almost Stable Consumption For Every Day". This reflects the conversations participants had around fridge consumption during Activity 2, some of which is shown in Table 6. From this, and from the explanation of the idea given to camera, it seems plausible to suggest that the *Data Insight* gained exploring the visualized data contributed to the idea generated during the combinational creativity in Activity 3. Investigations of other appropriate ideas have revealed similar histories.

## DISCUSSION

We have seen from our study that ideas for new products and services that are highly appropriate to the domain for which they are intended can be generated in creative design workshops that use visualizations of domain relevant data to help participants prepare for ideation. We have also seen that increasing ambiguity in the visualization participants explored to understand the context of the design problem had a negative impact on creative performance, in particular with respect to the appropriateness of ideas generated. This may not be surprising in light of previous work in the field of information visualization. However, it is not a subject that to our knowledge has been addressed experimentally before and our study provides both some empirical evidence, and a potential explanation for the effects observed. In turn, this has helped us better understand the role information visualization can play in stimulating stakeholder creativity during early stage design workshops, and also how we should design activities in which information visualization is used as a creative stimulus. We should be wary, in the preparation stage at least, of intentionally increasing the ambiguity employed in information visualization design. Rather, we might design workshop activities that include other creativity techniques to exploit the ambiguity inherent in the data itself; in the design context from which the data are taken; and in the different interpretations that participants' personal experiences, knowledge and viewpoints suggest.

In a more recent study [12], we have attempted to exploit ambiguity by combining the informal analytical work participants undertake using information visualization with intuitive activities that involve wishful thinking and generative creativity. This follows Miller's classification of deliberate creativity techniques on a continuum from those that are analytically dominant to those that are intuitively dominant [26]. The analytically dominant use structure to generate logical patterns of thought, for example, asking the classic journalist or detective 5Ws&H questions *"Who What Why Where When and How"*. The intuitively dominant techniques, such as *Wishful Thinking*, are more likely to arrive at solutions in a single step or without following a particular sequence. Generative activities, such as those demonstrated by Sanders [33], where ambiguity has been shown to have a positive impact on participant creativity would fall into the intuitively dominant class as they utilise both wishful thinking and imaging.

This time, participants were asked to explore a visualization designed in a style similar to the visualization IV1 described in this paper, and use the insights they gained to develop an imaginary description of the type of household that might have generated the energy consumption data being represented. This description was realised in the form of a large collage created using a combination of photographs and other types of ambiguous stimuli such as paper shapes. The insights gained were used to inform and guide later design activities.

Returning to the study reported here, given that the data represented were the same and that large elements of the colour scheme were consistent across both visualizations, we might expect those groups given IV1 first to have been more successful in their sensemaking when subsequently using IV2. This, however does not appear to be the case. We actually found very little evidence of ordering or learning effects in this study, indicating perhaps that there are other factors in play that limit participants' use of visual variables to retain knowledge. This is clearly an area for further investigation and one that potentially has wider implications for visualization design.

Another factor that we might expect to be influential in a small study such as this are differences between workshop groups. WS2 generated more ideas than any other group but like the others, a similar number in each condition. Also, WS2's mean idea rating was higher for both novelty and appropriateness using IV2 than IV1. This was unlike other groups. However, their questionnaire scores were consistent with those of other groups. Therefore, whilst group differences can affect studies such as this, further investigation is needed to understand what those effects are. This is something we should be aware of in future studies.

Similarly, we might have seen an impact on creative performance from our choice to give participants a single iPad per group rather than one per participant. However, we saw no evidence of production blocking, where one participant may dominate group work; evaluation apprehension, where participants may be reluctant to share ideas; or free riding, where participants may take a back seat and not contribute. In this study, as Figure 5 indicates,

the single iPad appeared to successfully support collaborative creativity. In addition, sharing a single iPad helped facilitate our analysis of participants' conversation during Activity 2. However, because these factors have been noted in other studies, for examples see [43], they should remain an area for future investigation.

## FUTURE WORK

Our work understanding how to exploit the growing amounts of domain relevant data to stimulate creativity in user-centred design is in its early stages and there remain a large number of outstanding questions we could fruitfully explore. In particular we need to investigate the factors that will lead to ideas that are judged to be significantly more novel as well as significantly more appropriate. We will also continue to investigate the effects that manipulating different dimensions of information visualization design have on stimulating creative thinking. Areas to investigate here include varying the degree of interactivity in visualization design; comparing visualizations that employ narrative for guided storytelling with those that are more exploratory; and comparing individual data exploration with collaborative use of visualizations.

In order to investigate the effectiveness of the insights and ideas generated using information visualizations through the whole of a design project we should also undertake a more longitudinal case study. Here we will more effectively be able to separate preparation and idea generation stages of creativity and gain a better understanding of how the ideas and insights gained from data can develop with longer incubation periods. In this way we might demonstrate the relative depth of different insights gained. A longitudinal study would also give us the opportunity to study how we can use information visualization in the idea selection and evaluation or verification stages of creativity and design.

Finally, we believe there should be ways in which increased ambiguity in information visualization design could be exploited more effectively in the context of creative design activities. The space for multiple interpretations that ambiguity offers might require more effective facilitation and more structured workshop activities than we offered in this study. Perhaps, for instance, explicitly requiring participants to work with each of the possible interpretations they make with regards to the visualized data would be effective as part of an exercise in transformational creativity [2].

## ACKNOWLEDGEMENTS

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# Using Information Visualization to Support Creativity in Service Design Workshops

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## Abstract

In this paper we outline ongoing PhD research in which we are exploring how information visualization can be used to make quantitative data more accessible and engaging to key stakeholder representatives during service design workshops. We also outline how such visualizations could be used in conjunction with applied creativity techniques to identify ideas for design requirements that are both novel and appropriate, and therefore considered creative. We illustrate this research with details of a workshop held with customers and staff of E.ON Energy in which the objective was to design new services that utilise the data generated by smart energy meters.

KEYWORDS: information visualization, creativity, smart energy services

## Introduction

In this paper we describe research exploring how quantitative data can be used to support the creative ideation of participants in service design workshops. We discuss how information visualization can make data more accessible to a wide audience and how applied creative thinking techniques could stimulate ideas that are both novel and useful. To illustrate this we describe a case study in which customers and staff of E.ON Energy came together for a workshop in which the objective was to design new services made possible by the data generated from smart energy meters. This research is important because a better understanding of how to stimulate creativity in workshop participants can help us address Norman's criticism that user-centred design methods often fail to produce major enhancements (Norman 2005, 2010). In addition, our aim is to find ways of extracting value from data, which compliment more common algorithmic techniques by utilising human creativity.

# Background

Data play an increasingly prominent role in modern life. We nearly all carry smart phones that help us contribute to the large amounts of personal, social and location data being generated. In addition, devices such as smart energy meters that generate fine-grained consumption data or 'black box' vehicle monitors that record data about our driving are also becoming increasingly familiar. At the same time, data such as census and demographic information, government spending and service provision, housing market statistics and real-time transport information are readily accessible via websites such as data.gov.uk. These data are becoming key to the way major societal issues are approached. For example, one primary motivation behind the planned rollout of smart energy meters to upwards of twenty four million UK homes and businesses by 2020 is the expected impact the data they generate will have on consumption behaviour. It is hoped that these data will enable new services that encourage customers to shift energy consumption away from peak demand times, reduce the need for standby power stations and help the UK meet sustainability targets (DECC 2012).

Many current approaches to extracting knowledge and therefore value from these data are algorithmic and statistical, often making use of machine learning techniques (Witten 2005). However, there are a number of potential problems with such 'Big Data' methods. These may relate to data's context and meaning, to the ethics of using data, and to claims for data's objectivity and accuracy (Boyd & Crawford 2012). Our research takes a different approach, utilizing human creativity to place data in their wider context, to investigate the impact they might have on the lives of various stakeholders, and to suggest ideas for new products or services that respond appropriately. We believe that these data are an important resource that can be used to inspire creativity, particularly at the front end of design projects, where outcomes are not yet certain. To achieve this we employ information visualization tools to provide representations of quantitative data generated within the domain for which new products or services are to be designed, as part of workshop activities undertaken by representatives of key stakeholder groups.

Information visualization has classically been defined as "the use of computer-supported, interactive, visual representations of abstract data to amplify cognition", its purpose being "insight not pictures" (Card, Mackinlay & Shneiderman 1999:7). To achieve this, information visualization techniques make use of the human visual system's powers of pattern recognition and discrimination to explore large amounts of what may be complex data (for a detailed explanation, see Ware, 2012). Wattenberg and Kriss (2006) have demonstrated how information visualization is an effective method of making data more accessible and engaging to a public audience, encouraging people to undertake data analysis socially. Authors such as Tufte (1983) and Few (2009) have provided influential design guidelines. Information visualization has also been identified as a key tool to support creativity in the 21st century (Shneiderman 2001). In particular, the opportunities it provides for comparing alternatives thoroughly and rapidly by coding with visual variables such as colour and size; using computational power to filter or refine dynamically; and then utilising human perceptual skills to identify patterns trends or outliers and gain insight. Hans Rosling's Gapminder (www.gapminder.com) presentations of international development data, and Aaron Koblin's Flight Patterns (www.aaronkoblin.com) which displays the flight paths of US air traffic, are well known examples showing different styles of information visualization.

# A Case Study in Designing Smart Energy Services

This case study describes a workshop held in Milton Keynes, UK with customers and staff of E.ON Energy. The objective of the workshop was to generate ideas for new services that utilise data generated by smart energy meters. There were thirteen participants, ten male and three female. Eleven participants were E.ON customers recruited from households taking part in a long-term trial of smart energy technologies being run by E.ON in Milton Keynes. The remaining two participants were members of E.ON staff, employed on their smart meter programme. All participants were familiar with energy monitoring and the data that smart meters generate, they had prior experience with simple visualizations of energy data through the monitors used in the technology trial. The customers who took part in the workshop were already engaged in and informed about energy related issues. This is evidenced by their voluntary participation in E.ON's technology trial and the commitments required for this.


## Visualizing Energy Consumption Data

We designed a custom information visualization (Figure 1) to use in the workshop. This was based on simulated smart meter data generated from a model of typical energy consumption built for the wider project this case study was part of (Gruber & Prodanovic 2012). These data represent seven days' energy use for one household, based on a selection of possible consumption patterns rather than particular demographic factors. There is no single correct description of the people who might make up such a household. The design of this information visualization was informed by a pre-workshop study in which we found that increasing the ambiguity in the visual encoding of data elements resulted in ideas that were considered significantly less appropriate to the domain of domestic energy.

In the information visualization we show the energy consumption data for nine classes of appliance. Each class contains a number of specific instances of appliance. For example, the cooking class contains instances of cooker, hob, kettle, microwave, coffee machine and extractor hood. Consumption can be explored as kilowatt-hours or as a cost in pounds sterling. The appliance type and unit of measure currently selected are indicated with a red highlight. To introduce participants to the idea of tariffs in which the price of energy units vary at different times of day we created five simple price bands covering different periods. These are indicated through colours ranging from green to blue. Such variable price tariffs are one possible route towards shifting peak energy demand.

In designing the information visualization we used in this workshop we were informed and guided by our work with visualization experts at City University London's giCentre, who we were collaborating with to design new visualizations for E.ON energy analysts (Goodwin et al 2013). Further guidance came from considering Tufte's (1983) and Few's (2009) influential design guidelines; Moere and Purchase's (2011) discussion of the role design plays in information visualization; and Wattenberg and Kriss' (2006) description of designing for social data analysis through the use of expressive spectator interfaces. The visualization uses a linear timeline and bubble graph to show consumption over time, with a colour scheme derived from colorbrewer.org to represent the variable pricing scheme, and area chart to depict the percentage of energy used when different prices are in effect (Figure 1 left). Details for each hour's consumption are available by selecting the bubble representing that hour (Figure 1 centre), with further details available for each day's consumption (Figure 1 right).
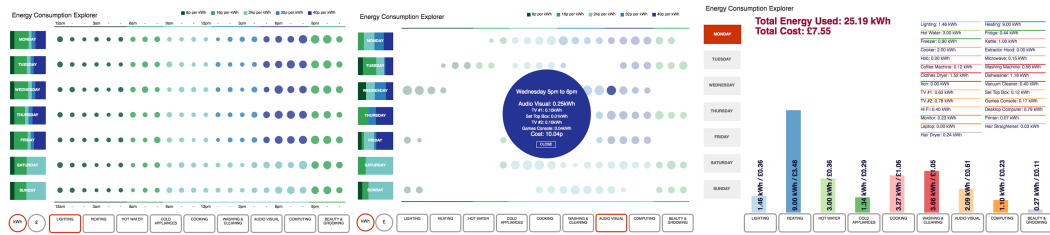
**Figure 1: Screenshots of the information visualization used during workshop activities**

This follows Shneiderman's mantra of "Overview first, zoom and filter, then details on demand" (Shneiderman 1996). The information visualization is available in its interactive form online at www.dadc.co.uk/eon . Workshop participants were given the information visualization on iPads. This was to support interactive exploration and because the form factor and portability of an iPad makes it particularly suitable for small group collaboration in a workshop setting.

## Workshop Activities

The workshop was made up of five main activities. The first two of these were information gathering, data exploration activities. These activities played the role of the preparation phase common in many models of creative processes such as Wallas' four-stage model, which includes *preparation incubation illumination* and *verification* stages (Wallas 1926). Treffinger (1995) characterises this preparation stage as including processes of mess finding, data finding (through information search), and problem finding. Here, the information visualization played a key role and it is these activities that will be discussed in greatest detail. The third activity was designed to gather evaluation data, this is discussed in the Evaluation section and the fourth was a group brainstorming activity, which is not discussed here. In the day's fifth and final activity, participants developed their favourite ideas and described them at three key stages. This activity will be outlined in more detail in the Activity 5: Generating Service Designs section of this paper. The activities described here were undertaken in small groups of three or four participants. Participants self-selected these groups, with the only criterion being that each group should have at least one member experienced and confident using an iPad, as this was how they would interact with the information visualization.

## Activity 1: Who Lives Here?

For this activity each of the small groups was given an iPad showing the information visualization app, an A1 sized worksheet and a creativity toolkit consisting of marker pens, post-it notes, coloured paper shapes, glue, tape, scissors and around three hundred photographs of people, buildings, transport, food and technology.

Participants were asked to explore the information visualization and imagine what type of household might be represented by the energy consumption data it is based on. They were asked to spot patterns of consumption indicating who the household were, what their lifestyle is like and what their attitudes to energy and technology could be. The purpose of this activity was to encourage participants to explore possible energy consumption behaviour and use the insights they found as the basis for discussions about the context in which that behaviour might take place. We wanted participants to share their knowledge, experience and concerns regarding energy related issues. The information visualization is based on simulated data, derived from models of typical consumption patterns rather than from demographics. We had no single correct answer in mind to the question 'Who lives here?'.
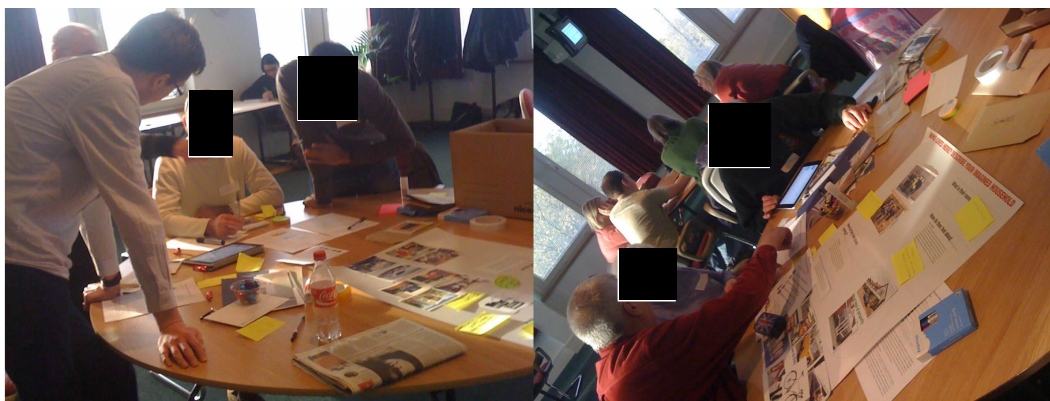
**Figure 2: Participants creating representative households in Activity 1**

Each group used the worksheet and creativity toolkit to create a collage that described the household they imagined best reflected the insights they found in the data (Figure 2). The importance of this type of generative activity has been demonstrated by Sanders (2005), who describes how understanding what participants make, as well as what they do or say, brings to light their experiences and highlights desires or requirements that might not otherwise be expressed. The worksheet contained areas to show the household's members, the type of property they live in, the type of energy consumer they are, how they might feel about technology, what their mealtimes might look like and the ways they travel. The activity ended with each group presenting their household to camera. These representative households were subsequently used as personas that the group would consider when assessing the appropriateness of their smart energy service ideas.

## Activity 2: Win a State of the Art Smart Home

In this activity, participants were again asked to explore the energy consumption data represented in the information visualization. This time their task was to suggest ways for their representative household to be smarter in their energy use. This could mean reducing the total amount of energy they consume or changing consumption behaviour to reduce their potential energy bill. Activity 2 took the form of a competition with each group completing an entry form on which they listed their top five ideas. The entry form also contained a tiebreaker question in which we asked each group to briefly describe a piece of smart home technology that would improve their representative household's lives and lead to smarter use of energy.

## Activity 5: Generating Service Designs

In the final activity, each group of participants selected one or more of the ideas generated during the day, which they then developed more fully into a new service. This service would utilise smart home energy data and reflect the needs of the representative household they had created in the first activity. Each group was given three more A1 worksheets to describe their service at three key stages. On the first worksheet they were asked to describe what it is like when the household sign up for the new service, addressing factors such as their household's motivations. On the second worksheet they described how it felt the first time that the service was used by their household. On the third worksheet they described what it was like once the service was an established part of their household's life. These worksheets were completed in a similar fashion to those in Activity 1, using the same toolkit. This activity ended with each group presenting their service idea to camera.

**Figure 3: Representative households created during Activity 1**

## Evaluation

We used two methods to evaluate the support the activities incorporating the information visualization provided for participants' creativity. In the first, we asked each participant to complete three postcards. This task was the third workshop activity. On each of these postcards we printed a prompt that addressed aspects of creativity or insight support identified from the literature. These prompts were derived from the Creativity Support Index questionnaire (Carroll et al 2009) that we have used previously and from an understanding of how users gain insight using information visualization derived from Yi et al (2008) and North (2006). Participants were asked to reflect on and respond to these prompts when they completed the postcard. This evaluation method is discussed in detail in (Dove & Jones 2013). Participants' responses were transcribed for analysis, which was undertaken in a manner similar to the analysis of open questions from a questionnaire.

We also assessed the creativity of the outputs produced in the workshop's activities. In the outputs from Activity 1 (Figure 3) and Activity 2 we were looking for evidence that participants had explored a number of possible alternatives and that they had used these to develop rich descriptions of their representative households. A rich description would show detail in their household's background and would consider the context around its energy use. We looked for evidence that insights gained exploring data were developed into rounded characteristics by the addition of aspects from the participants' own experience and knowledge. Here, the differences between each of the groups' representative households and the imaginative details in the stories behind these households would indicate that visualized data can provide effective stimulation for participants' creativity. In the service design outputs created during Activity 5 (Figure 4) we were looking for evidence that participants had developed ideas appropriate for their representative household and which reflected the insights into energy consumption they gained. We were also looking for evidence of novelty in the form of new services or new implementations of services.

## Results

Our analysis of the postcards completed by participants during Activity 3 indicates that using the information visualization during Activity 1 and Activity 2 was engaging and supported collaboration. This is demonstrated when we look at individual quotes from our participants: *"Our group was engaged and excited. We really used the tech to answer the Q's"*; *"I felt engaged and absorbed with the tasks…. The technology was very useful"*; *"I fully immersed myself in the activity…. The technology was extremely useful and very interactive"*.
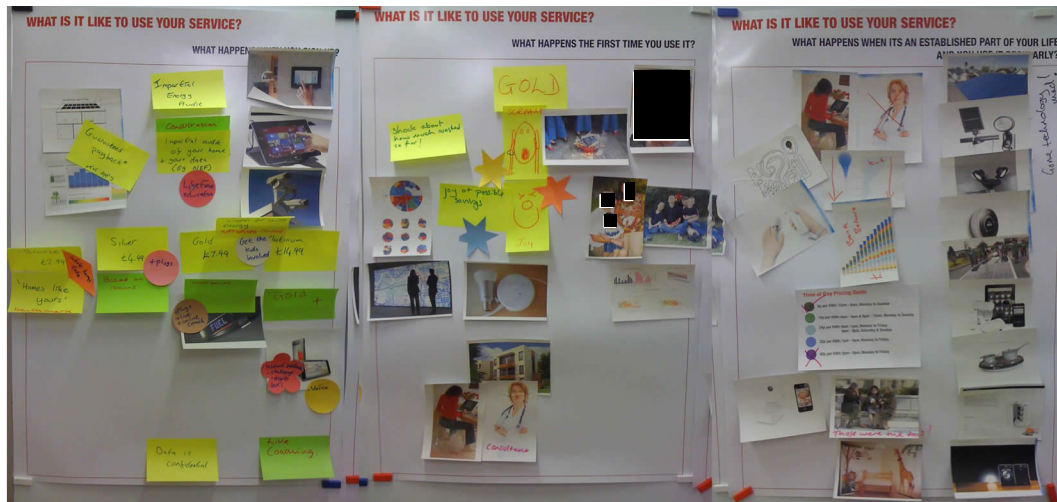
**Figure 4: Example service design output from Activity 5**

We also found that participants were able to build on their existing knowledge, with individual quotes again being informative. *"The iPad data visualisation was very useful as it made it surprisingly easy to look at each piece of data…. I could also use it with my own knowledge which I had to do for the first task."*; *"Easy to imagine the type of people in the house. My existing knowledge fitted well with the issues raised by the data"*; *"It was easy to incorporate this data with existing knowledge"*. Insight seeking was also supported, with both overview, and patterns and relationships being easy to discover. Once more this is well illustrated with individual participant's reflective comments. *"Yes it clearly helped you to understand patterns. Usage, timelines and others quickly"*; *"Definitely. You had a broad overview and you could drill down to get clearer answers"*; *"It was easy to get an overview about each group of data…. and that made it very easy to compare the data and come to assumptions about it"*.

The worksheets completed during Activity 1 (Figure 3) show how each group found insights they thought important in the data and then used their existing knowledge and experiences to develop these into rich descriptions of the kind of household they thought the data might represent. The following are a few brief examples. The first group saw a pattern in which the household used entertainment equipment late at night and another pattern showing relatively frequent washing machine use. They thought the data best represented a family with children. Our second group also saw these patterns but thought that additional patterns showing irregular cooking and repeated use of a hairdryer indicated that the household might be single, urban and female. Our third group also spotted the irregular cooking patterns but thought that this indicated an outdoor lifestyle, which suggested that the household were 'concerned greens'. Finally, the fourth group spotted that more cooking was being done on Monday and thought this meant the household might batch cook meals and reheat them later in the week. They also noted a pattern in the heating that suggested a household member worked from home or worked part-time.

In our assessment of the final service design outputs (Figure 4) we were looking for evidence of two key factors. First, that participants had developed ideas appropriate for their representative household and which reflected the energy consumption patterns they uncovered. Here there was evidence of success as each group's service was a development of the insights and ideas gained exploring the information visualization in the first two activities. In each case we can tell a coherent story of how the service ideas respond to the needs of the representative household users. The second factor we were looking for was novelty in the form of new services or new implementations of services, different from those already familiar to participants. Here the evidence is less strong. Two groups developed ideas for detailed energy audits. This takes the desire for more granular information and for

historic reports, both of which had been expressed elsewhere during E.ON's longer-term technology trial, and extends them into a complete service. A third group developed an automated shopping service based on a smart fridge. This is similar to ideas that have been around for the last decade, occasionally gaining a high public profile (Kuniavsky 2008). The final group developed a service to automatically manage heating and lighting based on what it has learnt about the household's behaviour. This is similar in many ways to the Nest thermostat (www.nest.com), a product the group were aware of. All of these ideas were expressed creatively, with elements of novelty and in a format appropriate to the needs of their users. However, they can be considered to show what one might term incremental creativity as they build on the already familiar and are not suggestions that would necessarily lead to radical new solutions.

## Discussion

The type of workshop we describe in the case study requires significant commitment from participants, takes a large amount of planning and can be expensive. Whilst it is important to develop techniques that engage participants and which help them express their existing ideas creatively, our objectives go some way beyond this as we aim to use data to help participants develop ideas they would not otherwise have. Norman and Verganti (2014) discuss the difference between incremental innovation, which leads to doing something better, and the more rare radical innovation, which leads to doing something different. They argue that it is changes in the meaning ascribed to a product or service, perhaps following or alongside the introduction of new technology, which leads to these radical innovations. Such a change in meaning, they say, may be arrived at by exploring wider social and cultural changes that lead to a reframing of current solutions. Such a distinction between incremental and radical innovation echoes our desire to encourage a more radical creativity in the ideas for design requirements expressed by our workshop participants, and perhaps offers a framework that we can borrow to inform the design of future workshop activities. It is not uncommon in co-creation workshops for designers to work with participants, helping to facilitate and hone or develop ideas. In future workshops it may be useful for designers to help identify and explore social changes and future technologies and use these to direct participants' ideas towards areas of greater novelty.

Another approach that may prove instructive can be found in applied creative thinking techniques. Prominent examples of which include Osborn and Parnes' Creative Problem Solving (Parnes 1992), Gordon and Prince's Synectics (Gordon 1961), and De Bono's Lateral Thinking (De Bono 1970) and Six Thinking Hats (De Bono 2000). These techniques all start from the common premise that everyone has the capacity to think creatively and that the skills needed to do so can be systematised. Such applied creativity techniques have been effectively incorporated into the process of gathering requirements for large-scale socio-technical systems (Maiden Gazikis & Robertson 2004). Here, workshops using techniques such as constraint removal, brainstorming with creativity triggers and analogical reasoning, have helped stakeholder representatives generate important ideas for requirements that were considered both novel and appropriate and that may otherwise have remained unexpressed. These techniques again suggest a framework through which we could deliberately provoke participants to explore ideas that are outside their normal frame of reference, leading them to generate novel ideas for design requirements. In particular, the techniques characterised by McFadzean (1998) as being "paradigm breaking" offer a way to view a given problem or opportunity from different perspectives. Such a deliberate reframing of the problem at hand

has been shown to promote creativity and innovation (Seelig 2012), and offers a possible way to explore new meanings.

## Future Work

One of our key challenges is to develop workshop activities that enable participants to critically explore data in the context of wider trends. Another is to use the insights found through data exploration as inputs to applied creative thinking activities. Through this we aim to prompt participants towards greater novelty and increased creativity in their idea generation. Additionally we should seek to use information visualization to identify domain constraints. Onarheim (2012) has discussed how manipulating constraints can enhance design creativity.

## Conclusion

Data are likely to play an increasingly prominent role in the design of new services. In this paper we have discussed how information visualization can make these data more accessible and engaging to key stakeholder representatives during design workshops. We illustrated this with examples from our case study in the energy domain. We also outlined how applied creative thinking techniques could be used to extend these methods; stimulating creative, novel and appropriate ideas for design requirements that may not otherwise be expressed.

## Acknowledgement

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# Creative User-Centered Visualization Design for Energy Analysts and Modelers

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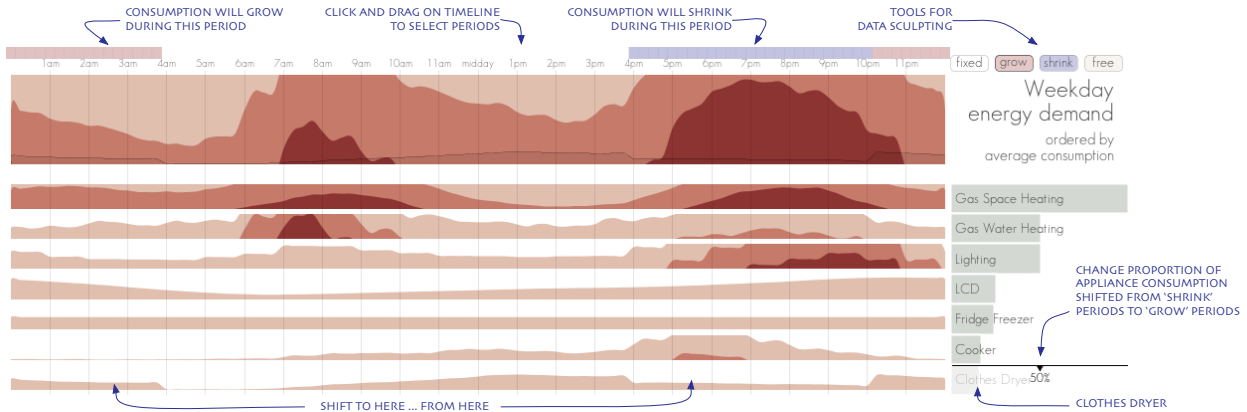
Fig. 1. *Demand Horizons* show modeled weekday energy demand over 24 hours amongst high consumption domestic appliances. *Data Sculpting* allows us to shift consumption interactively by 'moulding' the horizons to explore '*what if?*' scenarios. For example, here fifty percent of 'Clothes Dryer' consumption is shifted from the evening peak to a period when overall demand is lower.

**Abstract**—We enhance a user-centered design process with techniques that deliberately promote creativity to identify opportunities for the visualization of data generated by a major energy supplier. Visualization prototypes developed in this way prove effective in a situation whereby data sets are largely unknown and requirements open – enabling successful exploration of possibilities for visualization in Smart Home data analysis. The process gives rise to novel designs and design metaphors including *data sculpting*. It suggests: that the deliberate use of creativity techniques with data stakeholders is likely to contribute to successful, novel and effective solutions; that being explicit about creativity may contribute to designers developing creative solutions; that using creativity techniques early in the design process may result in a creative approach persisting throughout the process. The work constitutes the first systematic visualization design for a data rich source that will be increasingly important to energy suppliers and consumers as Smart Meter technology is widely deployed. It is novel in explicitly employing creativity techniques at the requirements stage of visualization design and development, paving the way for further use and study of creativity methods in visualization design.

**Index Terms**—Creativity techniques, user-centered design, data visualization, smart home, energy consumption

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## 1 INTRODUCTION

These are exciting times for utility companies and their energy analysts – the energy domain is data rich and globally significant. Energy analysts and modelers are now striving to effectively use the volumes of data from emerging Smart Home technologies to understand consumer behavior, conserve energy and manage supply and demand. Data visualization can offer great potential in this domain, but developing appropriate solutions presents considerable challenges, since the nature of the data are relatively unknown and the needs of energy data analysts and modelers are not yet well understood. The design brief is therefore essentially open-ended.

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Participatory approaches to user-centered design, in which users and other stakeholders are involved in co-creating requirements and designs for interactive systems can lead to solutions that are more useful and usable [35]. We have successfully used human-centered approaches in the design of visualization solutions before and have documented these in detail [27]. However, the role of *creativity* in these approaches has as yet been only implicit. Over the last decade some fields of interactive systems development have increasingly focussed on introducing elements of deliberate creativity into participatory user-centered design processes. The aim here is to enable all participants (users, designers and other stakeholders) to contribute to the exploration of new fields and the generation of requirements and design ideas for novel and useful systems [1, 6, 53]. Establishing requirements can be considered a fundamentally creative process whereby requirements analysts and stakeholders work collaboratively to generate ideas for software systems [29, 30, 32]. Indeed, Robertson [42] regards requirements analysts as inventors who bring about innovative change in designs to establish advantage. Techniques for deliberately introducing creativity into the process of user-centered design can be used effectively in this context. For example, Schmid [46] used creativity triggers [42] to help workshop participants invent requirements, whilst co-creation [45] and creativity workshops [24, 31] have been shown to be effective in generating novel requirements.

Here, we report on work in which we augment a user-centered approach to design with techniques for deliberately stimulating creative thinking when establishing context of use and developing requirements. We do so in the context of an investigation into ways in which a major energy supplier could use visualization to derive value from data that will become available following the wider adoption of Smart Home technology, by producing a series of prototypes to establish visualization possibilities. We evaluate the prototypes in terms of appropriateness, novelty and surprise and conclude that the creative impetus to our design activity had a long-term effect, contributing to designs that were found to be effective, informative and novel and a process in which creativity flourished. We offer a series of contributions that may be useful in energy visualization and beyond, namely:

i. a *creative design case study* where a user-centered process is augmented with means of deliberately stimulating creative thinking;

ii. *techniques* for the visualization of a new data source, including methods that contain some novelty, that may be transferable as data of this type becomes more common and voluminous;

iii. evaluation of *creativity methods* in an applied context to support the contention that deliberately stimulating creative thinking can result in designs that are novel and useful – especially in the context of open requirements in problem-driven visualization.

## 2 APPLIED CONTEXT

Smart Meter technology enables energy consumption to be recorded for multiple appliances within the home at frequent intervals. Data are reported back to both energy supplier and consumer enabling near real-time feedback on energy use. The European Commission recommends all member states adopt intelligent meter technology with the majority to be fully equipped by 2020 [13]. The installation of Smart Meters forms a major component of the shift from passive electricity supply to 'Smart Grids', which use digital technologies to manage the regulation of energy demand and production, allow for flexible tariffs and provide the potential to communicate directly with Smart Homes or appliances [13]. Advances in Smart Meter technologies are consequently becoming increasingly important to both energy suppliers and consumers, whilst data yielded from these new technologies is increasing the volume and value of data available to the industry exponentially [44]. Energy data analysts and modelers are beginning to investigate opportunities to utilize the emerging data to understand consumption trends and consumer behavior [14] and to manage supply and demand effectively through optimization and flexible tariffs [4].

Data visualization and visual analytics offer real opportunities for the analysis of Smart Home data both for the energy supplier and the consumer. On the consumer side, energy use information is reported through a Smart Energy monitor. While this is seen as beneficial in comparison to the traditional energy bill [18] less intrusive forms of consumption awareness are now being investigated [43]. Visualization solutions to enable the energy industry to gain valuable insight into customer habits, identify areas where consumption can be reduced and effectively manage supply and demand levels are, however, scarcely investigated in the literature. The benefits of using visualization to study aggregated household energy use to discover patterns and trends have been highlighted [12], however the data are based on diary entries rather than volumes of frequent automated recordings.

Our research with data analysts from a major UK energy supplier begins to investigate the benefits that data visualization can bring to derive value from the data emerging from Smart Home technologies and opens up opportunities for further research. It uses the two sources of Smart Home data currently available: *live data* from a Smart Home trial and *modeled data* simulating future scenarios. The live data contains electricity and gas consumption for all appliances (e.g. refrigeration unit or television set) as named by owners of a test-bed of 130 properties participating in a Smart Home trial. The data set consists of more than 18 million recordings taken over a 14 month period. It has challenging characteristics: timings are irregular; frequency of recordings varies significantly – from minutes to days; the sample of households is small (the UK contained 24.6 million households in 2012),

self-selecting and biased in terms of geography and demographics. Householders are also inconsistent in the appliances they monitor. The model [17] uses a separate source of detailed consumption data [56] to generate appliance-based energy usage scenarios for any number of households at 15-minute intervals over a given period of time.

Both sources contain numeric information for individual households (modeled or trial participant), such as total electricity consumption, consumption by individual appliance or outside temperature, along with the time of the recording. Derived values (average, max, min, count, standard deviation) are calculated in both cases by period of time (hour, day, week etc.) and by grouping categories (such as appliance type). The model can generate large volumes of data in this form with optimized outputs simulating the shifting and reduction of demand over time. Different outputs reflecting weekday and weekend activity are also available. Daily and seasonal variations in consumption and standby options are modeled with some sophistication for certain appliances. Outputs are somewhat limited however, in that appliance use and distribution of appliances to households are determined probabilistically [17] and so may not reflect real ownership or typical household usage patterns. Appliance co-ownership relationships are therefore not realistic and neither household demographics nor geographical location are accounted for in the simulation.

## 3 CREATIVE DESIGN PROCESS

Our design process for exploring the possibilities for data visualization within Smart Home data analysis followed an established user-centered approach [25, 27]. However, we augmented this by applying a number of creativity techniques [24, 29, 31, 37] early on in the process. Our aim here was to see whether we could tap into the latent creativity of our target users – the energy analysts – as well as that of the design team. While designers, of visualizations and other artefacts, may be used to developing creative responses to problems or design briefs, their customers, users, and other stakeholders may not be. We have previously employed such deliberate creativity techniques with air traffic controllers [31] and the police [38], who have not been accustomed to making creative contributions to design. Through the use of techniques such as those described below, they have, in each case, been able to generate requirements and design ideas for new interactive systems that were considered both novel and useful. Here we apply these methods alongside our established means of encouraging data owners to engage actively in visualization design and development [25, 26, 27, 41, 49]. The process is summarized in Fig. 2 with the creativity techniques being inserted in the early stages with the intention of introducing a creative climate that we hoped would persist.

### 3.1 Creative Requirements Workshop

Creativity techniques for use in our *Requirements Workshop* were developed through two internal pilot sessions. Techniques from methodologies such as creative problem solving (CPS) [37] and Synectics [16] were considered and additional literature reporting similar techniques was consulted [22, 34]. These included: aspirational thinking, analogical reasoning, metaphor, constraint removal, storyboarding and random combination. We tried methods out internally and adopted the techniques that were thought to be most practicable and potentially useful whilst rejecting some that might constrain – such as building a priority list or listing ideas based on their complexity. We augmented others, such as an established "*I wish*" exercise for wishful thinking [33] with prompts specific to the visualization context – "*I would like to see*". The methods were refined in collaboration with a professional creative facilitator, who coordinated the *Requirements Workshop*.

As well as tailoring the creativity techniques, we also paid careful attention to our choice of venue, as the physical environment in which activities are carried out can have a significant impact on the creative climate [11, 23]. We therefore chose to carry out the workshop in a quiet, light, neutral venue, away from the participants' normal places of work, with plenty of space and ample refreshment. The day long event was attended by five Smart Home energy analysts, who work together on a regular basis. They are often involved in thinking of new ideas and possibilities for Smart Home technologies, however, their
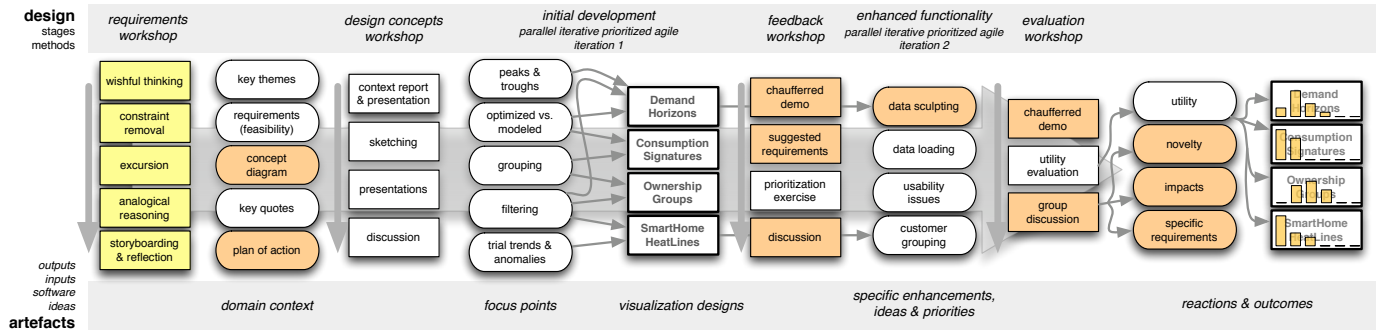
Fig. 2. The design process. Rectangles are techniques, those with thick edges represent software prototypes. Concepts are round edged. Arrows show direct links between concepts and prototypes. Other links are implicit and less direct. Yellow indicates deliberate creativity mechanisms. Orange highlights processes and concepts in which creativity amongst analysts was strong. Prototype utility is reported in detail in section 5.

knowledge of the new data sets available to them and the opportunities offered by data visualization were limited.

We began with some warm up activities. These included a playful introduction that encouraged participation and trust-building and introduced some analogical thinking by asking all participants "*if you were to describe yourself as an animal, what would you be?*" Some statements and quotations that emphasized creativity and exploration were also shared – for example, Albert Einstein's widely reported view that: "*if at first, the idea is not absurd, then there is no hope for it.*"

### 3.1.1 Wishful Thinking

The first creativity technique employed in the main part of the workshop was wishful thinking, in which the energy analysts were asked to think about aspirations for the Smart Home programme. We captured visualization specific '*opportunity statements*' [23] by asking: '*What would you like to know?*', '*What would you like to be able to do?*' and '*What would you like to see?*' Participants worked individually on Post-it notes in a brainstorming [36] exercise, then read their answers out to the group and placed them on flip-charts. We then asked the participants to form small groups and each was tasked with selecting the Post-it in which they were most interested. To push them further in their thinking, the analysts were asked to consider '*What next?*' and further aspirations were recorded (again on Post-its) assuming the chosen aspiration(s) had been achieved. The process continued until ideas were exhausted and some initial requirements had been teased out, revealing some of the types of innovation in which participants were interested.

### 3.1.2 Constraint Removal

After coffee, participants built upon this forward thinking with a constraint removal activity [24] in which barriers were transformed into a positive resource through which to create new ideas. Our energy analysts were first asked why the aspirations captured on Post-its had not yet been achieved. Once constraints were identified analysts were then asked for creative ideas about what would be possible if the barriers were removed to see whether ideas would develop further. A rapid flow of constraints resulted – from hardware technical issues, to people leading complicated lives and being difficult to understand, limited knowledge about Smart Homes, a lack of customer trust, limited time, resources and expertise as well as conflicting business priorities. 'Removing' some of these constraints unlocked a number of ideas about moving forward: in particular about improving and expanding the product, gaining the trust of customers and the energy industry and deriving value and knowledge from the live Smart Home data source.

### 3.1.3 Lunchtime Excursion

Lunch was held in an adjoining building during a lengthy break. Participants were asked to use this time to find something that had a connection (however abstract) with the Smart Home programme. This was based on the idea of an 'Imagery Trek' in CPS [36] or 'Excursion' in Synectics [16]. Both are techniques that can help develop highly novel

or unexpected ideas and assist participants in refining or elaborating their ideas through 'mental stretching' [23]. The idea is that participants remove themselves from a task, take a mental or physical journey to seek images or stimuli and then bring these back to make connections with the task. Participants returned from their excursion with all sorts of artefacts including photos of a painting and the view from the lunch room and a copy of Dickens' 'Great Expectations'. This activity set the scene for the subsequent analogical reasoning task.

### 3.1.4 Visualization Awareness using Analogical Reasoning

The analogical reasoning task was an extension of the '*Visualization Awareness*' activity that is central to our existing human-centered visualization design process [10, 25]. Here, however, we began by specifically explaining analogical reasoning and giving examples. We then asked the analysts to find analogies applicable to Smart Home visualization as they engaged in an otherwise relatively passive visual experience that introduced visualization examples by theme. Participants were given time to consider any aspects of the examples (data, layout, interactions, colors, aesthetic) that sparked a connection with the thinking that had occurred during the morning sessions. Reactions were again written on Post-its, and some of the participants created mind-maps to link the different visualizations to their ideas. In total ten analogical ideas arose while watching the visualization demos, including an idea to show wasted energy flows that was sparked by an animated visualization of millions of bike journeys [55] and an idea for using bubbles of energy consumption increasing and decreasing as used in the home, inspired by *Empires Decline – Revisited* [7]. Design requirements identified during the exercise included the need to filter, group and compare data such as by appliance type, temperature, user demographics, time and geography to understand consumption variability. Design elements identified as important included: '*everything in 3 clicks*', '*beautiful*', '*engaging*' and '*simplicity*'.

This activity took longer than planned, largely due to the large number of wide-ranging and increasingly ambitious ideas that surfaced. The session ended with a highly creative *Plan of Action* envisaged for the focus of Smart Home data analysis involving a three stage process to which we could make an important contribution, namely:

1. discover – find out where energy is used;
2. displace consumption – change behavior and control devices;
3. reduce energy production – specifically by the amount needed to close a power station (power plant).

### 3.1.5 Storyboarding

We have used storyboarding [3] previously in creative requirements workshops in other domains [29, 30, 31, 32] to draw together and prioritize the ideas generated. Here, pairs of participants used a comic strip template, writing materials and hard copies of the various visualization awareness examples to generate artefacts (sketches and collages) showing how the ideas generated during the day might be used in practice by imagining '*a day in the life of an energy analyst*'.

Table 1. *Wishful Thinking* revealed in '*Know/Do/See*' and '*What next?*' Numbers show total aspirations established at the *Requirements Workshop* (*Est.*) and those deemed feasible by the design team (*Feasible*).

| Activity | Aspiration Topic | Est. | Feasible |
|---|---|---|---|
| Know | Customers Habits | 10 | 5 |
| Know | Appliance Consumption | 6 | 6 |
| Know | The Value of the Data | 2 | 2 |
| Know | Visualization Design | 2 | 2 |
| Do | Improve Customer Experience | 5 | 2 |
| Do | Manage Energy Demand | 3 | 3 |
| Do | Advance the Technology | 3 | 0 |
| See | Data Analysis & Visualization | 8 | 6 |
| See | New Products and Services | 1 | 1 |
| — | ———— | - | - |
| Next? | Change Customer Behavior & Improve Life | 5 | 0 |
| Next? | Improve & Expand the Product | 6 | 0 |
| Next? | Understand Customer Habits | 3 | 2 |
| Next? | Gain Trust & Increase Customers | 5 | 0 |
| Next? | Educate Energy Industry & Manage Demand | 5 | 1 |

Key themes that emerged from the storyboards included the need for greater understanding of consumers' habits and the desire to understand customer behavior by grouping and comparing relevant data.

### 3.1.6 Reflection

To round off the workshop, participants were asked what they knew at the end of the workshop that they hadn't known at the outset. Their responses at this point were very positive, both in regard to the possibility of developing appropriate visualizations "*It's amazing how many techniques are applicable to energy*" and in regard to the workshop itself "*I understand more about the large scope of possibilities.*"

Overall the outcomes from the day's activities allowed us to identify five key themes that can be seen as important to the continuation of the Smart Home programme: *Analyze the Data*: to understand more about customers' energy habits and appliance consumption; *Develop Knowledge*: to start to prove / disprove myths and theories of energy saving and behaviors; *Communicate and Engage*: within the business, and with industry and the general public to manage demand and change behaviors; *Build Trust*: in the company and the products; *Improve and Expand Smart Products*: beyond energy to improving comfort and security. The first of these themes links directly with the first stage of the *Plan of Action*: *discover – find out where energy is used* (see end of 3.1.4), a key objective in which visualization can play an important role. Improving the understanding of customer and appliance consumption will also help pave the way to targeting some of these other themes and reaching the second and third stages in the *Plan of Action*.

The wishful thinking exercise generated 64 aspirations and opportunities of broad scope as shown through their grouping into topics (Table 1). We identified 30 of these as feasible for data visualization solutions in terms of the expertise, data and other resources available.

These key themes and feasible aspirations were reported to designers and developers in the team at a *Design Concepts Workshop*. We also presented other artefacts from the *Requirements Workshop* to establish the problem domain, describe the analysts' needs and identify where and how effective data visualization design might be beneficial.

### 3.2 Design Concepts Workshop: Development Iteration 1

Development took place over a one month period with two iterations using a rapid agile approach. Within each iteration features were prioritized using the MoSCoW technique [2] with frequent meetings between designers and developers in the team to re-prioritize and discuss design decisions in light of requirements.

The first iteration began at a half-day *Design Concepts Workshop* that brought together seven visualization designers and developers (all are co-authors) many of whom had limited background knowledge of the energy industry. We began the session by presenting and sharing the domain knowledge as well as the key themes and ideas from the *Requirements Workshop*. Contextual information including the 3 stage

*Plan of Action*, key themes, feasible aspirations, design requirements, mind-maps and a concept diagram generated in part from these, storyboards and some direct quotes were introduced and then pinned to the walls of the room in order to prompt movement, discussion and idea generation amongst designers. The two energy data sets were also introduced and their structure, provenance and limitations discussed.

Working in pairs we generated ideas, developed sketches and reported back to the group with reference to the requirements that the idea was targeting. This enabled us to derive visualization focus points – abstract combinations of task, data and design that form a basis for ongoing development: show *peaks and troughs* in daily demand to understand when different appliances are used; *compare modeled to optimized solutions* to see whether shifting consumption could help demand management; *group and filter* consumption by appliance and types of appliance across time to identify patterns in user behavior; and, identify *trends and anomalies* in the Smart Home trial data.

These focus points were further developed during the workshop and through subsequent activity into four prototype visualization designs. These addressed generic aspirations from the wishful thinking exercise, such as: "*to know how to show the business stakeholders the data in an engaging way,*" "*to find typical patterns and make predictions,*" "*to know where energy is going*" and "*to 'slice and dice' the data,*" as well as specific aspirations and questions as follows:

*Demand Horizons*: highlight peaks and troughs in the modeled hourly energy demand during typical weekend and week days to show how each appliance contributes – "*to know what an 'average home' does with their energy*" and "*to better understand how different appliances contribute to the peaks in energy demand throughout the day.*"

*Consumption Signatures*: show how each appliance has a different signature over time-of-day and day-of-week in the modeled data by visualizing large amounts of energy consumption data in comparable form on one screen – "*how can we visualize large amounts of energy consumption data on one screen?*" and "*can we compare the energy consumption signature of appliances or groups of appliances?*"

*Ownership Groups*: group appliances in the modeled data by ownership, time of use and average consumption – "*to know how lifestyle links to energy demand*" and "*to better understand how the data relates to the users.*"

*Smart Home HeatLines*: use a per-household representation of the live Smart Home trial data to identify patterns and anomalies – "*how to visualize all the data from the Smart Home trial to understand the usefulness of the data?*"

Developing designs in parallel enabled us to address multiple focus points concurrently, present alternative techniques of potential value to the domain experts and use an established means of generating high quality and diverse outputs [9]. It also offered plenty of 'breadth' in terms of enabling us to explore opportunities for ongoing creativity.

### 3.3 Feedback Workshop: Development Iteration 2

Following the first development iteration a number of enhancement possibilities were suggested by the design team and associated effort estimated for each. These suggested enhancements were the focus of a *Feedback Workshop*, involving the four analysts who had taken part in the *Requirements Workshop*, and four others from related departments in the same organization. We presented the aspirations gathered from the *Requirements Workshop*, reflected on how we had formulated these into focus points and demonstrated our initial designs by chauffeuring the visualization prototypes in an engaging and increasingly interactive visualization session held at the company's Smart Home test house. We then suggested enhancements (Table 2, 'Design Team').

Initial reactions, new ideas and other feedback were recorded for each design prototype. Our proposed enhancements and any suggestions identified by our users during the session (Table 2, 'Analysts') were then prioritized by the group. After the session, enhancements for each prototype were considered through a systematic re-prioritization process in terms of development complexity, time available, novelty of idea and priority through an agile procedure for planning estimation [5]. A number of key new features for each prototype were implemented (Table 2, 'Implemented') as described below.
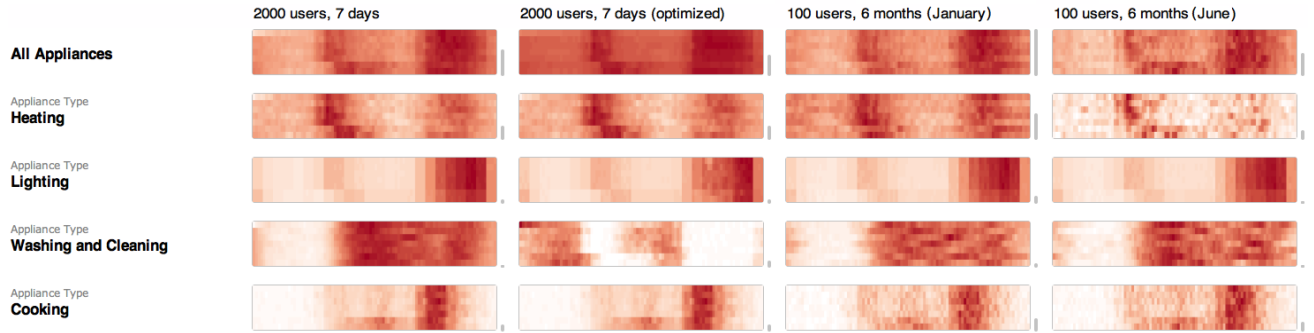
Fig. 3. *Consumption Signatures* allows modeled data to be loaded (columns) and reordered so that the weekly consumption patterns of appliances can be compared. Various coloring options scale sequential schemes by selected row, column or cell and allow diverging schemes to emphasize difference from selected items. Patterns in daily (*Lighting*), seasonal (*Heating*) and modeled (*Washing and Cleaning*) data are clear as are weekend differences (bottom two rows of each cell) such as the delay in the morning heating peak and more cooking during daytime at weekends.

Table 2. Prototype Enhancements – suggested by the design team and by analysts in the *Feedback Workshop*, and implemented in iteration 2.

| Prototype Name | Design Team | Analysts | Implemented |
|---|---|---|---|
| *Demand Horizons* | 11 | 7 | 6 |
| *Consumption Signatures* | 7 | 5 | 10 |
| *Ownership Groups* | 10 | 3 | 8 |
| *Smart Home HeatLines* | 10 | 3 | 6 |

## 4 RESULTS: VISUALIZATION PROTOTYPES

The four prototypes were developed with complimentary characteristics to explore different tasks, data and designs – as characterized by the focus points (section 3.2). The features are described below with detail of specific interactions explained in the supplementary video.

### 4.1 Modeled Data

Two of the prototypes used hourly consumption data modeled for 2000 households over a period of 30 days, with different average hourly rates calculated for households at weekdays and weekends

*Demand Horizons*: (Fig. 1) uses horizon charts [20] to show aggregated and appliance-based energy demand during a typical 24 hour period. Horizon charts can be switched to area graphs to aid understanding. Animated transitions [21] highlight the differences in consumption between typical days during the week and weekend. Appliances can be re-ordered by contribution to the total, morning or evening peaks and individual appliance charts can be added or removed for detailed investigation of the differences in demand between appliances and their effect on overall consumption. Several amendments were implemented in the second development iteration, including quick switching between gas and electricity appliances. In particular, a new feature was created in order to allow demand to be modified directly through the metaphor of *data sculpting*. This allows peaks to be flattened through the interface in two ways: the overall consumption of any appliance can be interactively varied to simulate improved efficiency; consumption can be time-shifted, using the *grow*, *shrink*, *fix* or *free* buttons, to simulate change in behavior (see Fig. 1 and video).

*Ownership Groups*: (as shown in the supplementary video) consists of a bar chart linked to a set of Tufte's [50] redesigned Tukey box plots [51]. Bars representing each appliance are sized by the number of households that own at least one of each. Bars can be re-ordered to show the appliances by proportion or alphabetically. The box plots show average hourly consumption of households. Upon selection of a particular appliance these are updated to show the average consumption of the households owning this appliance. Design enhancements implemented after the *Feedback Workshop* included new selection mechanisms and three additional means of ordering – by appliance type, subtype and total power/load on the grid. Alternative views related to co-ownership of appliances were also investigated.

*Consumption Signatures*: (Fig. 3) visualizes the model's highest resolution data, with records at 15 minute intervals aggregated according to time of day and day of week. Multiple outputs can be structured in to this weekly *signature* for comparison, including a six month simulation to show seasonal variation and a one week simulation with two algorithmically optimized alternatives. Multiple derived values (such as minimum, maximum and average consumption) were abstracted from the model outputs and households were sampled in the case of large data sets to ensure rapid responses. Calendar views [52, 54] visualize weekly consumption: seven rows relate to days of the week, with 96 columns – one for each 15 minute period of the day. These signatures are positioned in a matrix of small multiples in which data sets (columns) and appliances or groups of appliances (rows) are juxtaposed for comparison [15]. They are colored according to their values with two alternative schemes: a sequential scheme represents absolute values and a diverging scheme [19] shows the numerical difference between each signature and a selected item: a column (data set); row (appliance); cell (particular signature) or pixel (individual value). During the second development iteration the need to rescale the legend to the 'best fit' for each signature was identified and implemented.

### 4.2 Smart Home Trial Data

*Smart Home HeatLines*: (Fig. 4) represents the raw live data from the Smart Home trial. Individual households are represented as rows of values varying over time. Summaries (count, average, maximum and minimum) are calculated by household for each variable for particular time periods. Further data abstraction is available in real time as the temporal kernel can be interactively re-sized to aid pattern identification and avoid distortion due to inconsistencies in collection times. Sequential color schemes [19] are used to represent values, with a line graph to aid in the identification and interpretation of patterns and trends for any selected household. The summary statistic, source (electricity, gas or appliance) and time period (total and weekly or daily averages) can be varied interactively. Households (rows) can be re-ordered by value at a particular time period. Grouping by demographic type, sorting by similarity of profile and a map to show animated geographical variations over time were added during the second development iteration – as shown in the supplementary video.

## 5 RESULTS: VALIDITY AND CREATIVITY

Reflecting on both the visualization design evaluation literature [47] and methods for evaluating creativity [8, 28] we constructed a structured process to determine the extent to which both the visualization prototypes themselves and the design process through which they were generated were seen as both valid and creative (Table 3).

The extent to which the outputs of our process were themselves viewed as creative was a particularly important indicator of how successful we had been in our introduction of techniques for deliberately
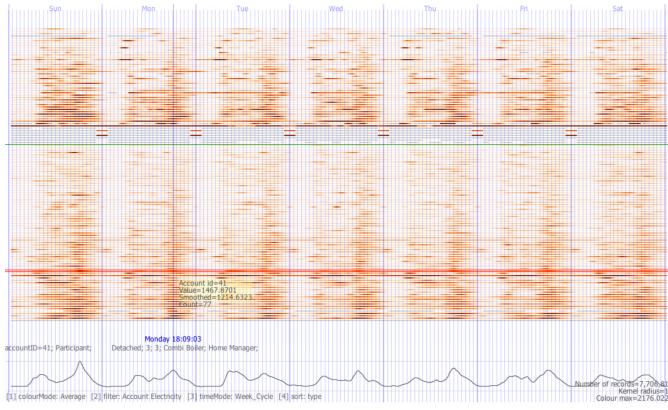
Fig. 4. *SmartHome HeatLines*: visualizes Smart Home trial data per household by time. Here, data are aggregated to show average weekly electricity consumption, with households ordered (top to bottom) by type of participant and consumption on Monday at 6pm.



Fig. 5. Responses to the Prototype *Appropriateness* Questionnaire. Strong agreement (1) with positive statements about utility in light of requirements to the left, strong disagreement (6) to the right.

stimulating creative thinking into the design process. A review by Dean *et al.* [8] reveals that most authors evaluate creative outputs through some combination of the dimensions of appropriateness, novelty and surprise. Our evaluation was therefore structured in this way, with questionnaires, a structured group discussion, and subsequent analysis of responses. The objective was to gather analysts' views of the *appropriateness* of the designs, in terms of whether or not they satisfied relevant requirements, their *novelty*, in relation to the analysts' previous experience, and the *surprise* that they engendered.

We conducted an *Evaluation Workshop* with four of the five energy analysts who participated in the *Requirements Workshop* at the Smart Home test house. We began by presenting the four prototypes and demonstrating the enhanced functionality that had been added during the second development iteration through (increasingly analyst directed) chauffeuring, linking this to specific requirements and feedback. Chauffeuring was deemed appropriate as a rapid means of getting analysts to use the software to access the data and as we were not evaluating the usability of the prototypes but rather the value of the approaches developed in regards to established opportunities.

After each demonstration analysts evaluated the appropriateness, or utility, of each prototype by completing a questionnaire that asked them to assess the extent to which various relevant requirements were satisfied by the prototype by rating strength of agreement on a six point scale ranging from strongly agree (1) to strongly disagree (6). Due to the small numbers of prototypes and participants involved in the study, it was not appropriate to attempt any quantitative evaluation of the novelty or surprise factors of the prototypes, and we therefore adopted a qualitative approach to evaluating these aspects. Thus the *Evaluation Workshop* ended with a structured group discussion where the prototypes were again used through directed chauffeuring on a shared screen to prompt discussion relating to the novelty of each design, and the surprise they engendered.

Our aim in evaluating the creative user-centered process through which the designs were developed was to gain some initial insights into the extent to which it could be seen as being effective and creative, and the impacts this may have had on designers and other stakeholders, as well as on the prototypes that were developed. We relied predominantly on the reflections of our experienced design team, informed by inputs from other stakeholders during the structured group discussions (see section 5.3), as documented in section 7.

## 5.1 Appropriateness of The Prototypes

Responses to the questionnaires reveal that 3 of the 4 prototypes score highly for meeting the needs of the energy analysts as expressed during the *Requirements Workshop* – responses tending to the left in Fig. 5.

*Demand Horizons* returned a modal score of 2 for the questionnaire responses, and the energy analysts thought of many uses for the tech-
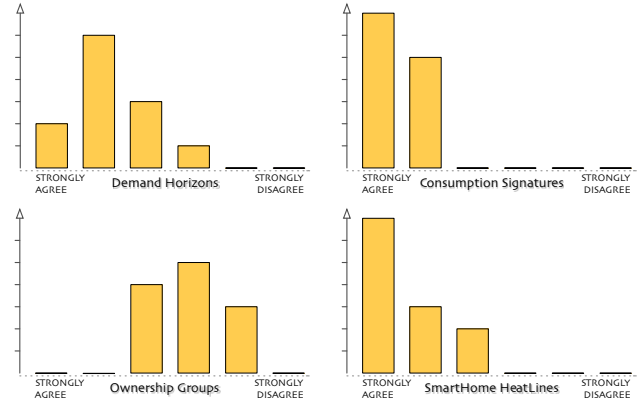
Table 3. Evaluation Process

| Considering | Evaluating | Method |
| --- | --- | --- |
| The Prototypes | Appropriateness | Questionnaire |
| The Prototypes | Novelty | Structured Group Discussion |
| The Prototypes | Surprise | Structured Group Discussion |
| The Design Process | Validity & Effect | Structured Group Discussion |
| The Design Process | Creativity | Reflection by Designers |

nique, some of which were beyond the initial remit: "*it starts to become an interesting customer's view.*" The analysts found the design particularly appealing and engaged especially with the *data sculpting* feature, which is discussed in more detail in section 6.

*Consumption Signatures* scored 1s and 2s in the questionnaire (signifying *strong agreement* or *agreement* that requirements were satisfied). The energy analysts were excited and fascinated by this application. It was seen as "*very powerful and very useful,*" highlighted as being a particularly intuitive design that allowed analysts to gain insights quickly: "*you could spend months searching the data for insights but this just points you straight at it.*" It was also seen as an excellent knowledge building tool: "*I could imagine ... just taking a week off and just letting your curiosity dive in and out.*"

*Ownership Groups* scored 3s – 5s in the questionnaire and was the only prototype not seen as immediately useful by the analysts. While the questions being asked were notably valid and useful to the industry: "*just knowing what people have allows you to size up the market,*" the modeled data does not group appliances with users in realistic ways. This lack of validity in our data limited opportunities for insight and thus utility. The slick and elegant design, whilst meeting the criteria gathered from the *Requirements Workshop*, was in part also deemed inappropriate – the Tufte [50] style box plots being unpopular.

Showing the live trial data through *Smart Home HeatLines* caused particular excitement and engagement. All scores were between 1 and 3 with a mode of 1 indicating that it was considered highly relevant to the analysts' needs. The tool was deemed appropriate for "*a very wide user base*" in fact "*anyone interested in gaining insight from energy consumption data.*" The focus group discussion also revealed that it could improve communication of the Smart Home project amongst colleagues: "*we could be there for days, sharing it with other people.*" The value of exposing the analysts to the trial data in this way was explicit: "*this would be invaluable in starting to prove that some of these electronic [Smart Home technology] approaches work.*"

Alongside our evaluation by energy analysts, we also asked the energy modelers, who had generated the data on which three of the prototypes were based, to informally evaluate our prototypes. We engaged with them throughout the development process and found that they considered all four prototypes very appropriate to the needs of the en-

ergy industry and in particular to the needs of a modeler: "*The way you solve a problem is by doing some visualization in your mind and these tools help you greatly to facilitate that.*"

## 5.2 Prototype Novelty and Surprise

The four design prototypes in general were described by one of the analysts as "*creative approaches which show us the density, variability and value of our data.*" The techniques used were "*very different*" and new to the analysts: "*the methodologies would not have come out of my head.*" Overall the designs were deemed novel and valuable: "*you have brought something that we couldn't have thought of ... and the [Smart Home] project will be better for it.*"

Novelty and surprise were expressed in reactions to *Smart Home HeatLines* during the *Feedback Workshop*: "*I think this is brilliant*"; as well as after reflection in the *Evaluation Workshop*: "*it gives us a whole new way of analysing people,*" "*18 million data points! [It] is just impossible for us to get our head around the real value that is contained in that*" and "*I did not realize how diverse the different profiles were.*" The prototypes visualizing the less familiar modeled data also resulted in expressions of surprise and evidence of novelty. The heat mapping in *Consumption Signatures* can not be termed novel as a technique, but the sheer volume of data and the possibility to compare so much through juxtaposition and color variation was deemed by analysts to be "*really clever.*" The appliance based sorting in *Ownership Groups* was seen as both novel and useful: "*The 5 way sorting ... by category, load, subclass is not something we've seen before.*" Initial reactions to the animated transitions in *Demand Horizons* when shifting from weekday to weekend highlighted the novelty of this feature and the sorting of the appliances by their contribution to the peaks was seen as: "*really interesting – you just could not get that out of numbers.*" The *data sculpting* feature also received positive feedback from analysts suggesting novelty and surprise (see section 6).

Interviews conducted with the data modelers revealed that they also regarded the designs to be novel: "*they give me the opportunity to analyze the data in a different way.*" The designs also enabled the modelers to see surprising structure in their outputs: "*I didn't expect to see these patterns*" and "*I wouldn't be able to spot the problem before I saw this graph.*" The modelers' view on the trial data changed completely upon seeing *Smart Home HeatLines*: "*before I thought the trial data could not be used due to errors and outliers. The visualization showed me that you can use this data and detect different patterns and user behavior.*" There were also clear opportunities identified for data visualization within the energy data modeling domain: "*it has got great potential ... to spot problems, abnormalities, see the patterns, come up with new ideas, new theories, new models.*"

## 5.3 Process Validity and Effect

The analysts felt engaged in the process, that they had contributed and that they had learned through doing so. They were pleased with the responses to their suggestions: "*you actually listened to our feedback, helped us shape that feedback and then delivered.*" The process of developing the prototypes was deemed to be educational and stimulating helping the analysts understand the possibilities that data visualization can offer and the value of considered visual design: "*I realize that actually this has got many potential applications and many many uses,*" "*the data is a crucial thing and the visualization of that data is almost as important to move ... from information to insight.*"

## 6 CASE STUDY: DATA SCULPTING

One example of novelty, as perceived by the energy analysts, relates to the ability in the *Demand Horizons* prototype to engage in *data sculpting*. Documenting the lineage of the idea through our development process draws attention to the creative processes and enables us to reflect on the impact of the creativity methods we used.

## 6.1 Requirements Workshop

It was evident that the potential impact of successfully implementing the *Plan of Action* (see section 3.1.4), that arose out of visualization awareness with analogical reasoning, would be significant in economic

and environmental terms: power stations are costly on both counts. The importance of the power station as a unit of production was also very clear: they are used to accommodate peaks in energy consumption, difficult to switch on and off and expensive to maintain – hence the significance of reducing peaks below the threshold at which a particular plant is needed. We thus took the *Plan of Action* to the *Design Concepts Workshop* as one of our key inputs as we had been informed that: "*the better stage 1 is, the better stage 2 and 3 will be.*" A designer explains how this inspired the development of *Demand Horizons*.

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**The Designer's Story – Initial Development**

*I chose to design to "**How can we use visualization to better understand how different appliances contribute to the peaks in energy demand throughout the day?**" The objective was to design paper prototypes to meet this requirement without consideration of data or development constraints. Having some experience of developing data visualization techniques and systems, I was keen to make a contribution that fitted technique to requirement in a creative way. Knowing that many appliances might have to be shown concurrently, I was looking for a visual technique that was graphically compact, but visually distinctive. Horizon charts [20] seemed particularly appropriate as energy production jumps between discrete quanta when power stations are fired up or shut down in line with demand. This had a natural fit with the discrete 'horizons' of the chart. Thus the initial prototype comprised a set of horizon charts – one per appliance – and a single summed horizon chart representing total consumption. Each discrete band might represent the consumption necessary to cause a power station to be brought online (see Fig. 6).*

*The modeled data populating the horizon application were somewhat approximate and subject to change as the consumption model changed. This uncertainty informed the smoothed line design of the horizons as well as the smooth transitions implemented when moving between weekend and weekday consumption models (see Fig. 1).*

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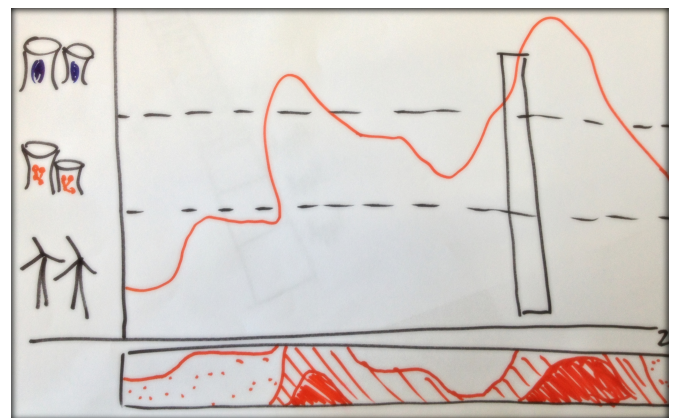


Fig. 6. Design Sketch: The *Demand Horizons* view of the *Plan of Action*.

## 6.2 A Creative Feedback Workshop

Initial reactions to the prototype at the *Feedback Workshop* were very positive: analysts liked the ability to play with the representation and see things change – a novelty to them in terms of their use of their data: "*there are so many touch points and ways I can move around that data – it gives you a Wow! factor*" and "*I think this is very powerful.*" Switching quickly between standard and horizon graphs helped explain the horizons and we were soon in a position where discussion about the data flowed with theories and requirements explored enthusiastically: "*if this data was live I'd like to be able to look at specific days - i.e. load shifting for tumble dryer could relate to specific days such as [when we have] rain.*" The ability to switch between weekday and weekend consumption was positively received and emphasized the

fluidity of the interface and ability to change the data seamlessly and quickly to suit particular lines of enquiry. This emphasis on fluidity and flexibility seemed to inspire some creative thinking about using the data that gave rise to interesting ideas and subsequent requirements in terms of managing energy consumption – "*cooker goes off, dishwasher comes on! Can we shift the dishwasher?*" – and important discussion around the timings of usage of washing machines (mainly in the morning) and driers (main usage in the evening): "*[could consumers] use the washer, they leave it and then they dry it when they come home?*" The significance here is that if consumers are prepared to wait to use energy consuming devices there is scope for offsetting usage to reduce the evening peak – perhaps below a power station *horizon*.

This exploration of patterns in the modeled data gave rise to further creative thinking about using the interface to model changes in consumption – through changes in behavior and more energy efficient devices: "*you can't shift lighting time ... but we can remove a percentage by changing the bulbs*" and "*[what if we] switched everyone to a more efficient fridge freezer for example?*" The aim of moving the dark peak below the upper horizon was implicit in the vigorous discussion. The design appeared to have been revealing and instructive in focusing activity on the need to reduce consumption below the levels emphasized by our horizons – much in the way anticipated by our designer, and clearly in line with the *Plan of Action*.

In turn these ideas rapidly gave rise to discussion about the interface and how we might interact with data to explore these theories: "*could we drag and drop and move something from that time to another time - to imagine [model] time shifting?*" We began to explore these ideas collectively: of reducing the consumption profiles of particular devices by a proportion and of moving consumption of particular devices from one time to another to remove the top horizon. Animated discussion ensued in front of the projected images with ideas being developed rapidly about how to select and represent times, percentages and shifts. This was intensive, creative design work inspired directly by data and analytic need, the latter being identified directly prior to the design ideas discussion through our prototype interface. The analysts were excited by their increased understanding and interpretation of the data, design possibilities and new ways of interacting with the models to address their objectives. This was evident in ensuing discussions about deployment and the immediate request for screen dumps to be used in an imminent internal meeting. Our focus here was very definitely on step 2 of the *Plan of Action – displacement –* as the data prototype had addressed much of step 1 – *discovery*. The ideas captured during this highly creative discussion at the *Feedback Workshop* were particularly useful as they were stimulated by both interface and the data analysis it enabled, in the context of an identified objective. They were communicated to our developers for the second development iteration.

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**The Designer's Story – Enhanced Functionality**

*The requirement to allow '***what if?***' remodeling of consumption patterns was clearly expressed, leading to the need to be able to edit the data shown in the horizon charts. Rather than separate the editing from the data exploration tasks, I combined the two processes under the metaphor of '***data sculpting***', enabling analysts to interactively select time periods and then vary consumption levels for particular appliances with immediate graphical feedback. This idea arose in part from previous work I had seen and developed for '***sculpting***' terrain models where interactive graphical tools are used to raise and lower parts of a gridded elevation model [39, 40]. It also follows the design pattern of '*data as interface*' that I had found successful previously [10]. The metaphor was reinforced and partly inspired by the use of a clay colored color scheme and the smooth curves used in the charts that make the graphs look as though they are mouldable.*

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## 6.3 Evaluation Workshop

The *data sculpting* feature sparked a vibrant discussion at the *Evaluation Workshop* with plenty of ideas of possible uses. It seems to be a technique with scope for helping explain the concept of demand shifting and reduction and to explore its possibilities: "*I am more confident*

*that internally I could use something like this to demonstrate that it [flexible demand] will work.*" Known aspirations for switching cold appliances off and on were discussed, with the interface encouraging new thinking: "*the fantastic thing about grow is you can grow before hand as well so you can super cool fridges or freezers.*" The feature was deemed "*a very useful dynamic tool*" that could pave the way for a new data storage strategy to ensure that data is of sufficient resolution to allow for this kind of visualization.

The modelers also liked the idea of *data sculpting* and had not considered using visualization in this way: "*this is really good. It represents what we have tried to do with the optimization tool but when I produce a model or amend it we need to re-run it. This does it instantly!*" The modelers were positive when asked whether *data sculpting* would be useful to help with building and editing the optimization algorithm itself: "*yes, if I had something similar to that I would definitely use that.*" New ideas were also created such as relating the horizons to energy cost thresholds: "*if the cost exceeds the thresholds you would have a penalty. You could visualize it and see it.*"

## 7 REFLECTION

The evaluation and case study reported above demonstrate some success in terms of our applied designs. Approaches such as *data sculpting* in *Demand Horizons* and the comparison through color variation and alignment used in *Consumption Signatures* and the multi-scale interactive analysis through *Smart Home HeatLines* demonstrate some novelty, seem useful in this context and may be applicable in other domains and scenarios. In this section, we share the reflections of experienced designers on the extent to which the process we have undertaken can be seen as *creative*, and consider the impacts this may have had on designers and other stakeholders.

In an applied client-based project such as this, evaluating the impact of the methods used by means of a controlled study is not feasible. Our approach to gaining some initial insights on the impact of our creative methods on the process of visualization design has therefore been to reflect, as designers, on our experience in this project, in order to compare it with the numerous other projects in which we have been involved over the years. Without a control we are unable to prove that adding the creativity methods at the outset of the project had any specific impacts on the process as a whole: good visualization design projects almost always involve creativity and novelty and we actively emphasized and valued these characteristics here. However, we did feel that the creativity methods opened up particular opportunities for creative thinking. They established the true breadth of a situation in which requirements are open with familiar reference points. They took participants out of their comfort zones and enhanced the 'away day effect' of shared purpose. The explicitly creative activities helped visualization designers and domain experts communicate, share experiences, establish trust and work as a team. We experienced creative thinking about data as well as about design and the creative thinking may indeed have helped us "*push domain experts to discuss problems, not solutions*" [47]. Based on our experience of past projects, we identify the elements where we feel the use of deliberate creativity methods had the greatest impact in Fig. 2 and discuss these further below.

Some of the simplest creativity methods seemed surprisingly effective. The animal introductions required some audacity on the part of our facilitator, but this was handled with aplomb. Developing analogies and revealing some personal information in a controlled and safe manner required openness on behalf of all participants. It seemed useful preparation for future exercises in initially putting all participants on an equal footing, establishing trust and involving surprise – suggesting that anything was possible from the outset. The excursion worked well as a preparation exercise to get participants in the frame of mind for the next activity and remind them that lunch was an opportunity to think and communicate. Everyone understood, brought something interesting back and had time to make a contribution.

Our impression following the visualization awareness activity was that use of analogy was very evident. Participants applied many of the ideas shown in visualizations from other domains creatively and effectively to their own area of interest. This activity spurred on a long and

interesting conversation about what was possible with the data to hand and might be achievable given the visualization examples presented. It seemed that these ideas generated after the visualization demos were stimulated by the morning's activities. We regarded them to be more numerous and creative than is the norm in these sessions and the outputs – such as mind maps developed during the awareness activity – were sophisticated. The storyboards produced in the activity that followed were not as useful as we had hoped. This may have been due to a lack of energy or the fact that previous discussions meant that we were overrunning – partly because graphical summaries were already being produced as participants took the initiative to generate mind maps in response to the analogical reasoning activity. Sketches or stories that are more data focussed may be more useful in our domain and we are likely to encourage the mind-mapping as a visualization storyboard during analogically focussed awareness activity in the future.

The novel ideas established at the subsequent *Feedback Workshop* are not easy to attribute directly to the initial use of creativity methods, but were rare in our experience of user-centered visualization design in terms of their quality, relevance and originality. The expressions of novelty and surprise (see section 5.2) were particularly embedded in organizational context, including evidence of insights, and realizations of new capacity and scope for the group. Possible changes in the way that the organization stores and uses data were suggested. Our sense was of a strong link and our activity felt focussed with participants particularly engaged and able to make excellent and sometimes unexpected suggestions for design possibilities throughout the process. We claim above that creativity may have persisted throughout the one-day *Requirements Workshop*. We also suggest that the early use of creativity methods may have had longer lasting effect through our study. Equally, being explicit about our desire and efforts to be creative may have been beneficial – a positive example (in design terms if not in experimental terms) of the experimenter effect in an *in vivo* situation where controls are not feasible. The *Designer's Story* (see section 6.1) offers some evidence to support this suggestion.

In terms of process, the analysts felt that they had made beneficial contributions and been able to communicate effectively with the design team. They reported benefits in terms of both understanding the data and visualization possibilities (sections 3.1.6 and 5.3). We felt that levels of engagement and learning were high and would associate this with the persistent sense of creativity that we are reporting. We acknowledge that this sense of contribution and ownership may have an effect on the evaluation – a positive bias being highly likely. However, it may also have an effect on uptake, which could be evaluated through a longitudinal study post implementation [48].

Our designs were not wholly successful in terms of analyst reactions however. *Ownership Groups* quickly revealed that the modeled data did not capture the kinds of relationships between users and appliances that we had hoped to explore. The lack of a realistic pattern emerging meant that analysts were less engaged with this application than the others, reinforcing established findings [27]. Reflecting back, it seems that we may have been collectively over-optimistic in anticipating that we could either find or imagine patterns where our data did not support them (see the data description in section 2). Perhaps the creative nature of our *Design Workshop* resulted in some inefficiency and inappropriate design. Perhaps explicitly creative visualization design processes may produce more 'misses' than standard approaches and thus be particularly costly. Perhaps – but benefits may also be associated with this cost. We captured plenty of suggestions that our prototypes were relevant beyond the original use cases and target group (see section 5), with various ideas for *Smart Home Heat-Lines* and *Demand Horizons* being used in other organizational and customer facing contexts. Additionally our designs were deemed useful by the modelers, who used them to develop insights and expressed interest in building aspects of the prototypes into their workflows (see section 6.3). We are unable to establish whether this is due to the open requirements, unknown data and design to focus points rather than formal task analysis (all used in previous design studies), or the parallel design or the creative approaches used in this case. Further work is needed to explore these various possibilities and any effects.

## 8 CONCLUSION

Our experience of using deliberate creativity techniques in the visualization design process has been very positive. We present reactions from the domain experts – energy analysts and data modelers – and reflect on our own experiences to support this view. We describe a series of candidate designs for energy visualization that have been developed through intensive user-centered collaboration. They have been enthusiastically received in most cases in light of initial requirements and expectations and have resulted in insights about data, new knowledge about analytical and visualization possibilities and potential behavior change in individuals and within organizations. They may be more widely useful as energy visualization becomes more widespread. Our evaluation supports the conclusion that they constitute a successful exploration of possibilities for analytical Smart Home data visualization.

Energy analysts and modelers found the designs novel and useful. Designers also developed methods they deemed novel in collaboration with and response to analysts. We claim, through reflection informed by our experience of what has been a lengthy and intense process, that *the explicit use of creativity methods is likely to have contributed to the development of novel and effective solutions that are well aligned with established need*. This is particularly significant in a situation where requirements are open and data largely unknown. We cannot trace back through the hundreds of prioritized requirements and captured reactions, the hours of discussion and the piles of sketches to establish a direct causal link between the creativity sessions and our designs – we don't think this is how it works. Visualization design is much more holistic, taking ideas from all sorts of influences often in parallel – just as good visual thinking uses multiple stimuli concurrently to generate ideas and make decisions. Indeed, we suspect that *the very fact that we were explicit from the outset about creativity being a focus in the project may well have made us more creative in our approaches*. The *Designer's Story* (section 6.1) suggests that this may well be the case.

We conclude that *the deliberate use of techniques to enhance creativity early in the visualization design process can contribute to success in terms of process and outcomes*. In our experience this proved highly likely to be the case in: establishing a creative working environment; developing requirements; pushing designers and developers to novel solutions; and building a sense of trust, common purpose and ultimately achievement in a diverse team. Furthermore we suggest that *using creativity techniques early in the visualization design process may have longer term positive effects on creativity and satisfaction that persist throughout a design process* and perhaps beyond.

In applied design projects domain experts' time is limited and valuable. We find real benefit in encouraging them to be as creative as possible early in the process as our experience suggests that creative methods challenge mental and social barriers, can enthuse and energize participants and engage them in design. Carefully facilitated, visualization focussed, use of *wishful thinking*, *constraint removal*, *excursion*, *analogical reasoning* and *reflection* may be straightforward 'discount' methods that contribute to buy-in, satisfaction and the efficient use of participants' time. We see room for using these creativity techniques and others, such as creativity through random combination [37], at various stages through the design process to explore their effects. Indeed, we plan to use creativity techniques in future projects as they seem to provide a low cost means of establishing a beneficial creative climate. We call on others to do the same. Perhaps documenting and reflecting upon the creative aspects of the design and indeed analytical processes in a series of projects will be the best way to share and assess experiences. We may then begin to understand more about the specific effects of creativity on user-centered visualization design.

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# Using Data Visualization in Creativity Workshops: A New Tool in the Designer's Kit

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## ABSTRACT

Creativity workshops have proved effective in drawing out unexpected requirements and giving form to participants' novel ideas. Here, we introduce a new addition to the workshop designer's toolkit: interactive data visualization, used as stimuli to prompt insight and inspire creativity. We first describe a pilot study in which we compare the effectiveness of two different styles of data visualization. Here we found that a less ambiguous style was more effective in supporting idea generation. Following this, we report a case study in which we employ data visualization within a service design workshop, where participants gain insights that are later realized in design ideas.

## Author Keywords

Creativity support, workshop techniques, data visualization

## ACM Classification Keywords

H.5.m Information Interfaces and Presentation (e.g., HCI): Miscellaneous

## INTRODUCTION

In recent years, generative co-design and creativity workshop techniques have become increasingly familiar. Their effectiveness has been demonstrated during requirements gathering for socio-technical systems [11] and in early stage design research [14]. In this paper we propose a new addition to the workshop toolkit: interactive data visualization. We do so in order to take advantage of the data that result from the increasing ubiquity of computing systems [1]. This data offers a wealth of domain relevant information that could be an important resource for design.

First, we outline a pilot study in which two styles of data visualization were compared to investigate whether the clear and explicit representation of data values, cited as important in the information visualization literature [2,7], runs counter to the tolerance of ambiguity, identified as having a positive impact on ideational fluidity in creativity studies [10]. Following this we report on a case study, undertaken with the support of E.ON Energy, in which our techniques are applied during a service design workshop

investigating data generated by smart homes.

## RELATED WORK

### Design Workshops

The research presented in this paper builds on the previous work of one of its authors [11]. Here, representatives of key stakeholder groups participate in a range of workshop activities including the use of creativity triggers, analogical reasoning, constraint removal and storyboarding in order to generate novel and useful ideas that can be translated into requirements for future systems. Similarly, Sanders [14] has shown the effectiveness of generative co-creation workshops in early stage design. Here, participants use toolkits made up of a large number of ambiguous stimuli to create artifacts expressing their design ideas. We build on these approaches by using data visualization to support participants' exploration of domain relevant information. We combine this visual exploration of data with generative creativity activities designed to encourage consideration of the wider context from which the data is taken. Our aim is to support participants seeking insight into existing practice.

### Data Visualization

In using the term data visualization we are referring to the graphical representation of information, data or concepts. The examples of data visualization outlined in this paper are all interactive. Information visualization has been identified as a transformational tool to support creativity [15]. In this paper we describe how it is used to support the creativity of participants in design workshops. The data visualizations we use must reflect the collaborative, relaxed setting we try to foster workshops. In this respect, the work of Wattenberg and Kriss [17] exploring *social data analysis*, and in particular their discussion of *expressive spectator interfaces* is influential. So too are Pousman, Stasko and Mateas [13] who introduce us to *casual information visualization*. The distinctions they draw between four different types of insight are particularly helpful.

## PILOT STUDY

### Introduction

Tolerance of ambiguity has been identified as a key component in the psychology of creativity since the foundational research of Guilford [10]. Gaver, Beaver and Benford [8] note its usefulness as a resource in interaction design and Sanders [14] its role in promoting creativity in design workshops. Conversely, ambiguity is commonly

seen as something to be avoided or reduced when visualizing quantitative data [2,7]. We wanted to see if this requirement for clarity and explicitness when representing data values, ran counter to the ideational possibilities offered by ambiguity.

**Pilot Study Methods**

We held a series of four workshops where the objective was to suggest ideas for new products or services utilizing the data generated by smart home energy technology. In each workshop, participants undertook one round of activities with a data visualization designed to heighten ambiguity and another round with a data visualization designed with ambiguity reduced. The order in which participants used the different styles of data visualization was varied to reduce ordering and priming effects.

*Data Visualizations*

The two data visualizations used in this study were based on data from a trial of smart home technologies E.ON Energy are conducting in Milton Keynes, UK. Each data visualization shows the total electricity consumption and the consumption of eight individual appliances for each of the twenty-four hours, on each of the seven days of a single week. This data can be displayed as consumption in kilowatt-hours or as a cost, measured in pounds sterling. Each day's consumption is represented in five separate price bands. Such variable pricing has been identified as one possible future direction for energy tariffs. The more ambiguous visualization is shown as a screenshot in Figure 1 and is available in its interactive form online[1]. The less ambiguous style of visualization is shown as a screenshot in Figure 2 and is available in its interactive form online[2].

*Participants*

Each workshop had three participants, post-graduate students and staff from City University London's schools of Informatics and Engineering. There was a mix of seven female and five male participants aged between 25 and 54. Participants were not selected for their domain expertise.

*Workshop Activities*

Control has been identified as a key smart home concept by E.ON. In the first activity, participants were asked to brainstorm ideas for things or people who exert control. In the second activity, participants worked collaboratively exploring the first data visualization and noting individual observations of important or interesting things. To encourage insight seeking participants were asked to consider five prompts: *'What do you see?' 'What do you think it is for?' 'What are you thinking whilst you explore?' 'What do you notice in the visualization?' 'What story does it tell?'*. At the end of this activity, participants collated and shared their observations, which were then put on display.

[1]  [1] http://grahamdove.com/eon/ambiguous.html

[2]  [2] http://grahamdove.com/eon/unambiguous.html
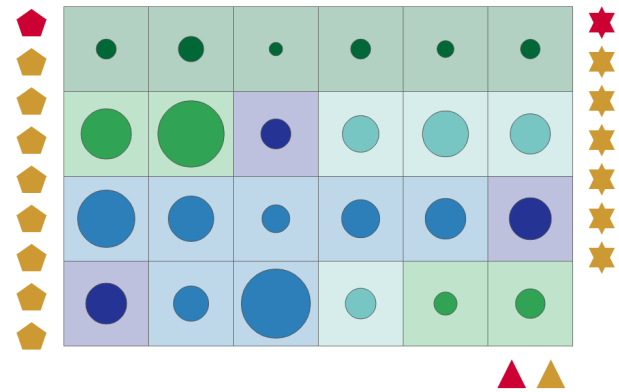
**Figure 1. More Ambiguous Visualization Style**
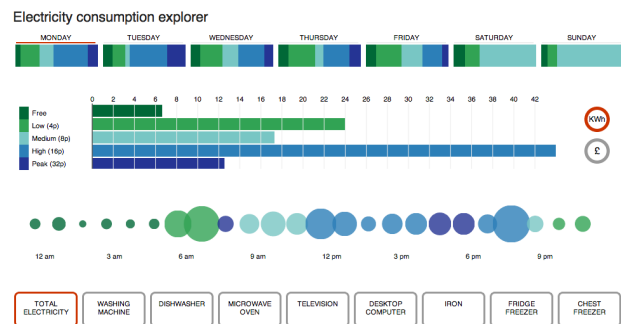


**Figure 2. Less Ambiguous Visualization Style**

In the third activity, participants worked individually. Examples from the first activity were combined with insights from the second to generate ideas for innovative products or service, using a wishful thinking technique. The fourth activity was a repeat of the second but those who had previously seen the more ambiguous data visualization were now given the less ambiguous version and vice versa. The fifth activity repeated the third, this time combining outputs from the first activity with insights from the fourth.

**Data Collection and Analysis**

The outputs from the second and fourth activities were analyzed to assess support for insight discovery. These were grouped by type, using thirteen categories. The ideas generated in the third and fifth activities were counted and assessed for novelty and appropriateness by independent domain experts as a measure of creative output [4]. Further evaluation data came from a questionnaire participants completed at the end of each workshop condition. This was derived in part from the Creativity Support Index [3] and in part from discussion of insight in the visualization literature [12,18]. Finally, observer notes and video recordings of each workshop were analyzed.

**Pilot Study Findings**

The key finding from our pilot study was that the less ambiguous style of data visualization provided more effective support to participants. Not only were they better able to explore the underlying data and gain insight, but they were also more likely to discuss factors from the wider

context not directly shown, such as possible lifestyle choices of the household they thought might have been using the energy. This study is discussed in more detail elsewhere [5].

## CASE STUDY: E.ON ENERGY DESIGN WORKSHOP

### Background

This case study describes a one-day creativity workshop held in Milton Keynes, UK, and which is part of a larger research project, funded by E.ON International Research Initiative investigating the use of data visualization tools to engage creatively with energy data. The objective of this workshop was to outline ideas for new services that utilize the data generated by smart home technologies.

### Data Visualization

The interactive data visualization employed in this workshop was based on the less ambiguous style from our pilot study. It was updated to reflect feedback we received from participants and input from data visualization experts. The visualization is based on data generated by a model of typical energy consumption developed by partners in the project [9], and represents one week's energy consumption for a possible household. Screenshots of the data visualization are shown in Figure 3 and Figure 4, it is available in its interactive form online[3].

### Participants

There were ten male and three female participants, two were E.ON staff and eleven customers recruited from a long-term technology trial E.ON are undertaking. Their ages ranged from teen-age to pensioner. All participants were familiar with energy monitoring and smart home data, and had experience with visualizations of energy data through their smart home monitors. Participants self-allocated into one of four groups.

### Workshop Activities

Each group was given a toolkit consisting of marker pens, post-it notes, colored paper shapes, glue, tape, scissors and around three hundred photographs split into categorized envelopes containing people, buildings, transport, food and technology. The visualization was presented to the workshop participants using iPads.

*Activity 1: Personas* In their groups, participants used insights gained from the data visualization to help them describe the type of household it might represent. They realized this imagined household by making a collage on an A1 worksheet. Here they were given prompts to explore the lifestyle and context surrounding energy consumption. These included asking them to picture the household and the property; how they might feel about technology, their mealtimes and the ways they might travel.

*Activity 2: Preparation* Again in groups, participants explored the data visualization to uncover smarter ways

their imagined household might use energy. This could be either by reducing the total amount of energy used or reducing their energy bill through responding to the variable pricing bands. Their top five ways to be smarter with energy were entered into a competition entry form together with their response to a tiebreaker asking them to briefly describe the piece of smart home technology, either real or imaginary, that would most improve their imagined household's lives.

*Activity 3: Reflection* Participants individually completed a set of three reflective postcards to provide evaluation feedback.

*Activity 4: Brainstorm* In a single large group, participants undertook a three-stage brainstorm. Ideas for different types of data a smart home may generate and for products or services that might utilize this data were suggested before their emotional responses to these ideas were captured.

*Activity 5: Service Design* In their small groups participants created a storyboard describing their service at three key stages: point of sign-up, when it used for the first time, and once it had become an accepted and regular part of their household's life.
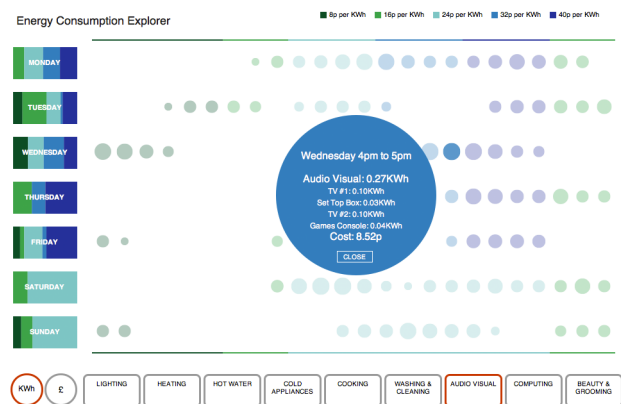


**Figure 3. Hourly Consumption Detailed View**
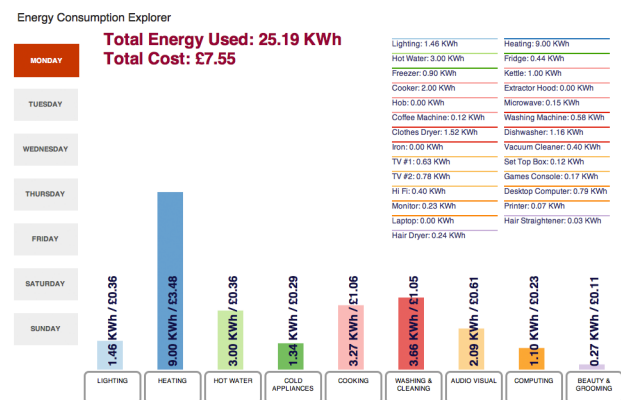


**Figure 4. Daily Consumption View**

[3]   [3] http://grahamdove.com/eon/index.html

**Data Collection and Analysis**

To evaluate participants' self-reported perceptions of the effect the data visualizations had had on their creative activities, we designed Activity 3 in which they completed three reflective postcards. This is discussed in more detail elsewhere [6]. In addition, the outputs from the first two activities, in which the data visualization played a central role, were analyzed for evidence that participants gained insights, explored alternative options and created rich descriptions of their imagined households. These would contain numerous details about the background of the imagined household and the context of their energy use. The final service design outputs were analyzed for evidence of an identifiable path, traced from insights gained in data exploration, through to their application in design ideas.

**Workshop Findings**

Our analysis indicates that participants felt engaged and easily able to collaborate whilst using the data visualization, they felt able to build on their existing knowledge and that there was strong support for participants gaining insight, with both overview, and patterns and relationships being easy to discover. The outputs from the first two activities showed evidence that insights gained from the data could be used to inspire imaginative responses that reflected the participants' wider experiences. Analysis of the final service designs indicates that these insights and the ideas they prompted played a significant role in their outputs. This indicates that using the data visualization prompted participants to seek domain relevant insight in an engaging way, and that these insights could be developed to support the creativity in participants' prototype service designs. This case study is discussed in more detail elsewhere [5].

**DISCUSSION AND FUTURE WORK**

In this paper we have begun to demonstrate how interactive data visualization can be a powerful addition to the workshop toolkit. In our pilot study we discovered that clarity and explicitness does not run counter to the ideational fluency that has been associated with ambiguity, and in our case study we discovered that participants can gain insights from data visualizations during workshop activities before realizing them in design ideas. Our research appears promising and we now need to replicate our findings in other domains, using different types of data and different styles of data visualization.

**ACKNOWLEDGMENTS**

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# Inspired by Information: Combining Data Visualization and Generative Techniques in Early Stage Design Research

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**ABSTRACT**
The growth in online services and ubiquitous computing has resulted in organizations holding large amounts of valuable data. The technical and monetary barriers to reusing these data for new products or services are relatively low. To be successful however, such products or services require a potentially radical re-framing so that these data acquire new meaning. In addition, the contexts surrounding these data present all the difficulties associated with 'wicked problems'. In this paper I will outline research investigating how we might utilize generative design methods, creativity techniques and information visualization to address some of the challenges in this design space. These challenges include the need to better understand what these data mean at present, how the context they come from is experienced and what these data could potentially do or mean in future. This will be illustrated with the work undertaken in two case studies.

**Author Keywords**
Design Research; Information Visualization; Workshop Techniques

**ACM Classification Keywords**
H.5.m. Miscellaneous.

**General Terms**
Human Factors; Design.

**INTRODUCTION**
The recent trend for placing services and transactions online, together with the increasing ubiquity of computing systems, means that many organizations are now in possession of a growing amount of valuable data. Because these data are digital they can be re-purposed with relative technical ease and at a relatively low cost. This presents an opportunity to create new products and services that generate additional value and enable individuals and organizations to gain new benefits from existing resources.

Design projects that result from this opportunity are likely to be initiated by the availability of data. Their motivation being 'What can we do with data X?' rather than 'How can

we solve problem Y?'. In this way, such projects, where designers investigate additional uses for new or existing data, share similarities with the type of *Radical Innovation* identified by Norman and Verganti [5]. This is because they seek a re-framing that could provide new meaning to accompany new technology. In addition, the contexts these data are generated in can be deeply human, highly complex and contain all the difficulties associated with the now familiar 'wicked problems' of design. These are problems that require an understanding of more than just the technical difficulties and monetary constraints.

Such projects will require design research that seeks to gain a deep understanding of the materials at hand, in this case data, and the context they come from, which will often be inextricably linked to the experiences of the people whose lives generate these data. They will also require an early focus on creativity and methods that utilize critical perspectives to explore alternative ways of interpreting common or shared experiences, so that data can be re-imagined and innovative products or services created.

**RESEARCH OBJECTIVES**
In my PhD studies I am investigating how we might utilize information visualizations in conjunction with generative design methods that include creativity techniques to begin to address some of the challenges and opportunities presented by this emerging design space. I am exploring this combination of tools both as a way to gain an understanding of data and the contexts they come from, and also to support the critical evaluation and re-framing that will help in re-imagining data and their future purpose.

By information visualization I am referring to the graphical representation of data. This will often, although not exclusively, be interactive. Information visualizations are used for their ability to support users gaining insight and acquiring a deeper understanding of data. Following the distinctions made by Pousman, Stasko, & Mateas [6], such insights might be *analytical*, like those associated with traditional exploratory visualizations, or *reflective*, like those associated with more artistic styles of visualization. A distinction that I see as being useful when moving between activities that seek to explore present context and those that seek to imagine possible futures.

By generative design I am referring to methods in which stakeholder representatives are provided with the tools to generate new ideas that reveal requirements or inspirations for design. Here the creativity techniques used by Jones,

Maiden & Karlsen [4] and the generative research methods described by Sanders [7] are influential. So too are the ideas behind Gaver & Dunne's cultural probes [3], which provide inspiration for how generative design research may be used to explore current experience through a critical lens and suggest possibilities for alternative meaning.

To carry out this research I am undertaking a series of case studies within projects where real world design opportunities have resulted from the availability of data.

## CASE STUDY 1: SMART ENERGY DATA
The initial case study undertaken for my research is part of an investigation with E.ON, a major energy provider, into new products or services that could be developed using the data generated by smart home technologies. Within this project a sophisticated model of typical energy consumption patterns has been developed. Data generated by this model was used to build interactive information visualizations that provided stimuli during a one-day creativity workshop held with E.ON customers and staff.

These visualizations were used as part of a pair of workshop activities. In the first, participants worked in small groups to create collages describing different aspects of the household they imagined might be represented by the energy consumption data. In the second, these data were further explored to complete a competition entry outlining ways in which the imagined household could be smarter in their energy use. These imaginary households and the contexts of their energy consumption behaviour were later used as inspiration in service design activities. Further details of this case study are presented in a paper submitted to this conference [2]. We are currently evaluating the prototype designed as a result of this workshop.

This case study showed evidence that using information visualizations within generative activities can be an effective means through which workshop participants are able to better understand data, explore the context they come from and gain insights which remained evident in later design ideas.

## CASE STUDY 2: REFLECTIVE LEARNING APPS
In my second case study, I am investigating how data generated by a collection of apps that are being developed to explore different aspects of reflective learning within a European research project, can be shared, combined and reused creatively to provide new services from existing resources or provide new meanings that suggest new contexts of use. This case study is at an early stage and we recently held an initial one-day workshop where we looked to build a shared understanding of data generated by the various apps. To achieve this we used a series of generative techniques culminating in the creation of a large-scale paper 'map'. This map is made up of a number of individual collages that participants created to describe an apps' data and the context of its use. Having placed these on the map, connections between data in different apps were made explicit using colored ribbon, and ideas for new connections were added.

The next stage in this project will be to design a digital version of this map and augment it with visualized examples of the available data. This will provide an online platform to enhance our understanding, share insights and suggest alternative ways data might be viewed. We will then arrange a second workshop where the objective will be to explore alternative meanings and generate ideas that reuse data creatively for innovative services.

## CHALLENGES
The key challenge I currently face is identifying effective evaluation methods. We have developed a technique for assessing participants' responses through reflective postcards that will be presented in a workshop at this year's CHI [1], and there are established methods to evaluate the product of a design process. However, a satisfactory way to evaluate the processes taking place remains elusive.

## CONTRIBUTION
This research will contribute to the design community by suggesting ways to approach an emerging design space. It will contribute to the creativity research and visualization communities by identifying and explaining connections between insight, data, visualization techniques, generative activities and creativity.

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# Evaluating Creativity Support in Co-Design Workshops

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## ABSTRACT
Participatory, co-design and creativity workshops can lead to more useful, usable and innovative systems design. However, evaluating the effectiveness of the creativity support provided by different technologies and workshop techniques is challenging. This is especially so when evaluation takes place during the workshop and maintaining a creative atmosphere is important. In this paper we briefly outline the development of one simple method of evaluation we have designed whilst studying the use of information visualizations within generative design workshops. Here we discuss how reflective postcards are used to replace questionnaires as a way to collect participants' responses.

## Author Keywords
Evaluation, Creativity Support, Participatory Design

## ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## General Terms
Human Factors; Design;

## INTRODUCTION
Participatory approaches to human-centred design, characterized by the active involvement of users and other stakeholders, can lead to more useful and usable systems [7]. Through practices such as co-creation [9] and creativity workshops [6], it has also been shown that such methods can be an effective way to discover novel requirements for complex socio-technical systems and design future experiences for their users. A key aspect of these approaches is the requirement for designers to provide the tools and facilitation skills that elicit participants' possibly latent creativity. It is therefore crucial that as far as possible any such workshop retains an atmosphere that is relaxed, supportive, engaging and playful.

When undertaking academic research to study the effectiveness of particular technologies, techniques or activities, it is sometimes important to collect evaluation data from participants during the workshop itself. This

creates something of a conflict as stopping generative activities to ask participants to complete questionnaires serves only to highlight academic concerns. This can also draw attention to any possible concerns participants have that they themselves are being judged, which can be a cause of anxiety. Because of this we have sought evaluation methods that become part of the workshop's creative activities. In this paper we will briefly outline the development of a simple method that, whilst not entirely novel in its intentions, is one we hope will be of interest. We have found it useful in capturing evaluation data similar to that in questionnaires but using a form factor that is more appropriate to the workshop context. Here, individual postcards containing prompts designed to capture participants' reflections are used to assess selected aspects of the workshop up to that point. We do this in order to evaluate the support participants feel a particular technology or technique has provided them for their role in the workshop activities they have just undertaken. In the following sections we will first provide some background to our wider research, before discussing the stages that led to the development of this evaluation method. We will then describe how it has been used in practice and close with a brief discussion of its effectiveness.

## BACKGROUND
In our research [4], we are investigating ways information visualization can be used in conjunction with generative tools and creativity techniques to support participatory design research. This is in response to the large amounts of data organizations now hold, following the movement of services and transactions online and as a result of the increasing ubiquity of computing systems. These data can be reused, offering an opportunity to create innovative products and services, but the contexts surrounding these data present all the difficulties associated with 'wicked problems'. To address these challenges we seek to provide participants with a combination of tools, techniques and support that enables them to better understand data, explore current context and imagine possible futures. By information visualization we are referring to the graphical representation of data. This will often, although not exclusively, be interactive. By generative tools we are referring to methods whereby stakeholder representatives are provided with the materials and techniques, such as those needed for making collages, to help them generate new ideas that reveal requirements or inspirations for design.

In our research we need to evaluate the introduction of information visualizations into different types of generative workshop activity. In addition we need to evaluate how effective different generative activities are in helping participants and designers gain a shared understanding of data. We must also evaluate the effectiveness of different styles of information visualization and their appropriateness within our workshop activities. Each of these evaluations takes place within the context of participatory design workshops. Following Warr and O'Neill's description of design as a social creative process [10] we frame these evaluations in three parts, addressing the creative process, the creative product and the creative person. This is described further elsewhere [4]. In the remainder of this paper we will outline our method for assessing participants' self-reported evaluation of how effectively they feel a particular technique or technology has supported them in their role as a creative person within an ongoing workshop.

## DEVELOPING THE REFLECTIVE POSTCARDS

### Stage 1: Separate Questionnaires
In an earlier piece of research, evaluating the support a large-scale interactive visualization of student satisfaction data provided for collaborative ideation [3] we had used three separate questionnaires to address system usability [1], creativity support [2] and insight support. The third of these was a questionnaire we developed ourselves based on previous work outlining the nature of insight as discussed in the visualization community [8] and analysis of how such insights are acquired whilst visually exploring data [11]. Whilst each of these questionnaires was successful in addressing the concerns it covered, the process of completing them all was a chore for participants. This had a negative impact on the quality of the responses to subsequent open questions we asked to probe participants' qualitative experiences.

### Stage 2: A Single Questionnaire
As a result of this, when we undertook a study comparing the effectiveness with which two different styles of information visualization provided stimuli for ideation, we decided first to separate out the usability evaluation and then to combine the creativity support and insight support questionnaires into one. Here we wanted to design a short and simple questionnaire that would quickly address participants' responses to the most salient aspects under investigation. This would then form a small but nonetheless significant aspect of our overall evaluation plans. The result was a seven-part questionnaire that used a Lickert scale rating, ranging from 1 strongly agree to 5 strongly disagree. The first four statements in it are derived from the Creativity Support Index [2] and the final three from the insight support questionnaire we had developed based on visualization literature [8,11]. The questionnaire statements are listed below:

1. I was very engaged and absorbed using the visualisation. I enjoyed it and would do it again.

2. I was prompted to generate ideas that were new and varied.

3. I was able to work together with others easily.

4. I felt able to explore many different options, ideas or outcomes.

5. I could easily identify relationships and patterns in the data that contributed to new ideas.

6. It was easy for me to gain an overview of the data using the visualization.

7. I was able to combine my existing knowledge with insights from exploring the visualization to generate ideas that I had not previously considered.

This questionnaire was successful in the context of a design experiment as it captured responses to our main concerns. However, here it was being presented at times when there was a clear and intentional break in the flow of creative activities, and where a change of atmosphere was both appropriate and desired.

### Stage 3: Reflective Postcards
This would not be the case in a workshop in which end users and other stakeholders were participants. Here we would want to keep the focus of those participants away from our academic concerns. We would not want them to feel they were being assessed and we would not want to break the flow of generative creativity. Here we would need an alternative format. The criteria we had for an evaluation method were as follows. First, it should feel personal, encourage reflection and allow for creative responses. Second, it should be relatively short but directed at answering particular areas of concern. Third, it should fit into the activities of the workshop without changing the atmosphere or drawing participants' attention to assessment. Fourth, it should use a mechanism that would be familiar to all participants. Finally it should be able to capture data replacing the Lickert scale responses and also the open questions we had asked in previous questionnaires.

Gaver & Dunne's use of cultural probes [5] tells us about the effectiveness of well-designed prompts and intriguing artifacts in eliciting responses from people, and this was a source of inspiration in our decision to use postcards as a medium to collect evaluation data. Postcards are individual artifacts that limit the space in which responses can be written but which are flexible enough to provide the opportunity for creativity. They have a form factor that is both familiar to people and evocative of sharing. They also suggested a playful means of collection to complete the activity, and so we made a small red postbox for participants to 'send' us their reflections.

## USING THE REFLECTIVE POSTCARDS
The workshop for which the postcards idea was developed was held as part of a research project undertaken in conjunction with E.ON [4], a major energy provider, in

which we are investigating possible new products or services that could be developed using the data generated by smart home technologies. Within this project a sophisticated model of typical energy consumption patterns has been developed. We used the data generated by this model to build interactive information visualizations that provided stimuli during a pair of workshop activities. In the first, participants worked in small groups to create collages describing different aspects of the household they imagined might be represented by the energy consumption data. In the second, these data were further explored to complete a competition entry outlining ways in which the imagined household could be smarter in their energy use.

These imaginary households and the contexts of their energy consumption behaviour would later be used as inspiration in service design activities, but we wanted to evaluate participants' responses to using the information visualizations immediately following the activities in which they were being used. In order to achieve this each participant was given three separate postcards. Each postcard had a different reflection prompt written on it that we asked participants to respond to. We chose to use prompts that asked for reflection rather than standard open questions because we felt that this approach would encourage participants to think critically and discuss both what had been effective and also what hadn't worked. These prompts were derived from the questions we had used in the earlier design experiment.

### Reflection Prompt 1
The first prompt addresses engagement and collaboration, similarly to statements 1 and 3 in our earlier questionnaire.

*"Please reflect on your involvement in the previous two activities. Write a few sentences thinking in particular about how engaged you were, how absorbed or distracted, and how easily you feel you worked with other members of your team. Try to think about the extent to which the technology helped or hindered you in this regard."*

### Reflection Prompt 2
The second prompt addresses idea generation, exploration of alternatives, and the ease with which participants could utilize their knowledge and experience. This is similar to statements 2, 4 and 7 in the questionnaire.

*"Please reflect on how you used the data visualization to first create your household and then to devise competition answers. Write a few sentences, thinking in particular about how easily you were able to explore possible options and come up with different ideas. Did you use your prior knowledge as well as the information shown? And how easy you found it to relate that prior knowledge to the data?"*

### Reflection Prompt 3
The third prompt addresses participants' ability to gain an overview and to identify relationships and patterns within data. This is similar to statements 5 and 6 in the questionnaire.

*"Please reflect on your understanding of the information contained in the data visualization. Write a few sentences, thinking in particular about how easily you managed to gain an overview of what was represented. Also think about how quickly you grasped what the information meant, did you spot clear patterns and relationships or did you find it confusing? Did it prompt you to think of ideas you had not previously considered?"*

### EXAMPLE REPONSES TO REFLECTIVE POSTCARDS
Participants responded well to the postcards, taking the time and effort to provide considered responses addressing both positive and negative factors. We have listed example responses to each of the postcards below.

### Reflective Postcard #1
*"It was easy to work with the group, we were open to each others opinions. Technology was useful for us to investigate our views and to help discussion. The display of the information was interpreted differently by others but this helped with discussion."*

*"I felt engaged and absorbed with the tasks and comfortable working with the other members. Some of the information in task 1 was a little overwhelming. The technology was very useful."*

### Reflective Postcard #2
*"The iPad data visualisation was very useful as it made it surprisingly easy to look at each piece of data and also caused the data to be better laid out. I could also use it with my own knowledge which I had to do for the first task."*

*"Did use prior knowledge and so did other team members. Needed to focus back on house and empathise what they were like. iPad data didn't really contribute to ideas."*

### Reflective Postcard #3
*"Definitely. You had a broad overview and you could drill down to get clearer answers. This interactivity flowed very well and really demonstrated well how this family behaved."*

*"It was easy to get an overview about each group of data due to how it was laid out and that made it very easy to compare the data and come to assumptions about it."*

### ANALYSIS OF REFLECTIVE POSTCARDS
Our analysis indicates that Reflective Postcard #1 and Reflective Postcard #3 successfully replaced the equivalent questionnaire items and elicited responses relevant to our concerns. In the case of Reflective Postcard #1 all 13 participants responded to the engagement aspect and 12 to collaboration. Reflective Postcard #3 gave us 12 responses to identifying patterns and relationships and 9 regarding overview. However, for Reflective Postcard #2, whilst 7 of the 13 participants responded to the prompt regarding use of their existing knowledge, only 2 addressed exploring alternatives and just 1 idea generation. We characterised each of these responses as being either positive or negative. The results are shown in Table 1.

| Evaluation Factor | Reflections | |
| --- | --- | --- |
| Engagement (Q1, P1) | +13 | -0 |
| Collaboration (Q3, P1) | +12 | -0 |
| Generating Ideas (Q2, P2) | +0 | -1 |
| Exploring Options (Q4, P2) | +1 | -1 |
| Building on Existing Knowledge (Q7, P2) | +7 | -0 |
| Patterns & Relationships (Q5, P3) | +10 | -2 |
| Overview (Q6, P3) | +8 | -1 |

**Table 1: Analysis of Responses on Reflective Postcards**

The Reflective Postcards are not designed to capture data in the depth required for a systematic qualitative analysis. However they do provide responses similar to those from open-ended questionnaire questions. This helped with Reflective Postcard #2, where responses had not referred directly to the subjects posed in the prompt. Here, participants took as much consideration as they did with the other postcards, but we found they were taking the opportunity to provide us with suggestions for improvement or more generally helpful feedback. For example one participant wrote:

*"Very helpful. Couldn't do it without. Some minor improvements (red for bad?). Took knowledge to use it. May be difficult for non-expert."*

Whilst another participant used it as an opportunity to relate the workshop to the wider trial of smart home technology that our participants are a part of:

*"To an extent, not having full Greenwave socket data on major appliances. Much of it was a 'guesstimate'."*

**DISCUSSION**
The responses to Reflective Postcards #1 and #3 suggest that they can be an effective replacement for questionnaires within a workshop. However the evidence from Reflective Postcard #2 suggests further refinement is needed to explore their limitations. It could be that participants did not specifically address the question of idea generation in Reflective Postcard #2 because the activities undertaken with the visualization were not obviously ones requiring divergent thinking or rapid idea generation and instead participants took the opportunity to share more general thoughts. Or it may be that this prompt, in addressing three separate concerns jointly, was too ambitious or simply not clear enough. Further study and improved piloting will help identify and militate against similar problems in future.

These postcards offer us more than a simple replacement for questionnaires though. Their format is flexible and affords participants the opportunity to be creative in their responses. They are also informal and do not draw attention to notions of assessment. In their use we are investigating participants' reflections regarding the support particular techniques or technologies can provide them in their role as a creative person undertaking workshop activities. We need to do this in a way that maintains the atmosphere of the workshop and the postcards seem to meet the requirements to achieve this. So far, participants have responded to the postcards with a good level of enthusiasm and they seem to like their somewhat homemade styling. In order to encourage this aspect we are continuing to adapt the postcards and develop them as artifacts by adding images and providing envelopes addressed to us personally, in case participants wish to take them away, reflect further and return them to us by post. As a method of evaluation, the postcards are simple and yet effective in assessing the support provided to participants as the creative person.

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# NARRATIVE VISUALIZATION: SHARING INSIGHTS INTO COMPLEX DATA

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## ABSTRACT

This paper is a reflection on the emerging genre of narrative visualization, a creative response to the need to share complex data engagingly with the public. In it, we explain how narrative visualization offers authors the opportunity to communicate more effectively with their audience by reproducing and sharing an experience of insight similar to their own. To do so, we propose a two part model, derived from previous literature, in which insight is understood as both an experience and also the product of that experience. We then discuss how the design of narrative visualization should be informed by attempts elsewhere to track the provenance of insights and share them in a collaborative setting. Finally, we present a future direction for research that includes using EEG technology to record neurological patterns during episodes of insight experience as the basis for evaluation.

## KEYWORDS

Narrative visualization, Insight, Creativity support, Information visualization, Evaluation methods

## 1. INTRODUCTION

We are increasingly required to make sense and use of complex data. This is not only due to the successes of the open data movement and to companies such as Google releasing increasing amounts of information, but also to factors like the growth of social networking and social media. In addition, advances in personal and mobile computing power, allied to faster broadband speeds, allow us to collect, process and distribute datasets far larger than was previously practical. Alongside these developments, we have also witnessed major upheavals in the way media is produced and consumed, opening new avenues to reach people directly, whilst simultaneously disrupting existing models. A key challenge posed by these trends is the task of creatively engaging with the public, and one response has been *narrative visualization* [17] in which interactive data visualization techniques are incorporated into story telling. Examples of this can be found in the data journalism of The Guardian [25] and New York Times [26] websites, and it is further evidenced by events such as the *Telling Stories with Data* workshop at the VisWeek conference [27].

One of the distinguishing features of narrative visualization is the use of interactive exploratory techniques to enhance the communication of ideas and promote insight through discovery. It is our view that this combination of communication through narrative and discovery through exploration offers new opportunities for authors to successfully share insights with their audience. This is because the exploratory nature of interactive data visualization offers an opportunity for the end-user to experience a similar moment of insight to that which the author had experienced earlier. Crucially, however, the end-user is guided by the context of the narrative structure in which the visualization is presented and she is not required to take on the entire cognitive load of unguided discovery.

In order to exploit these opportunities we first need a better understanding of the nature of insight and how it can be shared. With this in mind, we present a two part model of insight derived from the Information Visualization (InfoVis), Cognitive Psychology and Neuroscience literature. We then go on to discuss how narrative visualization design can be informed by efforts to support insight sharing made elsewhere. We discuss this first from the perspective of authors sharing insight with end-users and secondly from the perspective of social collaboration between end-users. Finally, in the future research section, we discuss possible new approaches to evaluating narrative visualization using electroencephalography (EEG). The main contribution of this paper is to provide a theoretical background to communicating insights about complex data through exploratory visual narratives and to suggest novel methods for their evaluation.

## 2. INSIGHT

It is an oft repeated truth that *'the purpose of visualization is insight not pictures'* [2]. In this section we seek to improve our understanding of insight and present a two part model that, we hope, indicates how insights can be communicated and shared more effectively.

Within the InfoVis community there has recently been interest in using insight as an evaluation metric. Typically, this has resulted in a unitary description. For example, Plaisant et al [12] declare *'Insight can simply be defined as a non-trivial discovery about the data'* whilst Saraiya et al [15] define insight as *'an individual observation about the data by the participant, a unit of discovery'*. Such a view has obvious merit when discussing a metric for evaluation but appears somewhat limited. North [11] moves away from the unitary view when he lists the important characteristics of insight. Here, insight is *'Complex'*, *'Deep'*, *'Qualitative'*, *'Unexpected'* and *'Relevant'*, although North retains the notion that insight is to a large degree the product or end-result of a task. Yi et al [23] extend this understanding, describing how insight is also likely to be the by-product of ongoing exploration and often serves as the starting point in theory creation. However, common to all these cases is the idea of insight as **something that is gained**.

The Cognitive Psychology literature, in contrast, speaks of insight as **something that is experienced**. Often described as an *'Aha!'* moment of sudden realization, insight is said to occur when an inappropriate representation is restructured to overcome a mental block, giving new understanding. For example, Schooler et al [16] describe insight as *'a transitional event in which a solver moves from an impasse state to a solution state'*. Similarly, Csikszentmihalyi & Sawyer [4] state that *'insight seems to involve (1) an existing state of mind or mental structures relevant to the topic and (2) a moment of realization, consequent to new information or a sudden new way of looking at old information, resulting in (3) a quick restructuring of the mental model, which is subjectively perceived as providing a new understanding'*. More recent work in the field of Cognitive Neuroscience [1, 10 & 14] has used neuroimaging techniques, electroencephalography (EEG) and functional magnetic resonance imaging (fMRI), to support this idea of insight as something experienced.

We take the view, following these descriptions, that the best way to understand insight is in two closely coupled parts. First, there is the insight experience as described by psychologists and second, there is the product of this experience, the changed mental model that represents new knowledge or understanding; this second part being closer to the way insight is discussed in the InfoVis community. It therefore seems appropriate that when attempting to communicate and share our insights, we do so not only via their products but also by attempting to reproduce the experience of having them. This, we believe, is the opportunity presented by narrative visualization.

## 3. THE DESIGN OF NARRATIVE VISUALIZATIONS

As Tufte [18 & 19] shows in his discussions of Minard's map of Napoleon's march on Moscow and John Snow's map of cholera cases in London, story telling has a long history as part of successful data visualization. However, it is this intention to tell a particular story that distinguishes narrative visualization from much current research in InfoVis. Hullman & Diakopoulos [9] address this intentional aspect, building on Segel & Heer's [17] design space categorization with an analysis derived from semiotics, critical theory, journalism, decision theory and political theory they call *visualization rhetoric*. Their aim is to show how

design choices can influence user interpretation of the original data and they provide a guide to how such visualization rhetoric may be used to positively inform those choices, therefore providing a narrative structure to support insight sharing. Elsewhere, Rojhas & Ju [13] show the potential of data visualization to engender empowerment and synthesize personal narratives. In each case, the authors' aim of sharing particular insights about data they find interesting through both exploration and story telling is clearly shown.

The field of social data analysis, in which data is visualized and discussed publicly online, is emerging roughly parallel with that of narrative visualization. Research on the use of websites and interactive applets such as Many Eyes [20] and NameVoyager [21] address important issues like democratising visualization technology, data handling with a lay audience and designing for asynchronous collaboration. Work by authors such as Heer & Agrawala [8] and Willet et al [22] extend these ideas into collaborative visual analytics looking at factors that support awareness, establish common ground and support sharing insights through hypothesis generation. In each case, there is clear evidence for the effectiveness of shared interactive visualizations in communicating and developing insights.

Research into recording and tracking insight provenance during visual analytics sessions is also illuminating, as it attempts to discover which factors regarding the visualization state, data transformations and patterns of user interaction are significant in effectively capturing and sharing insight. Gotz & Zhou [7] identify a tier of domain independent, semantically meaningful user *Insight Actions* which are *'performed by users as they discover or manipulate the insights obtained over the course of an analysis'* from which they attempt to infer a high level logical structure. Similarly, Gersh et al [6] introduce *rich information collections* in which the analyst's original information collection is augmented with *'an executable specification for finding similar information, and the annotation describing her insight'*. In each case, the visualization tool acts in a way Fischer et al [5] would term a *boundary object*, used to support distributed cognition in creative tasks. Understanding this role, and the techniques that best support it, are important in efforts to reproduce an author's insight experiences in the end-user audience through successful narrative visualization design.

## 4. FUTURE RESEARCH

Investigation should be made into the effect design choices have on the extent to which a narrative visualization is able to tell a compelling story whilst simultaneously facilitating data exploration and insight discovery. This should be guided by Segel and Heer's [17] design categorization and Hullman and Diakopoulos' [9] visualization rhetoric, and informed by discussions about the role of interaction in InfoVis [e.g. 24]. Such studies could be usefully enhanced by building on the neuroscience work of Bowden et al [1], Kounis & Beeman [10] and Sandkhuler & Bhattacharya [14]. This would involve undertaking evaluations that compare factors such narrative structure and data exploration techniques using EEG to record insight experiences. This should be carried out in conjunction with other techniques such as observation or self-reporting, taking further inspiration from the way Carroll & Latulipe [3] have combined these methods to measure creativity support. In this way, it may even be possible to record the pattern of neurological activity present when an author experiences insight during initial explorations and see if there is any correlation with patterns observed in end-users as they later interact with the narrative visualization product.

## 5. CONCLUSION

Narrative visualization is a creative response to the need to communicate effectively and share insights about complex data with a public audience. We believe that their combination of exploratory elements and narrative structure enable authors to communicate discoveries more successfully by reproducing something of the experience of finding them. A better understanding of insight, as both something that is experienced and also as the product of that experience, will further help authors to tell effective data stories. In addition, recording EEG data offers a novel approach to recognizing episodes of insight experience and studying the relationship between narrative structure and interactive data exploration, therefore providing new approaches to the evaluation of narrative visualization.

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# Visualizing Perspectives for Creative Collaboration

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## ABSTRACT

Every day, more and more data is collected, and we are increasingly being provided with open access to it. The hope is that this will be the driving force behind a wave of innovative new businesses that are able to lead us out of our current financial problems and give rise to a generation of better informed, active consumers who will engage with the kind of changes necessary to reduce global warming and prevent a pensions crisis. However it is not enough to simply release this data, people must also be given the tools to understand and engage with it creatively. The research presented here draws together current approaches from data visualization, creativity research and human-computer interaction to provide a framework in which personal data stories can be used to present a range of perspectives and support collaboration between people with different experiences and varying levels of domain expertise.

### Author Keywords

Data visualization, creativity support, user engagement

### ACM Classification Keywords

H.5.m. Miscellaneous.

## INTRODUCTION

That we live in the Information Age has become something of a truism. However, the value created through understanding data is clearly demonstrated in the ongoing success of Google and the IPO valuation of Facebook. It is further evidenced by the impact of the Open Data movement and in the UK government's recently announced *midata* initiative, whereby companies are being encouraged to release personal data back to their customers in secure, portable, electronic formats. The hope is, that through such initiatives, innovative new businesses can be built that will power the knowledge economy and lead us out of the current economic difficulties. Furthermore, it is also hoped that this will encourage consumers in areas such as energy provision, telecoms and financial services to become more active and be better informed. However, it is not sufficient to simply make data available, people must also be given the tools, confidence and motivation to engage with it creatively.

This research aims to support these objectives by enabling people to share their personal perspectives and visualize data not simply to provide an accurate representation, but also as a platform for argument and discussion, for storytelling and scenario testing.

## RESEARCH OBJECTIVES

The overall objective of this research is to study the effectiveness of using data visualization techniques as tools for supporting creativity and engagement. Firstly, as a platform to share perspectives within service design workshops and secondly to encourage and enable everyday creativity in the public. Through it, I aim to address the following questions:

- Can data visualization tools effectively support different experts in sharing their domain specific knowledge?

- Does the introduction of data visualization tools increase the number and value of ideas generated in a collaborative design workshop?

- Do data visualization techniques effectively engage lay audiences?

- Do personal data stories, which present individual perspectives, support users in gaining and sharing insight?

## RELATED WORK

### Information Visualization

Two current perspectives within the Information Visualization community, *narrative visualization* [1, 2] and *social data analysis* [3, 4] provide the background to this research and are covered below. In addition, Isenberg et al [5] provide a review of *collaborative visualization* that will inform its implementation.

#### Narrative Visualization

Whilst storytelling has long been a part of successful data visualization, e.g. Minard's famous map representing the catastrophic loss of troops during Napoleon's ill fated Russian campaign [6], the rise in data journalism [e.g. 7, 8] has seen a renewed focus on this communicative aspect. Segel and Heer [1] present a review in which they describe different visual and interactive devices that support storytelling to communicate insight. Hullman & Diakopoulos [2] demonstrate how technique selection and design tactics influence user interpretation of the original data, thus delivering the author's perspective. This they term *visualization rhetoric*. Such techniques could be used positively and inclusively to enable individual users to

present their own perspectives, promote engagement and encourage creative responses to data.

*Social Data Analysis*

Research into social data analysis, using online resources e.g. Many Eyes [3] and NameVoyager [4], has investigated how visualization technology can be democratized. Similar work with collaborative visual analytics [9, 10] investigates factors supporting awareness of others, establishing common ground and insight sharing. This work suggests there are both opportunities and also potential difficulties in reaching an audience that, whilst motivated, may be inexperienced with visualization tools.

**Collaborative Creativity Research**

Fischer et al [11] have adopted Star's [12] term *boundary object* to describe the kind of shared externalizations that they have created to provide a platform that allows members of *Communities of Interest* to share differing domain expertise and make tacit knowledge explicit. This is a role I believe interactive visualization tools are well suited to as they offer the opportunity to reflect different perspectives on aspects of the same data. This role will be important in engaging the wider public as well as during the design workshops.

**APPROACH**

This research will involve the iterative design and evaluation of prototype systems which enable users to create and share visualizations reflecting their perspective on a dataset and forming generative inputs in collaborative design workshops. This will be based on a user-centred design philosophy and a distributed cognition approach to human-computer interactions. The content and design of these prototype systems will be based on the requirements of specific case studies. The lessons learned from each case study will be fed into any subsequent research with the ultimate aim of providing a set of useful design criteria.

**STATUS OF THE RESEARCH**

A case study with a major energy provider is to be undertaken, starting March 2012 and lasting for ten months. This will investigate ways to engage customers with energy data and smart home and smart meter technology. Work will be undertaken to visualize existing data, both for customer profiling and consumption awareness. These visualizations will be used by staff and customers within collaborative service design workshops to investigate touch points through which the benefits of smart metering and energy conservation can be effectively visualized and communicated to customers.

**CONTRIBUTIONS**

This research will bring together current work within the data visualization, creativity research and human-computer interaction communities in order to investigate the increasingly important question of engaging a lay audience with complex data. This will lead to guidelines for more effective communication and insight sharing. In addition, I aim to show how visualization tools can act as boundary objects, representing different perspectives and supporting the domain specific knowledge and experience of participants in collaborative work.

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# Appendix B: Design Outputs

The case studies reported in chapters 5, 6 and 8 of this thesis were all part of design projects that produced outputs in different forms. Examples of these outputs, and links to accompanying web sites, are included in this appendix.

# 4 Case Study: E.ON

Following the case study undertaken with customers and staff of E.ON Energy, and reported in Chapter 5 of this thesis, a prototype Energy Audit service was developed. This prototype outlined a service that combined data collected from a household's smart meter and smart plugs with data from a sophisticated model of typical patterns of energy consumption and used these to make energy efficiency and money saving recommendations.

This service prototype is demonstrated online at:

http://www.grahamdove.com/energyaudit/
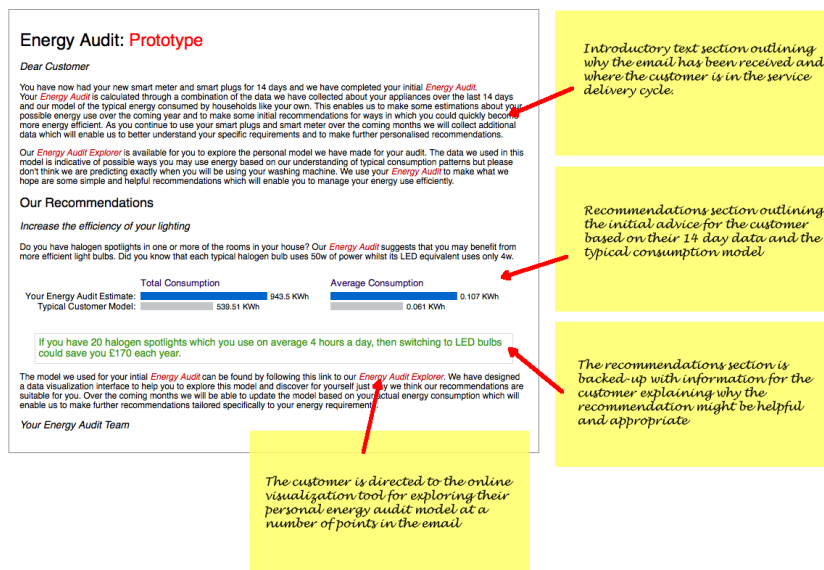


Figure 1: Annotated screenshot of the email sent as part of the prototype service developed as a result of the case study reported in Chapter 5 Case Study: E.ON
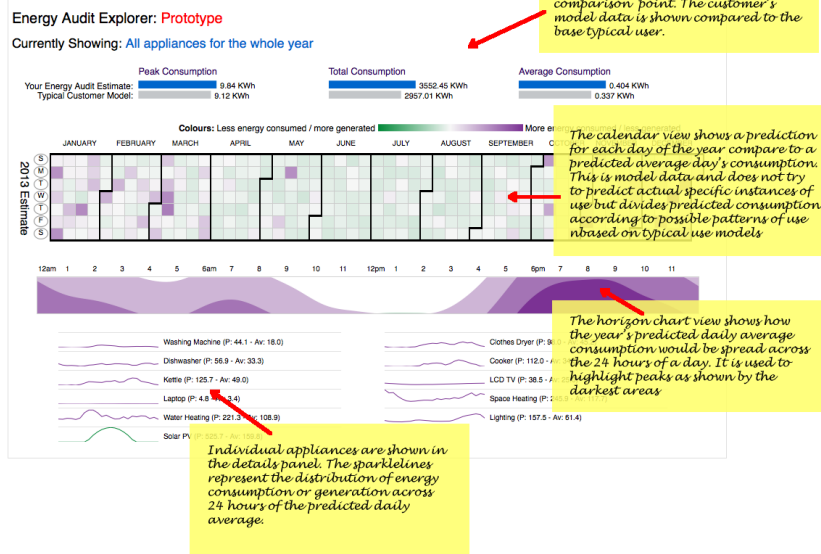
Figure 2: Annotated screen shot of the default view of the web interface of the prototype service developed as a result of the case study reported in Chapter 5 Case Study: E.ON



Figure 3: Annotated screen shot of the single appliance view o of the web interface of the prototype service developed as a result of the case study reported in Chapter 5 Case Study: E.ON

# 5 Case Study: MIRROR

Following the case study undertaken with representative of the MIRROR European FP7 research project, and reported in Chapter 6, the knowledge captured was built into a web site. This web site represents the design knowledge generated during the workshop and is available online at:

http://www.grahamdove.com/mirror/
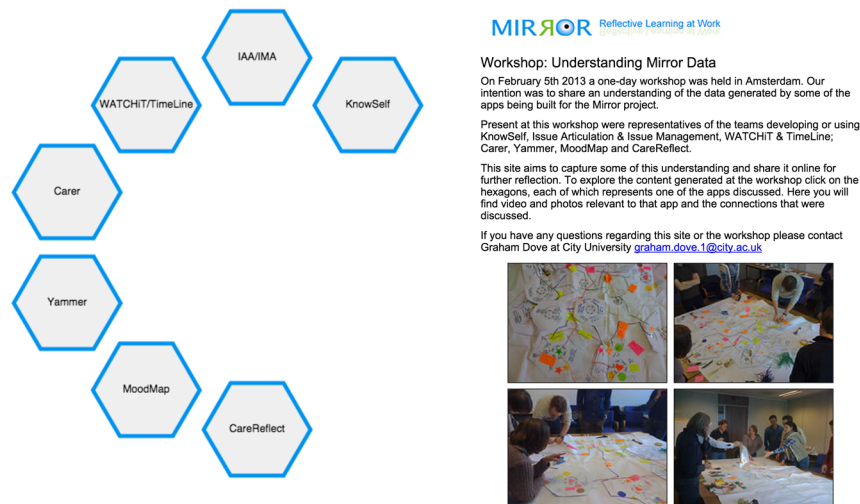


Figure 4: Screen shot of the web site developed to capture the design knowledge generated for the case study reported in Chapter 6 Case Study: MIRROR

# 6 Case Study: One Small Change

The case study reported in Chapter 8 Case Study: One Small Change was part of an ongoing design project in which I am working with representatives of City University London's Environmental Champions network and to design a service that will encourage environmentally sustainable behaviour, as part of the Nation Union of Students' Green Dragons initiative. The proposal outlining the co-designers' selected design idea that was presented to the NUS is included on the following pages.

one
small
change

How can we make general waste the bin of last resort?

# One Small Change: Design Proposal

## Summary

City University London is committed to achieving key sustainability measures, including a reduction in the amount of waste being generated and improved recycling rates. One Small Change is a project supported by the Student Union's Green Dragon's initiative that aims to use the creativity of City students and staff to develop a service that will support this by encouraging simple changes in behaviour that are both effective and long lasting. In the One Small Change design workshops we identified the large number general waste for incineration bins as a potential barrier to ongoing improvements in environmentally friendly behaviours. These general waste for incineration bins appear to be the default option, both when bins are being deployed and also when waste is being disposed of. We aim to address this by redesigning the way information about waste and recycling bins is displayed to include key data about waste, reuse and recycling in a context of messages that motivate environmentally friendly behaviour change in both an immediate and ongoing basis. These messages will be displayed within existing facilities and will aim to encourage students and staff to identify simple changes in their own behaviour that can be adopted easily and effectively.

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mobile: ███████████

# Background

City University London has a commitment to sustainability that includes a Sustainability KPI within the University's Strategic Plan. One Small Change is a project supported by the Student Union's Green Dragon's initiative that aims to use the creativity of City students and staff to develop a service that will support this by encouraging simple changes in behaviour that are both effective and long lasting.

# Current Situation

Stage one of the One Small Change project design workshop was to identify an opportunity through which we might help reduce the amount of waste generated at City University London through prevention or reuse; or if we cannot reduce the amount of waste generated, then to increase the amount of that waste that is correctly recycled. During this workshop we investigated two key data sets. The first reflecting the motivations for and barriers to students' environmentally friendly behaviours and the second indicating the ways in which different categories of waste bin are used or misused. Here we identified two key insights:

1. *There are more general waste for incineration bins than bins for recycling.*
2. *The general waste for incineration bins are more likely to be contaminated with items that should be recycled than recycling bins are with items that can't.*

Our investigation of the reasons underlying these insights identified a number of factors that might be contributing to the current situation:

- *General waste for incineration bins may already be in place and will therefore not be removed or replaced*
- *General waste for incineration bins are considered the default option both when adding a new bin and when choosing a bin to throw items into*
- *Environmental concerns are not considered to be a key interest for students*
- *There is less thought needed to dispose of items in the general waste for incineration bins*
- *There is limited awareness of options that may be available for reusable utensils and containers*
- *Labelling may be unclear and there may be limited awareness of what can be recycled*
- *Placing recyclable items in a general waste for incineration bin is not widely considered to be contamination*

## Project Goals

**"How can we make general waste for incineration the bin of last resort?"**

The insights gained during our initial workshop activities were distilled into the problem statement: *"How can we make general waste for incineration the bin of last resort?"*. This statement represents our aim to change the way general waste for incineration bins are both used and also deployed.

Our first goal is to go some way towards changing the behaviour of City University's students and staff so that the general waste for incineration bins are not considered the default or easiest option; the one that takes the least thought and effort; or the one to use because you are unsure or unaware of where else your waste should go.

Our second goal is to change the idea that so many general waste for incineration bins are required. Where there is limited space it should not be always be the case that a general waste for incineration bin is the one chosen, environmentally friendly behaviours may be better supported by not deploying a bin at all or by deploying an alternative bin for recycling.

## Creative Strategy

To address this situation we propose a simple intervention in which relevant information and key data are displayed at the locations that waste bins are deployed and at the outlets where packaging and waste often originate. These data displays will address the factors identified as motivating students to adopt environmentally friendly behaviours such as:

- *Make people feel confident that their behaviour change is real and has impact*
- *Highlight the positive effects of environmentally friendly behaviour*
- *Encourage a sense of responsibility and awareness*
- *Inform, educate and highlight positive rewards*
- *Make it fun and relevant to things that are done on a daily basis*

In addition to addressing the factors that immediately motivate environmentally friendly behaviour, these data displays will also appeal to the self-transcendent values of universalism and benevolence that are associated with continuing sustainable behaviours. To achieve this mix, each of the data displays will include imagery that highlights the positive, community aspects of City University life encouraging empathy and care for the welfare of other students and staff; or alternatively presents a picture of a positive natural environment in a City University context. Alongside this, some data

representing an environmental achievement or target to be reached should be shown. Photos of real City University students and staff along with real messages about how their selected behaviour change has had a positive impact on waste data should be used. Existing schemes such a City's Environmental Champions and Green Dragons might be used to identify students and message.

## Example messages

These examples show how we might create messages that display key data and information to encourage environmentally friendly behaviour. Here the aim is to reduce the number of disposable coffee cups being used at City University. This is achieved by demonstrating how a simple act can have real impact. A sense of empowerment, responsibility and ownership is encouraged by showing how individuals are able to make active choices and a sense of community and empathy for others is encouraged by asking people to respond to the challenge of find their own small change. Finally where information about the type of waste that goes into the general waste for incineration bins is given that information also encourages people to make or request alterative choices that are more sustainable.



Figure 1: A Simple Message Showing Positive Data About Sustainability



Figure 2: A Message Appealing to Community and Responsibility

Figure 3: Message Informing About Items of Waste for Incineration Bins and Alternative Choices

## Implementation Strategy

There are a number of opportunities to display relevant information and key data at the sites of existing waste and recycling bins. These include A4 frames and spaces on the body of these bins. Examples of where these opportunities are to be found can be seen in the appendix to this report. The A4 frames would be suitable for messages printed onto card or high quality paper. This would mean they could be produced and updated entirely in-house at City University, allowing them to be refreshed and replaced on a regular basis such as once a month. To utilise the spaces on the bodies of waste and recycling bins, messages and information would need to be printed onto self-adhesive plastic film. This would make them less suitable for updating on a frequent basis.

To achieve the best possible results on an ongoing basis we should, wherever possible, take advantage of the skills, knowledge and facilities already in place at City University London. With this in mind, members of City's Property and Facilities department, representatives of the Student Union and City's Environmental Champions should be asked to select and supply the key data outlining ongoing sustainability performance. These data would be combined with different templates that contain the elements representing individual motivational messages and values led environmentally friendly behaviour change triggers. To encourage and maintain interest, there should be a number of different templates that address different motivational messages and

behaviour change triggers, which could then be combined with different data targeting different instances of change and refreshed on a regular basis. Again, to take advantage of the skills and knowledge held in-house at City, these templates could be designed in conjunction with City University's Marketing department.

### Prototype Evaluation

Prior to implementation a suitable evaluation of prototypes should be undertaken. This would start with a comparison of the effects of different data, messages and design templates to investigate their effectiveness. Once the most effective designs have been identified these should be developed into a full-scale prototype. This prototype should first be evaluated to check that the messages remain effective when associated directly with the relevant waste or recycling bin. Following this the prototypes should be evaluated in situ alongside existing waste and recycling bins. The messages should be evaluated on the basis of their effectiveness in encouraging environmentally friendly behaviour change in both the immediate and longer terms.

### Prototyping Development Budget

The majority of the prototyping and evaluation work can be undertaken using existing facilities at City University London. A small cost will be incurred in purchasing high quality paper or card to use in the A4 display frames. The major cost associated with developing prototypes to evaluate will be incurred printing the self-adhesive plastic needed to display messages and information on the bodies of waste and recycling.

**Associated costs:**

Printing for A4 place holders: £50.00

Printing custom self-adhesive plastic messages: £250.00

Additional workshop and evaluation costs: £200.00

## Development Schedule

August and September 2014: Initial design and evaluation of data displays, information design and behaviour change messages.

October 2014: Development and evaluation of prototype data displays

January 2015:  Further test deployment of One Small Change data displays

# Appendix 1: Spaces Where Data Might Be Displayed
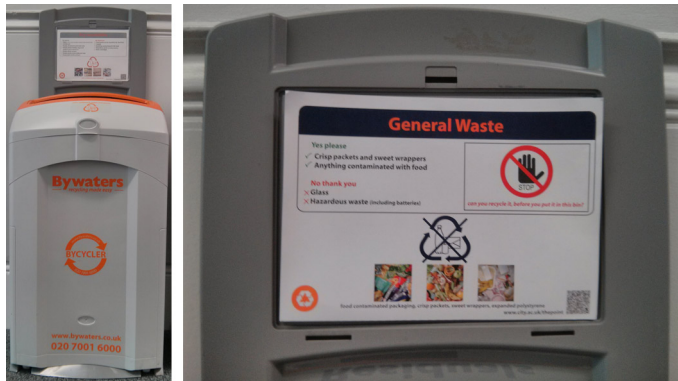


Figure 4: Example of A4 Display Space on Waste Bin



Figure 5: Alternative Example of A4 Display Space with Waste Bin
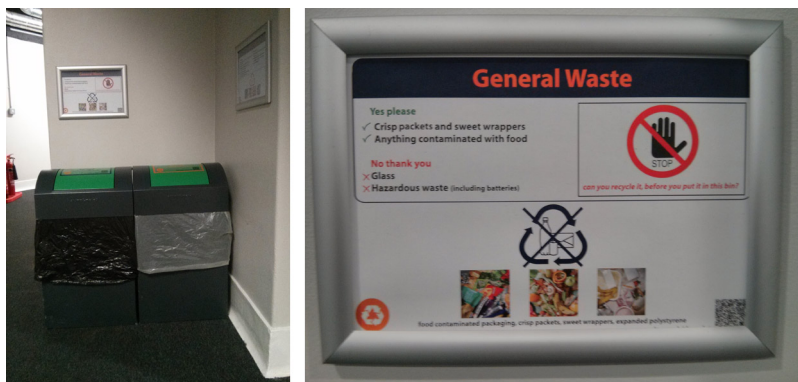


Figure 6: A4 Frame Used with Smaller Waste Bins



Figure 7:Alternative Spaces Where Data Might Be Displayed

# Appendix C: Workshop Materials

This appendix contains examples of the various workshop and evaluation materials used in each of the studies reported in this thesis. This includes examples of worksheets; the materials used in generative design toolkits; supplementary information sheets; questionnaires; and the prompts given to co-designers on Reflection Postcards

# 7 Ambiguity in Visual Encodings

In the study reported in Chapter 4 Ambiguity in Visual Encodings participants used two information visualization interfaces. These can be used online at:

http://www.grahamdove.com/eon/infovis1.html

http://www.grahamdove.com/eon/infovis2.html

They were also given a selection of typical workshop stationary: post-it notes, flip-chart sheets, coloured marker pens.

## 7.1 Activity 1

During Activity 1 the following definitions, synonyms and antonyms of control were displayed for participants using a projector.

### 7.1.1 Definitions of Control

*The power to influence or direct people's behaviour or the course of events*
*The ability to manage a machine, vehicle or other moving objects*
*The restriction of an activity, tendency or phenomenon*
*The ability to restrain one's own emotions or actions*
*A switch or other device by which a device or vehicle is regulated*
*The place from which a system or activity is directed or where a particular item is verified*

### 7.1.2 Synonyms of Control

Ascendency, Authority, Direction, Discipline, Guidance, Limitation, Restraint, Supervision

### 7.1.3 Antonyms of Control

Helplessness, Powerlessness, Relinquishment, Renouncement, Risk, Rush, Weakness

# 7.2 Evaluation Materials

Each participant was given a questionnaire to complete after each round of activities. This questionnaire was to gather evaluation data and was the same both times.

## 7.2.1 Post-activities Evaluation Questionnaire

**Participant #:_____       Visualisation:_____**

Please rate how you feel about using the visualisation of energy data according to the following statements. In each case the scale runs from 1 to 5, where 1 is strongly agree and 5 is strongly disagree.

A.   I was very engaged and absorbed using the visualisation. I enjoyed it and would do it again.

Strongly Agree 1          2          3          4          5        Strongly Disagree

B.   I was prompted to generate ideas that were new and varied.

Strongly Agree 1          2          3          4          5        Strongly Disagree

C.   I was able to work together with others easily.

Strongly Agree 1          2          3          4          5        Strongly Disagree

D.   I felt able to explore many different options, ideas or outcomes.

Strongly Agree 1          2          3          4          5        Strongly Disagree

E.   I could easily identify relationships and patterns in the data that contributed to new ideas.

Strongly Agree 1          2          3          4          5        Strongly Disagree

F.   It was easy for me to gain an overview of the data using the visualisation.

Strongly Agree 1          2          3          4          5        Strongly Disagree

G.   I was able to combine my existing knowledge with insights from exploring the visualisation to generate ideas that I had not previously considered.

Strongly Agree 1          2          3          4          5        Strongly Disagree

# 8 Case Study: E.ON

In the study reported in Chapter 5 the co-designers used a single information visualization interface. The guide they were given for this visualization interface is included below. The information visualization interface can be used online at:

http://www.grahamdove.com/eon

They were also given a Generative Design Toolkit. This included custom worksheets, photographs and stationary, such as coloured marker pens and paper shapes, to complete the worksheets during different activities.

# 8.1 Information Visualization Guide

## Energy Consumption Explorer: Guide for Users

### Time of Day View
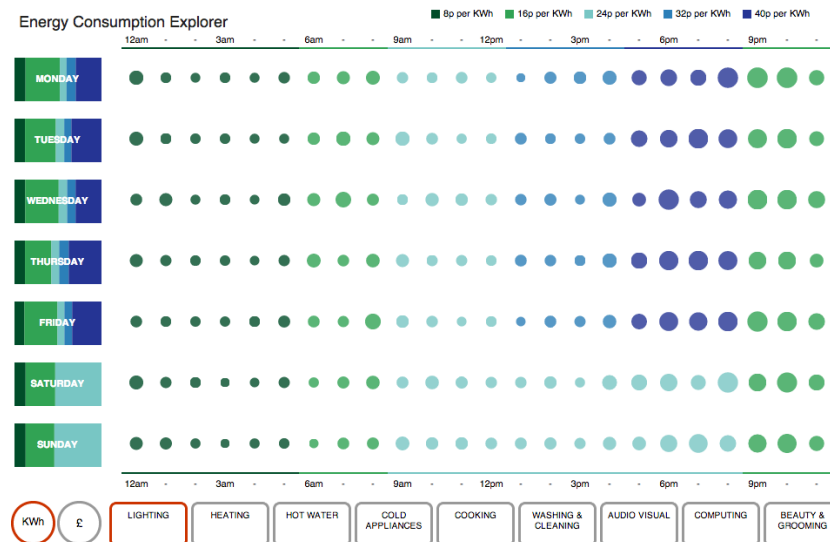


The visualisation represents one weeks energy consumption of a single household. It shows the week from Monday to Sunday vertically down the screen. Horizontally across the screen, each 24 hour period is represented from midnight to midnight. Each bubble is scaled to reflect the amount of energy consumed within a single hour period. You may also notice that there are five different colours of bubble. Each colour represents a different price band for the energy consumed in that time. There is a key to these prices in the top right of this screen.

### Appliance Buttons



Along the bottom of the screen there are a series of buttons. Selecting any one of these alters the data being viewed. For example selecting COLD APPLIANCES will show the data for any fridges and freezers or selecting WASHING & CLEANING will show the data for appliances such as washing machines, dishwashers, irons or vacuum cleaners. The currently selected appliance button is shown with a red border.

## Scale Buttons
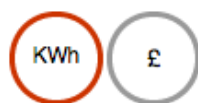


To the left of the appliance type buttons are the scale buttons. Selecting these allow you to vary the scale of the bubbles to show either the amount of energy consumed during that hour in KWH or the cost of that energy in pence.

## Details View
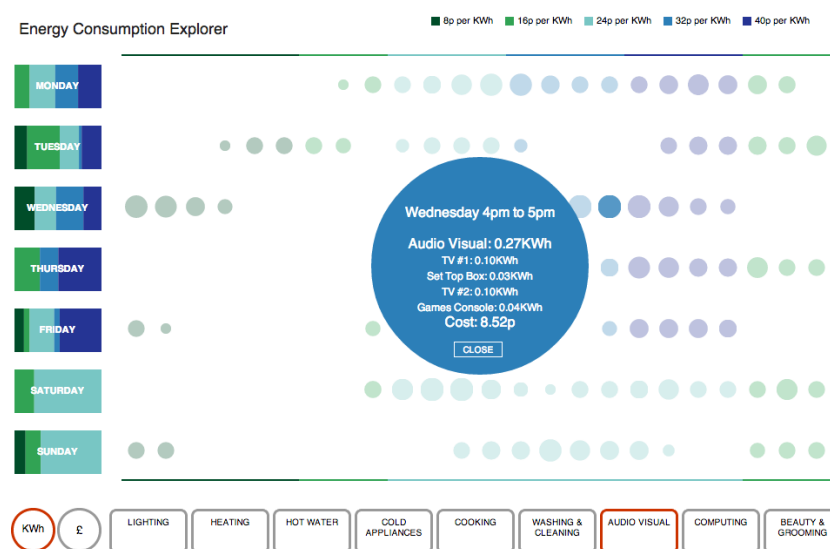


Selecting an individual bubble (by tapping it) will bring up the detailed view for that particular hour and appliance type. In the detailed view you will see the time period covered, the energy used for the appliance type and then for individual appliances. Finally the cost of the energy consumed at that time is shown.

## Day Buttons



On the left hand side of the screen are a series of buttons, one for each day of the week. These buttons are split into the same colours as those used for the bubbles. The proportion of each individual

colour represents the percentage of energy used within the relevant time period during the day. For example the amount of dark green reflects the percentage of energy used between midnight and 6am, whilst the amount of dark blue reflects the percentage of energy used between 5pm and 9pm. Selecting any one of these day buttons will lead to the view of the whole day details.

## Day Details View
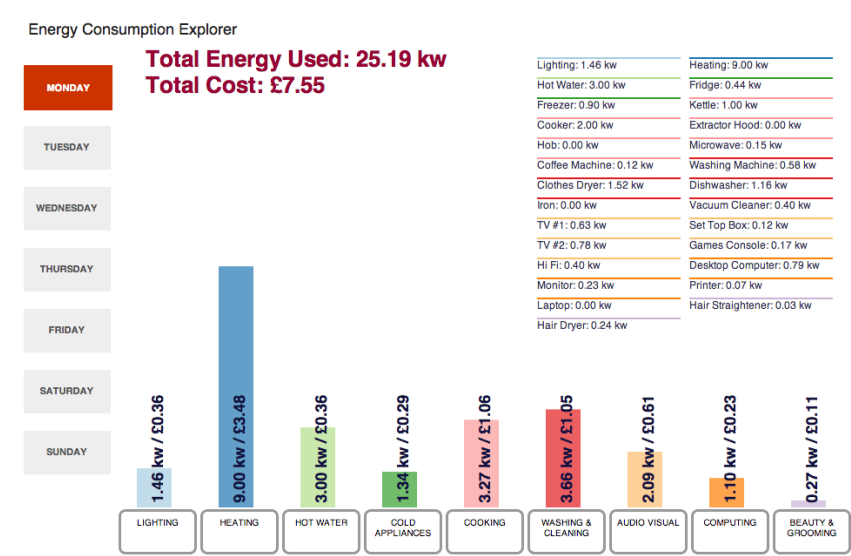


The view of each day's details will show you the total energy used for that day and the total cost of that energy for the day. Further details of the energy used and its cost for that day, in each of the appliance types, is shown in the main bar chart. Finally the total energy for the day used by each of the individual appliances being measured is shown in the table top right of the screen. Selecting any of the day buttons to the right of the screen will display the data relevant for that day. Selecting any of the appliance buttons will return you to the relevant time of day view.

# 8.2 Photographs

The toolkit contained around 300 different photographs taken from online sources and arranged into five categories. Three examples taken at random from each category are shown below.

# 8.3 Worksheets

Co-designers were given custom worksheets to help organise their ideas during activities.

## 8.3.1 Activity 1

**WHO LIVES HERE? DESCRIBE YOUR IMAGINED HOUSEHOLD**

What is their name?

What do they look like?

How do they feel about technology?

How do they feel about energy?

What type of property do they live in?

How do they eat?    How do they travel?
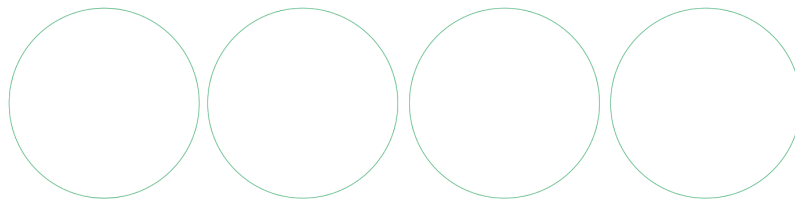
Figure 20: A1 sized worksheet used in Activity 1 of Chapter 5 Case Study E.ON

## 8.3.2 Activity 3
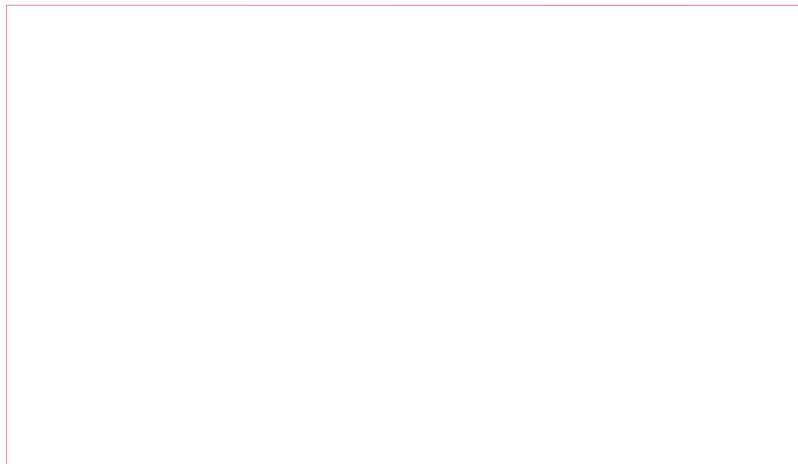
**SMART HOME HOUSEHOLD DATA**

**WHAT DATA IS BEING COLLECTED?**

**HOW DO YOU FEEL ABOUT THIS?**

**HOW COULD THIS DATA BE USED TO IMPROVE YOUR LIFE?**
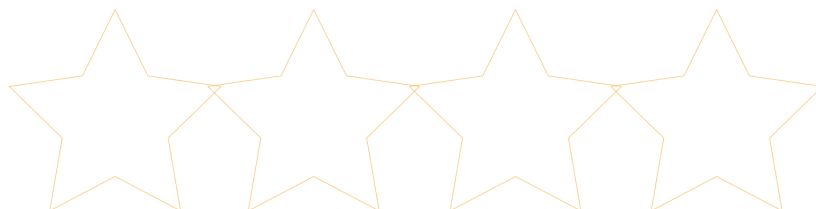
Figure 21: A1 sized worksheet used x4 in Activity 4 of Chapter 5 Case Study E.ON

## 8.3.3 Activity 5

**WHAT IS IT LIKE TO USE YOUR SERVICE?**

**WHAT HAPPENS WHEN YOU SIGN UP?**

Figure 22: A1 worksheet for Service Sign Up used in Activity 5 of Chapter 5 Case Study E.ON

# WHAT IS IT LIKE TO USE YOUR SERVICE?

**WHAT HAPPENS THE FIRST TIME YOU USE IT?**

Figure 23: A1 sized Service First Time Use worksheet used in Activity 5 of Chapter 5 Case Study E.ON

# WHAT IS IT LIKE TO USE YOUR SERVICE?

**WHAT HAPPENS WHEN ITS AN ESTABLISHED PART OF YOUR LIFE
AND YOU USE IT REGULARLY?**
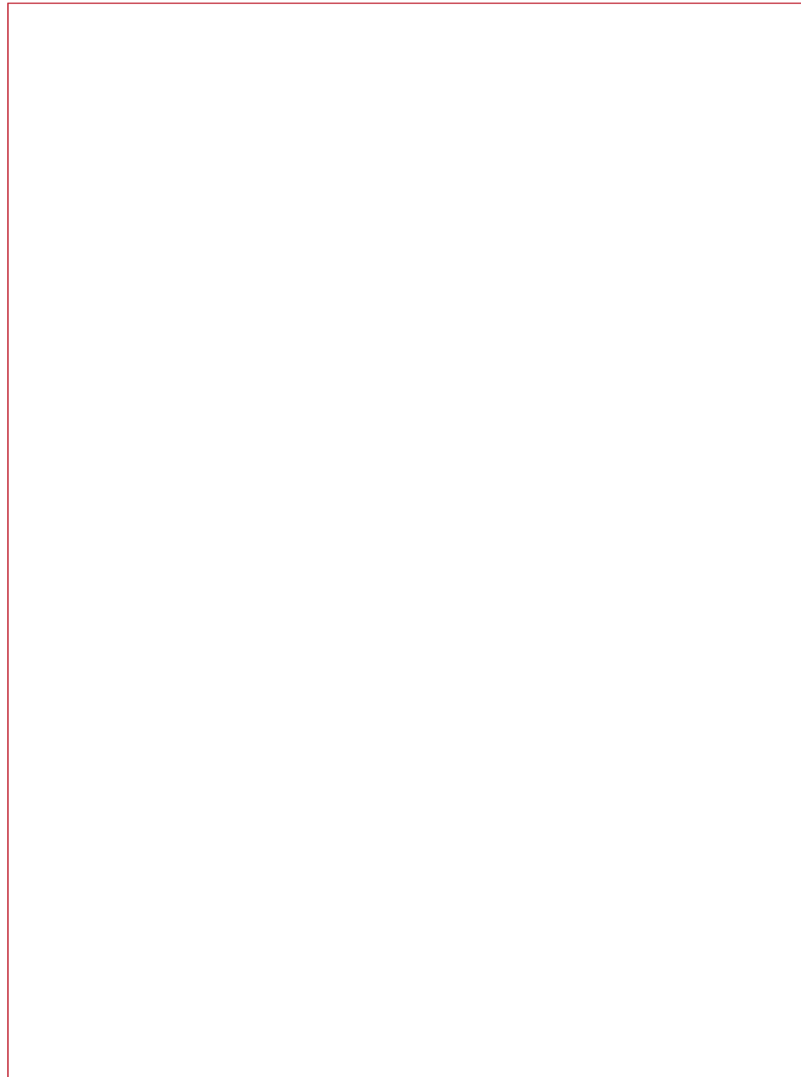
Figure 24: A1 sized Service Regular Use worksheet used in Activity 5 of Chapter 5 Case Study E.ON

### 8.3.4 Activity 2

To complete Activity 2 co-designers were given a competition entry form to complete. This is reproduced below:

# Win a State of the Art Smart Home

We are offering one lucky household the opportunity to completely retro-fit their home with the latest and smartest in household management technology. Designed to maximise your energy efficiency, improve security and deliver an unmatched level of comfort, control and convenience, your new smart home will be the envy of friends and neighbours alike. For your chance to win simply tell us five ways in which you could use energy more efficiently, and five ways to reduce your energy bill. As a tie-breaker, tell us in one short paragraph what piece of smart home technology, real or imagined, would most change your life for the better and how it would do so.

| Ways I could use energy more efficiently | Ways I could reduce my energy bill. |
|---|---|
| 1. | 1. |
| 2. | 2. |
| 3. | 3. |
| 4. | 4. |

What piece of smart home technology, real or imagined, would most change your life for the better? And how would it do so?

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

# 8.4 Evaluation Materials

To evaluate this study co-designers were given three Reflection Postcards to complete. The prompt on each of these postcards is listed below:

## 8.4.1 Reflection Postcard #1

*"Please reflect on your involvement in the previous two activities. Write a few sentences thinking in particular about how engaged you were, how absorbed or distracted, and how easily you feel you worked with other members of your team. Try to think about the extent to which the technology helped or hindered you in this regard"*

5.                                    5.

What piece of smart home technology, real or imagined, would most change your life for the better? And how would it do so?

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

## 8.4 Evaluation Materials

To evaluate this study co-designers were given three Reflection Postcards to complete. The prompt on each of these postcards is listed below:

### 8.4.1 Reflection Postcard #1

*"Please reflect on your involvement in the previous two activities. Write a few sentences thinking in particular about how engaged you were, how absorbed or distracted, and how easily you feel you worked with other members of your team. Try to think about the extent to which the technology helped or hindered you in this regard"*

### 8.4.2 Reflection Postcard #2

*"Please reflect on your understanding of the information contained in the data visualization. Write a few sentences, thinking in particular about how easily you managed to gain an overview of what was represented. Also think about how quickly you grasped what the information meant, did you spot clear patterns and relationships or did you find it confusing? Did it prompt you to think of ideas you had not previously considered?"*

### 8.4.3 Reflection Postcard #3

*"Please reflect on how you used the data visualization to first create your household and then to devise competition answers. Write a few sentences, thinking in particular about how easily you were able to explore possible options and come up with different ideas. Did you use your prior knowledge as well as the information shown? And how easy you found it to relate that prior knowledge to the data?"*

# 9 Case Study: MIRROR

In the study reported in Chapter 6 co-designers were given a Generative Design Toolkit. This included custom worksheets, materials (including embroidery thread, cut out figures and domain-relevant words) and stationary (such as coloured marker pens and paper shapes) to complete the worksheets during different activities.

## 9.1 Worksheets

Co-designers were given custom worksheets to help organise their ideas during activities.

### 9.1.1 Activity 1
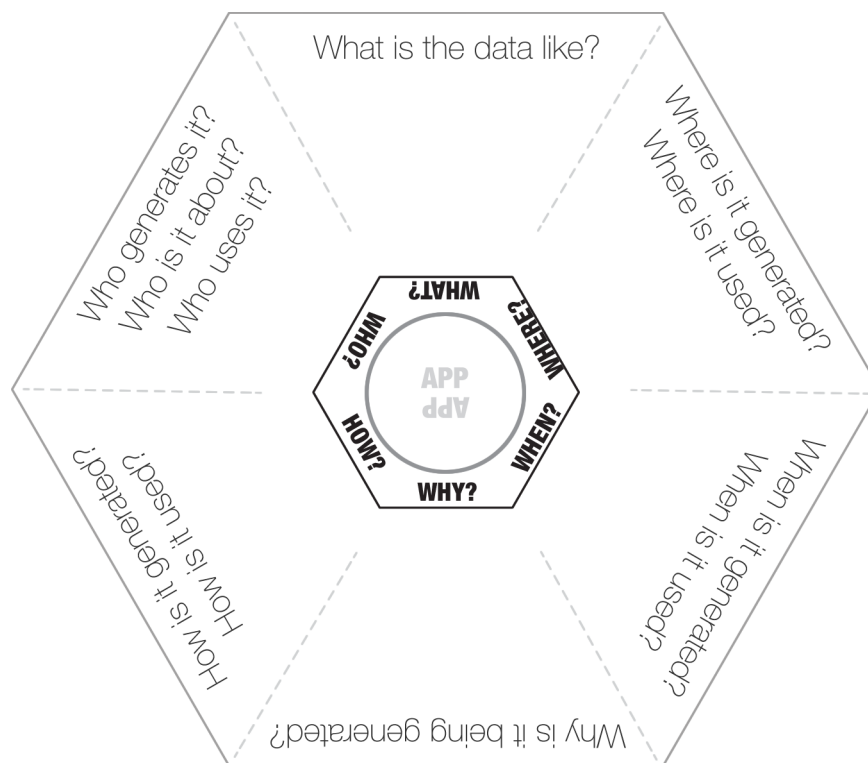


Figure 25: A2 sized hexagonal 5WsH worksheet used in Activity 1 of Chapter 6 Case Study MIRROR

## 9.1.2 Activity 3
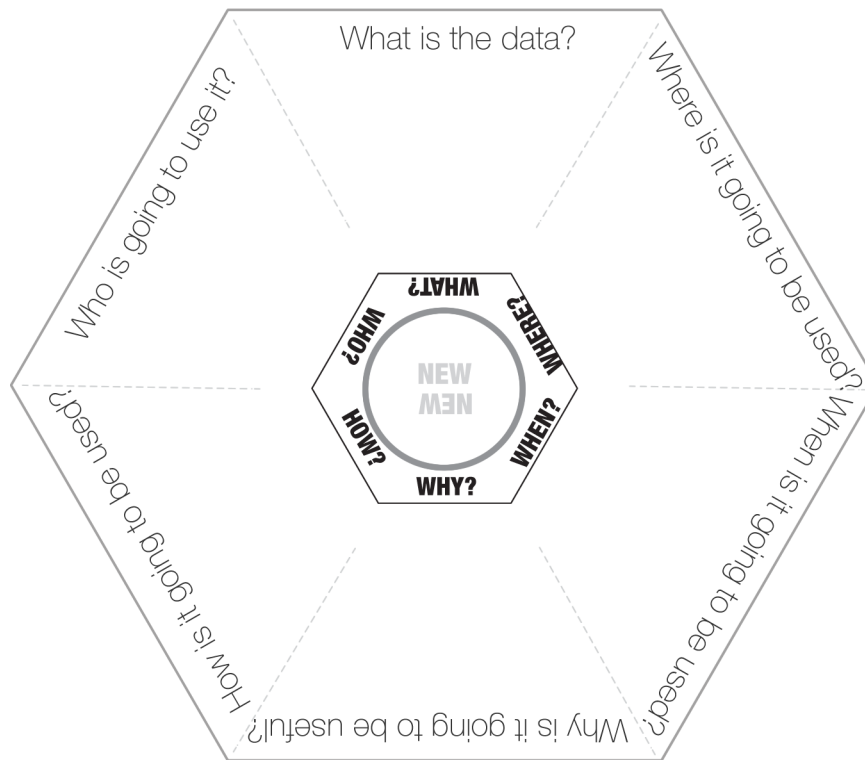


Figure 26: A3 sized hexagonal 5WsH worksheet used in Activity 3 of Chapter 6 Case Study: MIRROR

# 9.2 Evaluation Materials

To evaluate this study co-designers were given three Reflection Postcards to complete. The prompt on each of these postcards is listed below:

## 9.2.1 Reflection Postcard #1

*"Do you feel that the workshop has increased your understanding of the data being generated in the Mirror Project? Does the map we created represent this understanding?"*

### 9.2.2 Reflection Postcard #2

*"Do you feel that you were able to contribute new ideas and suggestions to the workshop? Were these reflected in the map we created?"*

### 9.2.3 Reflection Postcard #3

*"Do you feel that you were able to express your perspective on the Mirror Project data? Was this satisfactorily represented when we created the map?"*

# 10 Analytical & Intuitive Creativity

In the study reported in Chapter 7 participants in two of the four conditions used one of two digital design artefacts. These can be used online at:

http://www.grahamdove.com/energyshift/infovis.hml

http://www.grahamdove.com/energyshift/photos.html

Participants in another of the conditions were given two printed reports which are available online (Energy Savings Trust, 2012; Energy Savings Trust, 2011).

Participants in all conditions were given two supplementary information sheets, two worksheets to complete the activities, and a selection of workshop stationary. This included coloured marker pens and post-it notes.

## 10.1 Supplementary Information Sheets

All participants were given a brief document outlining the problem space and a guide document containing four questions. The content of each of the documents is reproduced below.

### 10.1.1   The Brief Document

### How Can We Use Domestic Energy More Sustainably?

*'The aim of this challenge is to come up with ideas for new products, technologies, services or incentives that shift domestic electricity demand to off-peak times in order to reduce carbon emissions.'*

The UK's electricity system is under increasing pressure to keep up with demand. When we flick the switch to turn on the lights, or use our electrical appliances, we expect them simply to turn on and work. Electricity cannot be stored easily, which means generation needs to be well adjusted to demand and demand fluctuates

throughout the day (see Figure 1). To ensure there is sufficient reserve capacity to maintain continuous supply during peak demand times requires a number of hot standby power stations to be in constant operation. The majority of these power stations are currently gas or coal-fired. Pressure on and from governments to move towards a low carbon economy adds complexity to this problem through the increased use of decentralised renewable energy generation. Renewable energy sources such as wind, wave and tidal energy are generally $CO_2$ neutral but are intermittent due to the unpredictable nature of the weather.
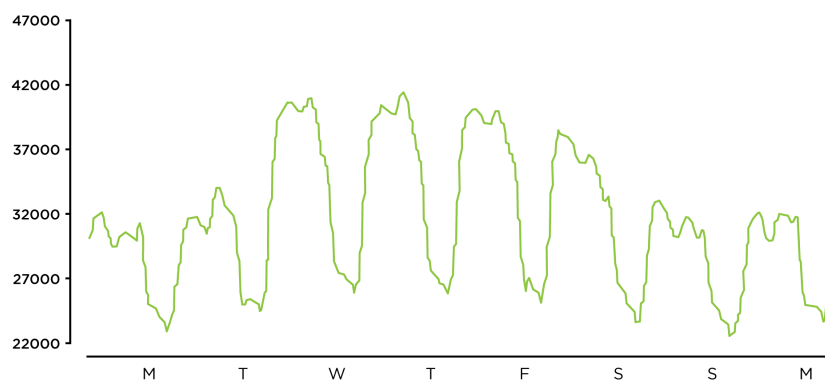
Figure 27: Electricity demand over seven-day period in May 2013 from Brief document Chapter 7 Analytical & intuitive Creativity

One solution to this problem is to flatten out demand for electricity by encouraging and enabling domestic energy consumers to move some of their consumption away from times of peak demand, which might be achieved by products that incorporate dynamic demand features. Dynamic demand requires domestic appliances to respond to an exchange of information with the national grid and adjust their own power consumption accordingly. Alternatively, consumers might make a conscious decision to shift their demand manually by choosing to use their domestic appliances during off-peak hours. In either scenario consumer engagement and support is key. This might be achieved through new services or incentives.

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Your responses to this challenge might be ideas for engineering products that manage the shift in electricity demand away from peak demand times automatically. They could be ideas for products or services that support consumers in managing this shift manually. They could be ideas for incentives that encourage people to adopt new technologies, take up new services or change their energy consumption behaviour. Your ideas might focus on individual households or they might be aimed towards whole communities such as local neighbourhoods or virtual communities. Please think of as many ideas as you can. You will later be asked to select and further develop your most creative idea.

## 10.1.2    The Guide Document

### How Can We Use Domestic Energy More Sustainably?

*How might different people use electricity?*
*What might be taking place that causes peaks in demand?*
*What are the constraints that cause electricity to be used*
   *at certain times?*
*How might these constraints be overcome?*

# 10.2 Worksheets

## 10.2.1    Activity 3

**IDEAS FOR SHIFTING ELECTRICITY CONSUMPTION AWAY FROM PEAK TIMES**

**INDIVIDUAL HOUSEHOLDS**

**TECHNOLOGY**

**BEHAVIOUR CHANGE**

**COMMUNITIES**
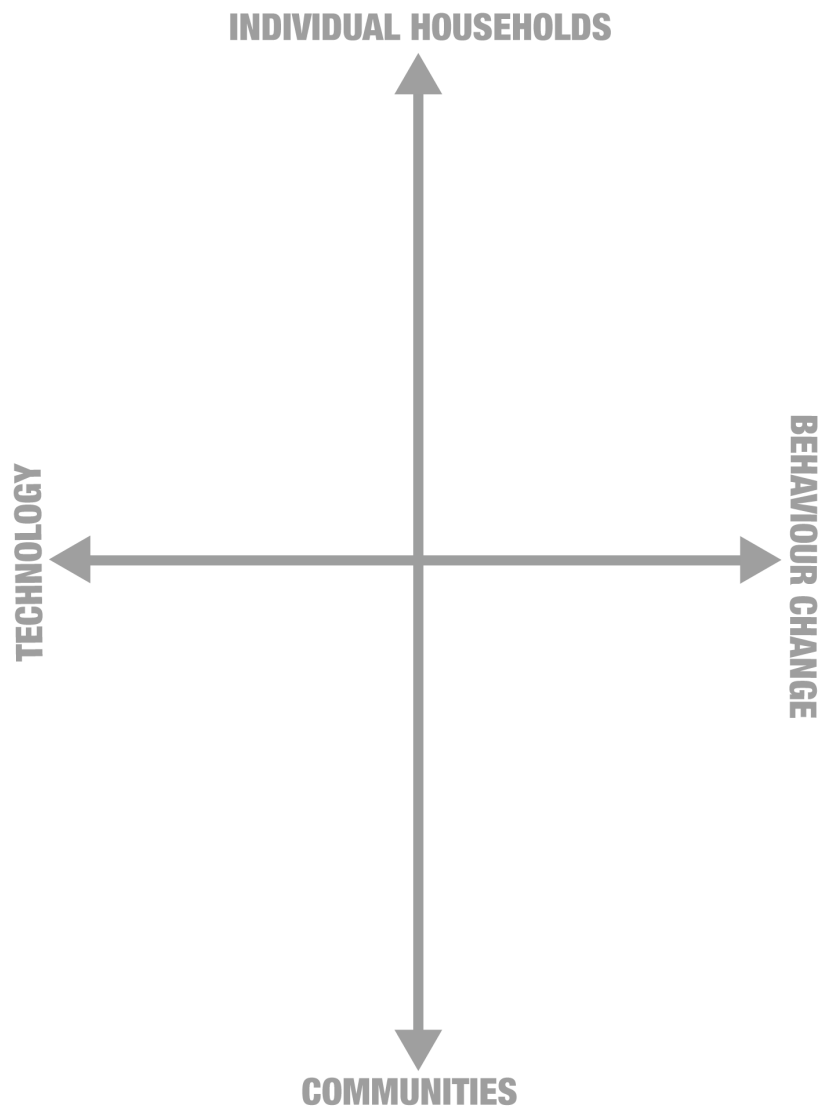
Figure 28: A1 sized worksheet used in Activity 3 of Chapter 7 Analytical & Intuitive Creativity

## 10.2.2 Activity 4
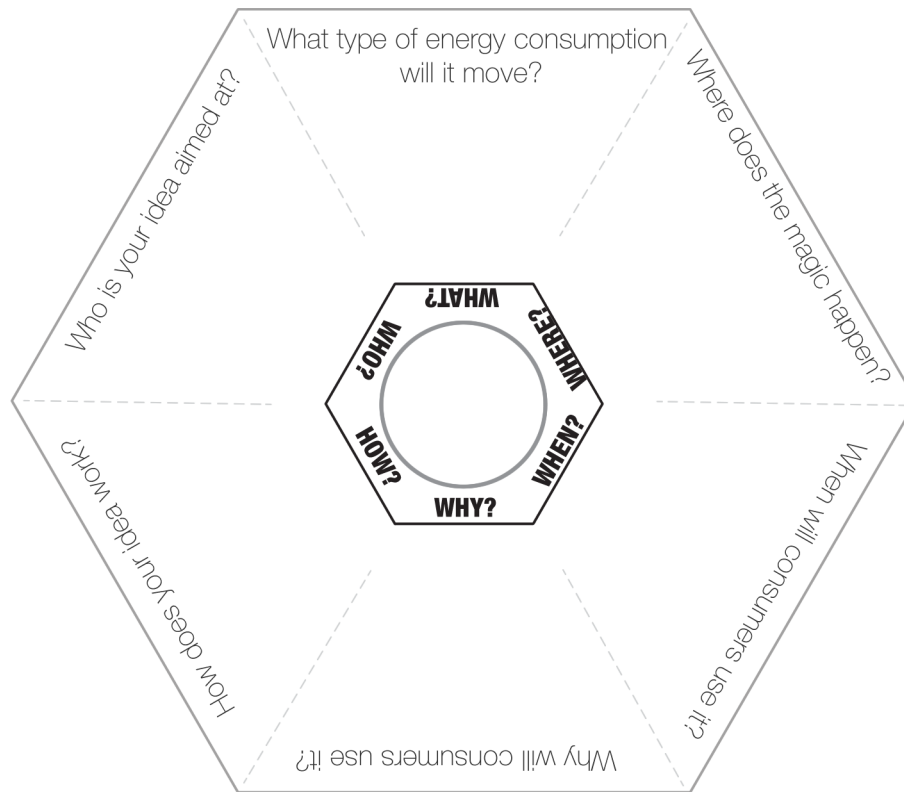


Figure 29: A1 sized hexagonal 5WsH worksheet used in Activity 4 of Chapter 7 Analytical & Intuitive Creativity

# 10.3 Evaluation Materials

Each participant in the conditions using either of the digital design artefacts or the printed reports was given a questionnaire to complete at the end of the workshop. The questionnaire given to those participants using the information visualization representing smart energy data is reproduced below. For those participants who used the visualization of Flickr photographs references to *the iPad information visualization* were replaced with references to the *iPad photo visualization* and with *energy data reports* for those participants who used the printed reports.

## 10.3.1 Post-workshop Questionnaire

Participant No_____

Please read the following statements and indicate to what degree you are in agreement. In all cases please rate your agreement from 1 meaning you strongly disagree with the statement to 9 meaning that agree strongly with the statement.

I was satisfied with what I achieved using the iPad information visualization:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

-------------------------------------------------------------------

It was easy for me to explore many ideas, options or outcomes using the iPad information visualization:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

-------------------------------------------------------------------

The iPad information visualization allowed other people to work with me easily:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

-------------------------------------------------------------------

I would be happy to use the iPad information visualization on a regular basis:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

-------------------------------------------------------------------

I was able to be very creative whilst doing this activity using the iPad information visualization:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

-------------------------------------------------------------------

My attention was fully tuned to the activity and the iPad information visualization was not intrusive:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

-------------------------------------------------------------------

I enjoyed using the iPad information visualization:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

-------------------------------------------------------------------

The iPad information visualization was helpful in allowing me to track different ideas, outcomes or possibilities:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

-------------------------------------------------------------------

What I was able to produce while using the iPad information visualization was worth the effort I had to exert to produce it:

Strongly Disagree   1   2   3   4   5   6   7   8   9   Agree Strongly

----------------------------------------------------------------------

Using the iPad information visualization allowed me to be very expressive:

Strongly Disagree   1   2   3   4   5   6   7   8   9   Agree Strongly

----------------------------------------------------------------------

It was easy to share ideas with other people using the iPad information visualization:

Strongly Disagree   1   2   3   4   5   6   7   8   9   Agree Strongly

----------------------------------------------------------------------

I became absorbed in the activity and was not distracted by difficulties encountered using the iPad information visualization:

Strongly Disagree   1   2   3   4   5   6   7   8   9   Agree Strongly

----------------------------------------------------------------------

I had many ideas as a result of using the iPad information visualization:

Strongly Disagree   1   2   3   4   5   6   7   8   9   Agree Strongly

----------------------------------------------------------------------

The iPad information visualization played an important role in the ideas I had:

Strongly Disagree   1   2   3   4   5   6   7   8   9   Agree Strongly

Please read the following statements and in each case indicate which of the two options is most important to you.

When using the iPad information visualization it is more important that I can...

| Explore many different ideas, possibilities or outcomes | OR | Work with other people |
| --- | --- | --- |
| Be creative and expressive | OR | Produce results that are worth the effort I put in |
| Enjoy using the iPad information visualization | OR | Become immersed in the activity |
| Become immersed in the activity | OR | Produce results that are worth the effort I put in |

| | | |
|---|---|---|
| Work with other people | OR | Enjoy using the iPad information visualization |
| Produce results that are worth the effort I put in | OR | Explore many different ideas, possibilities or outcomes |
| Be creative and expressive | OR | Become immersed in the activity |
| Work with other people | OR | Produce results that are worth the effort I put in |
| Be creative and expressive | OR | Enjoy using the iPad information visualization |
| Explore many different ideas, possibilities or outcomes | OR | Become immersed in the activity |
| Work with other people | OR | Be creative and expressive |
| Produce results that are worth the effort I put in | OR | Enjoy using the iPad information visualization |
| Explore many different ideas, possibilities or outcomes | OR | Be creative and expressive |
| Work with other people | OR | Become immersed in the activity |
| Explore many different ideas, possibilities or outcomes | OR | Enjoy using the iPad information visualization |

# 11 Case Study: One Small Change

In the study reported in Chapter 8 co-designers were given two information visualization interfaces. These can be used online at:

http://www.grahamdove.com/greendragons/attitudes.html

http://www.grahamdove.com/greendragons/contamination.html

Co-designers were also given a number of different worksheets to complete each of the day's activities, and a selection of workshop stationary. This included coloured marker pens and post-it notes.

# 11.1 Worksheets

## 11.1.1　　　Day 1 Activity 2

▫

## Examples of Waste



Figure 30: A1 sized worksheet used in Activity 1 on Day 1 of Chapter 8 Case Study: One Small Change

## 11.1.2    Day 1 Activity 3

▫

**Data questions**

**What are the barriers to reducing waste? Or to re-using items instead of recycling or disposing of them?**

one small change

Figure 31: A1 sized worksheet used in Activity 3 of Day 1 of Chapter 8 Case Study: One Small Change

## Data questions

### How might we motivate people to choose a re-usable option? Recycle more effectively? Or simply generate less waste?

one small change

Figure 32: A1 sized worksheet used in Activity 3 of Day 1 of Chapter 8 Case Study: One Small Change

□

## Data questions

### What items are likely to be causing the contamination in different bins?
### And why might these bins become contaminated?



Figure 33: A1 sized worksheet used in Activity 3 of Day 1 of Chapter 8 Case Study: One Small Change

□

**What are the barriers to reducing waste? Or to re-using items instead of recycling or disposing of them?**

one small change

Figure 34: A5 sized worksheet used in Activity 3 of Day 1 of Chapter 8 Case Study: One Small Change

□

**How might we motivate people to choose a re-usable option? Recycle more effectively? Or simply generate less waste?**

one small change

Figure 35: A5 sized worksheet used in Activity 3 of Day 1 of Chapter 8 Case Study: One Small Change

□

**What items are likely to be causing the contamination in different bins? And why might these bins become contaminated?**

one small change

Figure 36: A5 sized worksheet used in Activity 3 of Day 1 of Case Study: One Small Change

## 11.1.3    Day 1 Activity 4
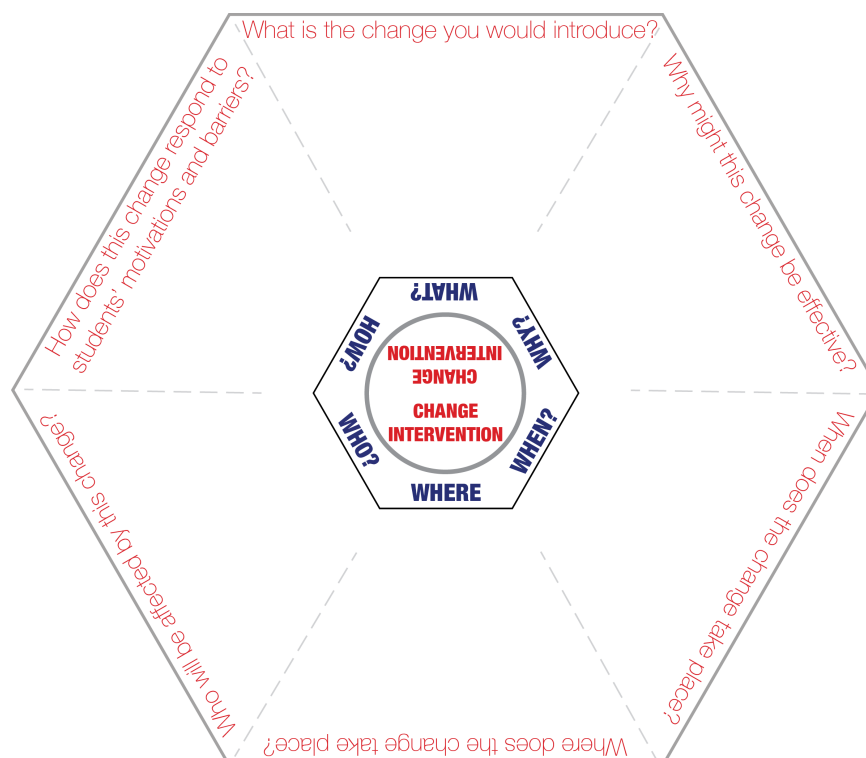


Figure 37: A2 sized hexagonal 5WsH worksheet used in Activity 4 Day 1 of Chapter 8 Case Study: One Small Change

## 11.1.4　Day 1 Activity 6

▫

## Problem abstraction

### What is the situation we'd like to change?

### Why might it be happening?

one
small
change

Figure 38: A1 sized worksheet used x2 in Day 1 Activity 6 of Chapter 8 Case Study: One Small Change

## 11.1.5    Day 2 Activity 3

▫

### Behaviour change

Making active choices helps people feel ownership of a
decision and makes them more likely to follow through

### What can we do to increase the sense of control, ownership and personal identification?

one
small
change

Figure 39: A1 sized worksheet used in Day 2 Activity 3 of Chapter 8 Case Study: One Small Change

## Behaviour change

People enjoy experiencing gains and go to great lengths
to avoid losses

### How might we emphasise gains and reduce losses?

Figure 40: A1 sized worksheet used in Day 2 Activity 3 of Chapter 8 Case Study: One Small
Change

## Behaviour change

A person's expectations about a service can change the way they actually experience it

### How can we set up positive expectations and provide feedback to reinforce commitment?

**one small change**

Figure 41: A1 sized worksheet used in Day 2 Activity 3 of Chapter 8 Case Study: One Small Change

## Behaviour change

People are more likely to choose the option they pay most attention to, whilst feedback can help themunderstand the consequences of their actions

### What can we do that will focus attention, reduce uncertainty and minimising decision-making?

Figure 42: A1 sized worksheet used in Day 2 Activity 3 of Chapter 8 Case Study: One Small Change

□

Making active choices helps people feel ownership of a
decision and makes them more likely to follow through

**What can we do to increase the sense of control,
ownership and personal identification?**

Figure 43: A5 sized worksheet used in Day 2 Activity 3 of Chapter 8 Case Study: One Small
Change

□

A person's expectations about a service can change
the way they actually experience it

**How can we set up positive expectations and provide
feedback to reinforce commitment?**

Figure 44: A5 sized worksheet used in Day 2 Activity 3 of Chapter 8 Case Study: One Small
Change

□

People enjoy experiencing gains and go to great lengths to avoid losses

**How might we emphasise gains and reduce losses?**

one small change

Figure 45: A5 sized worksheet used in Day 2 Activity 3 of Chapter 8 Case Study: One Small Change

□

People are more likely to choose the option they pay most attention to

**What can we do that will focus attention, reduce uncertainty and minimise decision-making?**

one small change

Figure 46: A5 sized worksheet used in Day 2 Activity 3 of Chapter 8 Case Study: One Small Change

## 11.1.6    Day 2 Activity 5 & Activity 7
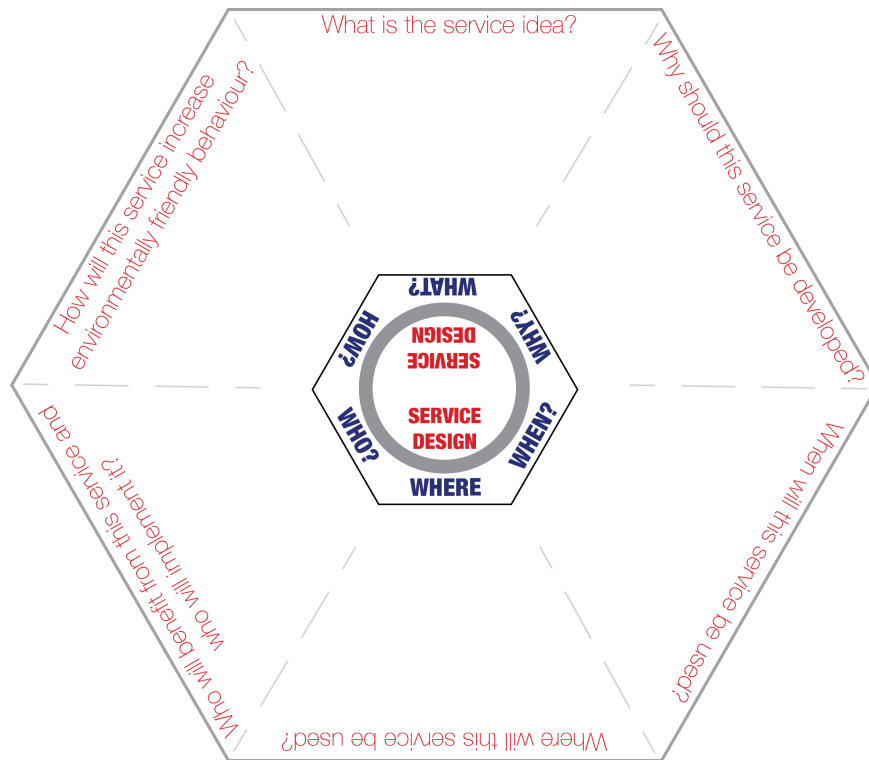
Figure 47: Hexagonal 5WsH worksheet used sized A3 in Day 2 Activity 5 and sized A0 in Day 2 Activity 7 of Chapter 8 Case Study: One Small Change

# 11.2 Evaluation Materials

To evaluate this study co-designers were given a Reflection Postcard to complete after each day of the workshop. The prompt on both postcards was the same and is listed below.

*Please reflect on your involvement in today's workshop. Write a few sentences thinking in particular about whether your understanding of the subject matter has increased and if so which were the particular elements of the workshop that helped you gain this improved understanding.*

Each participant was given a questionnaire before the first day of the workshop and after each day's activities. Each participant was also given a final follow up questionnaire one week after the workshop. Each of these questionnaires is reproduced below.

## 11.2.1　Pre-workshop Questionnaire

Participant No: _____

*Please circle the most appropriate selection*

**Age Range:**　18-24　　25-34　　35-44　　45-54　　55-64　　65+

**Gender:**　　Male　　　　　Female

**Experience With Information Visualisation** (select all that apply)**:**

      I use information visualisation in my work

      I am familiar with online interactive information visualisation

      I am familiar with info-graphics from newspapers, magazines or posters

      I have no previous experience with information visualisation

      Not sure

**Please rate your understanding in the following areas from 1 to 7, where 1 represents minimal knowledge and 7 represents a deep knowledge:**

The things that would make City students more environmentally friendly:

Minimal Knowledge　　1　　2　　3　　4　　5　　6　　7　　Deep Knowledge

The things that prevent City students' environmentally friendly behaviour:

Minimal Knowledge　　1　　2　　3　　4　　5　　6　　7　　Deep Knowledge

How students use the different types of bin available at City to dispose of things:

Minimal Knowledge　　1　　2　　3　　4　　5　　6　　7　　Deep Knowledge

## 11.2.2　Post-workshop Questionnaire Day 1

Participant No _____

<u>Part 1</u>

Please read the following statements and indicate to what degree you are in agreement. In all cases please rate your agreement from 1 meaning you strongly disagree with the statement to 9 meaning that agree strongly with the statement. Responses to these statements should be specifically based on the activities undertaken using the iPad information visualizations.

I was satisfied with what I achieved during the activities in which we used the iPad information visualizations:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

It was easy for me to explore many ideas, options or outcomes using the iPad information visualizations:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

The iPad information visualizations allowed other people to work with me easily:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

I would be happy to use the iPad information visualizations on a regular basis:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

I was able to be very creative whilst doing the activities in which we used the iPad information visualizations:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

My attention was fully tuned to the activities and the iPad information visualizations were not intrusive:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

I enjoyed the activities in which we were using the iPad information visualizations:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

The iPad information visualizations were helpful in allowing me to track different ideas, outcomes or possibilities:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

What I was able to produce in the activities we were using the iPad information visualizations was worth the effort I had to exert to produce it:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

Using the iPad information visualizations in the workshop activities allowed me to be very expressive:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

It was easy to share ideas with other people during the activities in which we were using the iPad information visualizations:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

I became absorbed in the activities and was not distracted by difficulties encountered using the iPad information visualizations:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

I had many ideas as a result of using the iPad information visualizations:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

My understanding of the topic under investigation improved as a result of using the iPad information visualizations:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

The iPad information visualizations played an important role in the ideas I had:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

I was better able to answer questions regarding the topic under consideration as a result of using the iPad information visualizations:

Strongly Disagree    1    2    3    4    5    6    7    8    9    Agree Strongly

---------------------------------------------------------------------

Part 2.

Please read the following statements and in each case indicate which of the two options is most important to you.

When using the iPad information visualization it is more important that I can...

| Explore many different ideas, possibilities or outcomes | OR | Work with other people |
|---|---|---|
| Be creative and expressive | OR | Produce results that are worth the effort I put in |
| Enjoy using the iPad information | OR | Become immersed in the activity |

| | | |
|---|---|---|
| visualization | | |
| Become immersed in the activity | OR | Produce results that are worth the effort I put in |
| Work with other people | OR | Enjoy using the iPad information visualization |
| Produce results that are worth the effort I put in | OR | Explore many different ideas, possibilities or outcomes |
| Be creative and expressive | OR | Become immersed in the activity |
| Work with other people | OR | Produce results that are worth the effort I put in |
| Be creative and expressive | OR | Enjoy using the iPad information visualization |
| Explore many different ideas, possibilities or outcomes | OR | Become immersed in the activity |
| Work with other people | OR | Be creative and expressive |
| Produce results that are worth the effort I put in | OR | Enjoy using the iPad information visualization |
| Explore many different ideas, possibilities or outcomes | OR | Be creative and expressive |
| Work with other people | OR | Become immersed in the activity |
| Explore many different ideas, possibilities or outcomes | OR | Enjoy using the iPad information visualization |

### Part 3

Now that you have taken part in the workshop, please rate your understanding in the following areas from 1 to 7, where 1 represents minimal knowledge and 7 represents a deep knowledge:

The things that would make City students more environmentally friendly:

Minimal Knowledge      1      2      3      4      5      6      7      Deep Knowledge

------------------------------------------------------------------------

The things that prevent City students' environmentally friendly behaviour:

Minimal Knowledge      1      2      3      4      5      6      7      Deep Knowledge

------------------------------------------------------------------------

How students use the different types of bin available at City to dispose of things:

Minimal Knowledge      1      2      3      4      5      6      7      Deep Knowledge

------------------------------------------------------------------------

# 11.2.3      Post-workshop Questionnaire Day 2

Participant No _____

## Part 1

Please read the following statements and indicate to what degree you are in agreement. In all cases please rate your agreement from 1 meaning you strongly disagree with the statement to 9 meaning that agree strongly with the statement. Responses to these statements should be specifically based on the activities undertaken using the iPad information visualizations.

I was satisfied with what I achieved during the activities in which we used the iPad information visualizations:

Strongly Disagree      1      2      3      4      5      6      7      8      9      Agree Strongly

------------------------------------------------------------------------

It was easy for me to explore many ideas, options or outcomes using the iPad information visualizations:

Strongly Disagree      1      2      3      4      5      6      7      8      9      Agree Strongly

------------------------------------------------------------------------

The iPad information visualizations allowed other people to work with me easily:

Strongly Disagree      1      2      3      4      5      6      7      8      9      Agree Strongly

------------------------------------------------------------------------

I would be happy to use the iPad information visualizations on a regular basis:

Strongly Disagree      1      2      3      4      5      6      7      8      9      Agree Strongly

------------------------------------------------------------------------

I was able to be very creative whilst doing the activities in which we used the iPad information visualizations:

Strongly Disagree     1    2    3    4    5    6    7    8    9     Agree Strongly

---------------------------------------------------------------------

My attention was fully tuned to the activities and the iPad information visualizations were not intrusive:

Strongly Disagree     1    2    3    4    5    6    7    8    9     Agree Strongly

---------------------------------------------------------------------

I enjoyed the activities in which we were using the iPad information visualizations:

Strongly Disagree     1    2    3    4    5    6    7    8    9     Agree Strongly

---------------------------------------------------------------------

The iPad information visualizations were helpful in allowing me to track different ideas, outcomes or possibilities:

Strongly Disagree     1    2    3    4    5    6    7    8    9     Agree Strongly

---------------------------------------------------------------------

What I was able to produce in the activities we were using the iPad information visualizations was worth the effort I had to exert to produce it:

Strongly Disagree     1    2    3    4    5    6    7    8    9     Agree Strongly

---------------------------------------------------------------------

Using the iPad information visualizations in the workshop activities allowed me to be very expressive:

Strongly Disagree     1    2    3    4    5    6    7    8    9     Agree Strongly

---------------------------------------------------------------------

It was easy to share ideas with other people during the activities in which we were using the iPad information visualizations:

Strongly Disagree     1    2    3    4    5    6    7    8    9     Agree Strongly

---------------------------------------------------------------------

I became absorbed in the activities and was not distracted by difficulties encountered using the iPad information visualizations:

Strongly Disagree     1    2    3    4    5    6    7    8    9     Agree Strongly

---------------------------------------------------------------------

I had many ideas as a result of using the iPad information visualizations:

Strongly Disagree     1    2    3    4    5    6    7    8    9     Agree Strongly

---------------------------------------------------------------------

My understanding of the topic under investigation improved as a result of using the iPad information visualizations:

Strongly Disagree    1   2   3   4   5   6   7   8   9   Agree Strongly

-----------------------------------------------------------------------

The iPad information visualizations played an important role in the ideas I had:

Strongly Disagree    1   2   3   4   5   6   7   8   9   Agree Strongly

-----------------------------------------------------------------------

I was better able to answer questions regarding the topic under consideration as a result of using the iPad information visualizations:

Strongly Disagree    1   2   3   4   5   6   7   8   9   Agree Strongly

-----------------------------------------------------------------------

Part 2.

Please read the following statements and in each case indicate which of the two options is most important to you.

When using the iPad information visualization it is more important that I can...

| | | |
|---|---|---|
| Explore many different ideas, possibilities or outcomes | OR | Work with other people |
| Be creative and expressive | OR | Produce results that are worth the effort I put in |
| Enjoy using the iPad information visualization | OR | Become immersed in the activity |
| Become immersed in the activity | OR | Produce results that are worth the effort I put in |
| Work with other people | OR | Enjoy using the iPad information visualization |
| Produce results that are worth the effort I put in | OR | Explore many different ideas, possibilities or outcomes |
| Be creative and expressive | OR | Become immersed in the activity |
| Work with other people | OR | Produce results that are worth the effort I put in |

| | | |
|---|---|---|
| Be creative and expressive | OR | Enjoy using the iPad information visualization |
| Explore many different ideas, possibilities or outcomes | OR | Become immersed in the activity |
| Work with other people | OR | Be creative and expressive |
| Produce results that are worth the effort I put in | OR | Enjoy using the iPad information visualization |
| Explore many different ideas, possibilities or outcomes | OR | Be creative and expressive |
| Work with other people | OR | Become immersed in the activity |
| Explore many different ideas, possibilities or outcomes | OR | Enjoy using the iPad information visualization |

### Part 3

Please think about your experiences in the workshop over the past two days and rate how important you think each of the following aspects were in helping you develop your ideas. Rate each factor from 1 to 7 where 1 represents unimportant and 7 represents very important.

Time spent thinking about the subject matter individually

Unimportant     1     2     3     4     5     6     7   Very important

-------------------------------------------------------------------

Discussions with other group members

Unimportant     1     2     3     4     5     6     7   Very important

-------------------------------------------------------------------

The expertise of other group members

Unimportant     1     2     3     4     5     6     7   Very important

-------------------------------------------------------------------

Doing activities with information visualizations

Unimportant     1     2     3     4     5     6     7   Very important

-------------------------------------------------------------------

Workshop facilitation

Unimportant    1    2    3    4    5    6    7    Very important

---------------------------------------------------------------------

## Part 4

Now that you have taken part in the workshop, please rate your understanding in the following areas from 1 to 7, where 1 represents minimal knowledge and 7 represents a deep knowledge:

The things that would make City students more environmentally friendly:

Minimal Knowledge    1    2    3    4    5    6    7    Deep Knowledge

---------------------------------------------------------------------

The things that prevent City students' environmentally friendly behaviour:

Minimal Knowledge    1    2    3    4    5    6    7    Deep Knowledge

---------------------------------------------------------------------

How students use the different types of bin available at City to dispose of things:

Minimal Knowledge    1    2    3    4    5    6    7    Deep Knowledge

---------------------------------------------------------------------

## Part 5

Is there anything else that you would like to tell us about your experience of taking part in the One Small Change workshops?

# 11.2.4    Follow-up Questionnaire

We are interested in finding out more about your use of the information visualizations provided in the One Small Change project workshops. Thinking about your experiences in both of the workshops please answer the following two questions in as much detail as possible, perhaps by providing examples to illustrate.

Q1. To what extent did the information visualizations *stimulate* and *focus* the *group discussions* you had?

Q2. To what extent did the information visualizations *stimulate* and *focus* your *individual thinking*?

# Appendix D: Evaluation Data

For each of the studies reported in chapters 4, 5, 6, 7 and 8 of this thesis evaluation data were collected. Examples of these evaluation data are included in this appendix.

# 12 Ambiguity in Visual Encodings

This section contains the following examples of evaluation data collected during the study reported in Chapter 4 of the main body of this thesis:

1. A collated list of all the ideas generated during each round of Activity 3 in all of the workshops
2. A listing of the scores given by the domain experts to each of the ideas generated during every instance of Activity 3
3. A listing of participants' responses to the questionnaire
4. A listing of the sensemaking analysis of the all the post-it notes recorded during every instance of Activity 2
5. Example transcriptions of the video recordings of both instances of Activity 2 in Workshop #2, including notes showing the sensemaking analysis
6. Example transcriptions of the video recordings of both instances of Activity 2 in Workshop #4, including notes showing the sensemaking analysis

# Ideas Generated in Activity 3

| Ref | Post-it Note | Transcription | Vis Type | Workshop | Participant |
|---|---|---|---|---|---|
| 1M1 | New Views | So basically in a house I want to have different views. So in a house you get bored of the same views or maybe you have annoying neighbours. | More Ambiguous | WS1 | P2 |
| 1M2 | House On A Wheel | If your house was on a wheel and it was moving it would be creating energy… and it would be nice if your neighbours were annoying you could rotate the house around and you don't see the neighbours | More Ambiguous | WS1 | P1 |
| 1M3 | Solar Powered Car | Solar powered car - because there's plenty of cars but not so much solar powered ones | More Ambiguous | WS1 | P2 |
| 1M4 | Using Too Much -> Energy Switched Off | Then there's the Draconian if you're using too much energy it would be switched off…. That's not an I wish it's a you could do this but… | More Ambiguous | WS1 | P1 |
| 1M5 | Incentives For Lowest Use Per Year | It turns into incentive for lower use | More Ambiguous | WS1 | P1 |
| 1M6 | Advice On How to Reduce Consumption - Daily / Above Threshold | Advice on how to reduce your consumption either on a daily basis or you might go above some threshold and you'd get some advice on how to bring it down. | More Ambiguous | WS1 | P3 |
| 1M7 | Compare Self With Others -> Ideas For Improvement | And similar sort of vein you could compare yourself with others in the street or neighbourhood and if you saw someone like you who's doing really well in energy consumption you could go to them for ideas on how to improve your own | More Ambiguous | WS1 | P2 |
| 1M8 | Wearable Monitor - Voice On your Shoulder | I had the idea of a wearable monitor… so that was the idea that you'd have the advice on your shoulder | More Ambiguous | WS1 | P1 |
| 1M9 | Penalties For Over Use Of Energy | Penalties for over use of energy…. | More Ambiguous | WS1 | P3 |
| 1M11 | Don't Need To Look At Bill | I don't want to look at my bill… I don't want a nasty surprise… | More Ambiguous | WS1 | P3 |
| 1M12 | Walls Changing Colour | So I got incentives and I got changing colours…. And I thought in the house if you had a button and you could switch it and all the walls… if you had some reactive paint.. And if you press the button and all the walls are red then I'm using a lot of energy..... some part of the environment could tell if your bills were going to be expensive or not. | More Ambiguous | WS1 | P3 |
| 1M13 | Change Of Light Based On Power Consumption | Change of light based on power consumption | More Ambiguous | WS1 | P3 |
| 1M14 | Money Spent Per Room | It culd be interesting to see the money spent in each room. To understand whats going wrong and where its going wrong | More Ambiguous | WS1 | P3 |
| 1M15 | Singing Energy Meter: Higher Use -> Higher Pitch | Singing energy meter so if you would lift the lid and a voice would come out and if you were using a lot of energy it would be really high pitched and if you were using little it would be really mellow. | More Ambiguous | WS1 | P3 |
| 1L1 | Age Based Pricing Exploits Habits | So starting from age and different ways of pricing the consumption.. We could have some age based pricing that exploits the habits of different people | Less Ambiguous | WS1 | P1 |
| 1L2 | Availability Of Appliance Based On Time | Based on the prison officer.. That appliances could be available just on certain times of the day so you can't use the washing machine during the day but just on a nightly basis because it cheaper | Less Ambiguous | WS1 | P3 |
| 1L3 | Meter Showing Price | Then I thought the meter could show the price… the different prices over the day. Then you cold think what is the current price I'm paying and what is the total price over the day. The meter could also show the personal consumption… not the meter the final bill… for households where… for shared households | Less Ambiguous | WS1 | P3 |
| 1L4 | Timed Appliances | Timing appliances. This is currently available for example for washings machines or dishwasers… You can select that in an hour its going to work out and it can probably be extended to other appliances | Less Ambiguous | WS1 | P3 |
| 1L5 | Green Advisor - Conscience That Suggests How To Use Greener Energy Sources | Green advisor… your conscience that suggests how you could use greener energy sources | Less Ambiguous | WS1 | P3 |
| 1L6 | Advert To Use Appliance -> Discount | To put some kind of screen with advertisements…. And based on that you get some kind of discount on the energy that you are using | Less Ambiguous | WS1 | P2 |

| | | | | | |
|---|---|---|---|---|---|
| 1L9 | Show Where You Can Share To Save | Its some way of telling your household if people are using the same sort of things… you could be brought together in the house… maybe you'd want to be in separate rooms for a reason..... but you might not know it and 2 people in the same house are both watching the same thing on TV and you'd be able to say 'you're both doing the same thing'.... some way of brining the family together.... Its all about the environment and how people are runing their lives. | Less Ambiguous | WS1 | P3 |
| 1L10 | Remote Control - For When Kids Are At Home Alone | and then you could have a remote control to turn things off! When the kids are at home alone…. | Less Ambiguous | WS1 | P2 |
| 1L11 | Energy Monitor - For When Kids Are At Home Alone | You could have an energy monitor to show you what energy is being used in your house when you're not there…. For example if your kids are home alone | Less Ambiguous | WS1 | P3 |
| 1L12 | Linking Energy Use To Something More Emotive - e.g. Polar Bears, Trees | Linking money to something that's more emotive than…. Well I suppose money is quite an emotive… but linking it to some polar bears dying or trees or something | Less Ambiguous | WS1 | P3 |
| 1L13 | Bills Cost less / Advert For New House Mate | The meter could also show the personal consumption… not the meter the final bill… for households where… for shared households | Less Ambiguous | WS1 | P1 |
| 1L14 | Consumption Watch | That bills cost less… that was my wish but it got me thinking that you could have some kind of consumption watch… I was thinking that if you had a watch and it could tell you where you consume energy that would be really fun… and then you could probably turn it into a game..... and basically say... it would be interesting and more personal to say where your energy consumption has gone and if you could turn it into a game and compare it with your friends... basically have a point system or something like that | Less Ambiguous | WS1 | P1 |
| 1L15 | Devices Fitted With Displays To Show / Warn Of High Energy Use | Devices fitted with displays that would show or warn you when you're using high energy | Less Ambiguous | WS1 | P1 |
| 1L16 | Getting Something Good For Free | Religion & habits… so it was basically like getting some thing for nothing… for free. | Less Ambiguous | WS1 | P3 |
| 1L17 | Get Money Off Bill For Going To Gods House | It's the same as … if you went to church… whatever money you donated to the church… the energy bill..... if they wanted to back it… basically an incentive for raising money for charity… and the company would get money off because its tax free and it would be good PR. Whatever money you donate to the charities you would get that off your bills. | Less Ambiguous | WS1 | P1 |
| 1L18 | Intelligent Advice On Change Of Habits e.g. Do Ironing Off-Peak | Intelligent advise on changing your habits… so you would get an anlysis of your habits over time and get some A.I. type of advise on how you could change your habits like doing your ironing off peak. And then you could tailor that to household type…. | Less Ambiguous | WS1 | P1 |
| 2M1 | Fridge / Dietician - Calculates A Healthy Diet Per Day / Week According To Whats In It | A fridge / dietician. It calculates your healthy diet per day or per week based on whats in your fridge. So making suggestions on what you can eat | More Ambiguous | WS2 | P4 |
| 2M2 | Weather / Daily Calendar - Wardrobe Suggestion (Visual/Monitor) Per Day Based On Forcast | I wish there was like a daily wardrobe suggestion. Like a monitor on the wardrobe so that you could see suggestions of what to wear based on forcasts… so that I don't have to panic in the morning when I getting up. | More Ambiguous | WS2 | P6 |
| 2M3 | Schedule / Colours - View Total Sleep / TV Watching / Calories Eaten etc. Per Week (Colour Coded) | I was thinking of a monitor with different colours for totals of everything…. Like total per week, per day of sleep, how much TV you watch how many calories you eat and things like that… like total for everything in the house | More Ambiguous | WS2 | P6 |
| 2M4 | Control Panel / Monitor Consumption - Fridge Orders Automatic When A Product Runs Out OR Central System In House | I was thinking about control panel and monitor consumption. I was thinking about the fridge that orders automatically when something runs out or it could be a central system in the house for everything not just for food but for everything in the house… like when the toilet tissue, cleaning solution whatever ran out it would just order it. | More Ambiguous | WS2 | P6 |

| | | | | | |
|---|---|---|---|---|---|
| 2M5 | Religion / Calendar - Devices In House Are Synced And The Recommend Or Give ifdeas According To Holidays (Religious Or Not) | Devices in the house are synced and they make recommendations based on holidays… religious or not. So today is Haneka you know so traditionally you eat this, traditionally you dress like that | More Ambiguous | WS2 | P6 |
| 2M6 | Police / All In One View - TV Displays Important Police Views - Wanted Persons etc | Television would display important police news on a certain channel that you could select and based on area so it wouldn't just be one channel for everyone | More Ambiguous | WS2 | P6 |
| 2M7 | Alarm Clock / Colours - Clock Lights Up In Different Colour Every Day To Recognise Days Of The Week | When you alarm clock goes off on different days there would be different colours so that you can remember what day of the week it is. So you don't have to panic on Saturday and think 'Oh my god its Monday I have to go to work' | More Ambiguous | WS2 | P6 |
| 2M8 | Bus / Calendar - The House Tells You Which (Bus) Comes Sooner As You Walk Out | As you leave the house, the house tells you which bus is closer to the bus stop or whever you are going as you walk out of the door | More Ambiguous | WS2 | P6 |
| 2M9 | Expiry Date / Visualise - Fridge Area Lights Up In Red If Product Is Expired Or If It Is Near Expiry etc | I was thinking the fridge would have sensors all over so when you put the food over the sensor and its near the expiry date the sensor lights up in different colours… so red for expired, orange for near expiry and so on.. | More Ambiguous | WS2 | P6 |
| 2M10 | Queen Bee + Hexagon - Energy = Power Get People Cycling To Power Their TV | I was looking at queen bee and the pentagon and I was thinking how hives are all powered by the bees and I had the idea that people could cycle to generate the power for their TV so they'd get their exercise… | More Ambiguous | WS2 | P6 |
| 2M11 | Cycle To Power Home Cinema Event About Energy Efficiency | Part b of that was to cycle power a home cinema for your friends and family and that you could do an event about efficiency showing films about the environment and things | More Ambiguous | WS2 | P6 |
| 2M12 | Make The Shapes Weather Related - So Rain Clouds When Bad Consumption + Suns When Good | Having an app about your consumption but having the shapes weather related so that if you were being good with your energy consumption you got little suns and if you were being bad with your consumption you got little rain clouds | More Ambiguous | WS2 | P4 |
| 2M13 | Reflect' - Get A Mirror That Everytime You Use Your Hairdryer It Shows A Clip Of Global Warming | We said reflect a lot and I thought you could have a mirror that every time you turn your hairdryer on or your straighteners, something that uses energy, it could be an interactive mirror and it shows ice caps melting and stuff like that and you'd think twice about whether you should be straightening your hair. | More Ambiguous | WS2 | P5 |
| 2M14 | Bus + Star / Legend - Get Famous Faces To Ride The Bus + Talk To People About Consumption | On those TV screens you get in buses now sometimes you could have famous people on the screens telling people about energy consumption… and you could even get them riding the bus which would be good.. | More Ambiguous | WS2 | P5 |
| 2M15 | Dreams' - When You Fall Asleep Its Detected + All Sockets Loose Power (So Nothings On Standby) | When you fall asleep you have something in you pillow or bed that detects when you're asleep and cuts off the power to all the sockets in your house so that anything you've left on standby automaticall turns off while you don't need it. | More Ambiguous | WS2 | P5 |
| 2M16 | Top Is Total + Government - Have A League Of Consumption + Top Families Get A Cash Prize | You could have a league of consumption that's measured antionally and if you're really good at it then the government could give you cash prizes | More Ambiguous | WS2 | P5 |
| 2M17 | Calculator + Teacher - Schools Give Hand Held Devices The Tot Up Usage | Schools could provide children with little handheld devices that tot up their usage… mobile ones | More Ambiguous | WS2 | P5 |
| 2M18 | Remote Control + 24 Squares - Randomly Drive A Remote Control Car Over A Grid + Wherever It Lands Is The Hour You're Allowed Consumption | There's remote control and 24 squares are hours and so there's a mat and every member of the family gets to drive a remote control car round and whatever square they land on that's the hour their allowed to use energy that day. So everyone gets an hour a day which is a bit random as you might have to get up at 3 but then you might get 6pm which would be nice. | More Ambiguous | WS2 | P4 |
| 2M19 | All in One + Line Manager - If Staff Reduce Consumption the Manager Wears A Onesy | This links back to one I suggested in the previous round.. If you did get your manager to link your energy consumption to your objectives and you stuck to it then they'd have to wear one of those horrible Onesy outfits to work for the day | More Ambiguous | WS2 | P4 |

| | | | | | |
|---|---|---|---|---|---|
| 2M20 | Hopes + Dreams + All In One View - Make Your Own Usage Organised From Play As You Wish The Month To Evolve | You could make your own usage organisation plan as you which for the month | More Ambiguous | WS2 | P4 |
| 2M21 | Self + All In One View -> People With Dementia Could Remind Themselves What They've Been Doing | People with dimentia for example can't remember what they're doing so having these type of visualisations could help remind them when they wer ironing or what they were doing it could be a good reflection tool | More Ambiguous | WS2 | P4 |
| 2M22 | Bus Routes + All InOne View - Modes / Routes Depending On Criteria -> Price / Time / Tastes Change | To have a function which would be like a ??? Which would be like a bus route. So you choose you direction for usage that day as you choose your bus route like in buses do you want the fastest 1 or the 1 with fewest changes? Here you could have a prices priority or you just want to iron fast and you don't care if its peak hours. | More Ambiguous | WS2 | P4 |
| 2M23 | Weather + Daily Calendar - Heating Predicitions | Heating predictions. You could have in the winter months for example you could have 'do I need to turn up the heating if its going to be very cold in the morning' | More Ambiguous | WS2 | P4 |
| 2M24 | Parent + Calendar - Room Overview By Device + Hour -> Child Control -> You Can't Lie When You Went To Bed | Parents could have a room overview of the usage in their childrens room so you can't really lie whether you went to bed at a certain time. | More Ambiguous | WS2 | P4 |
| 2L1 | Calendar -> Monitoring Electricity Usage Sum - Interactive Calendar That Sums Up Electricity Usage Per Day / Week /Month | Some sort of interactive calendarthat sums up the usage per day, week or month… like an app or something | Less Ambiguous | WS2 | P5 |
| 2L2 | Last.FM -> Nice Colours - Your Room / Object Changes Colour Depending On The Music You Listen To | To have your room or object or something in your home that you're using changing colours depending on music you're listening to. | Less Ambiguous | WS2 | P6 |
| 2L3 | Have To Submit Forms To The Electricity Board To Plan Monthly Usage - Then You Get Cut Off | You have to submit a form to the energy board to plan your monthly usage and when you get to your limit they cut you off | Less Ambiguous | WS2 | P6 |
| 2L4 | We Could All Wear Iron Easy Uniforms To Reduce Iron Use | We could all wear iron easy uniforms to reduce iron usage because that seemed quite pricey | Less Ambiguous | WS2 | P4 |
| 2L5 | Calendar Tool That Helps You Plan A Month Of Using The Washing Machine At The Best Time | A calendar that helps you plan your monthly usage in advance so that you work out… like an app so that it tells you when you need to do your washing because I always panic and haven't done my washing.. | Less Ambiguous | WS2 | P5 |
| 2L6 | Queen Bee -> Lazy - Motivation For Organising Consumption In An Efficient Way | Motivation for organising your consumption by having a role model of a Quee Bee or something like that to remember that you should be organised…. And not be lazy about how you act around your power and devices | Less Ambiguous | WS2 | P5 |
| 2L7 | Recycle Bin -> Key - Icons Interpreted In A Key For Rules Communication | So when I gave the idea of recycle bin I have always these icons in mind. They teach you how to recycle things by putting images of glass or something like that so this key we mentioned here could have a table form with some icons in it | Less Ambiguous | WS2 | P6 |
| 2L8 | Expiry Dates -> Eating Habits - Fridge Recognises Expiry Dates Predicts Optimal Usage Fridge Display | To have a fridge that recognises the expiry date on your food and then suggesting to you how to organise the optimal usage of your fridge contents | Less Ambiguous | WS2 | P6 |
| 2L9 | Start A Cult Of Convenience Where Everyone Joins Together To Make Usage More Efficient | Start a cult of convenience where everybody in your street gets together and you all go around to one house and watch TV … you find out who's watching Strictly and everyone goes round to that house for the evening | Less Ambiguous | WS2 | P6 |
| 2L10 | Have One Chest Freezer Per Road (Live In A Hive) To Save Energy | Have one chest freezer per street that you were all sharing | Less Ambiguous | WS2 | P4 |
| 2L11 | Dietician Advice Designed Around Cheaper / Less Wattage Equipment | A dietician whos advice was deliberately designed around methods of cooking that were cheap… so quick and easy foods that used the microwave etc | Less Ambiguous | WS2 | P4 |
| 2L12 | Humidity Clock - Humidity / Peak Hours | Humidity clock.. Humidity peak hours.. When you should be taking care of your hair | Less Ambiguous | WS2 | P5 |

| | | | | | |
|---|---|---|---|---|---|
| 2L13 | Alarm Clock -> Peak Hours Key Suggestion Alarm Sets Off When Energy Category Changes | To have some sort of a function that gives you some sort of a signal when the category of price level changes in these bars we have here | Less Ambiguous | WS2 | P4 |
| 2L14 | Last.FM -> Eating Habits (Coming From Speakers) Choice Of Music Suggests The Menu On The Fridge Display | Choice of music suggests a menu on fridge display | Less Ambiguous | WS2 | P6 |
| 2L15 | Set Targets Of Usage + Get Rewards For Sticking To It - Like Time Banking But Energy (Ambition + Totals) | Set yourself some target for the week and then get rewarded if you stuck to it…. I don't know if you've ever heard of time banking so like that but energy banking | Less Ambiguous | WS2 | P6 |
| 2L16 | Fit Equipment With A Speed Limit So They Won't Work At Peak Times Of Day | Fit your equipment with like a speed limit thing so that when.. So that it stops working for the peak hours in the day… so your washing machine stops and then finishes when it gets cheap again | Less Ambiguous | WS2 | P6 |
| 2L17 | Alarm Clock That Wakes You To Suggest Doing The Ironing When Its Free | An alarm clock that wakes you really early in the morning to do the ironing | Less Ambiguous | WS2 | P6 |
| 2L18 | Line Manager / Peak Hours - Calculate Individual Peak Capacity | Something to calculate when an individuals peak capacity is so that not everyone is pushed at the same time because we all have different capacity at different times | Less Ambiguous | WS2 | P6 |
| 2L19 | Blood Sugar Drip - Self / Peak Hours | A chip to calculate when your blood sugar gets low for diabetic people | Less Ambiguous | WS2 | P6 |
| 2L20 | Calendar / Suggestion - Calendar Function | A calendar function would be nice when people are trying to organise meetings to be able to put peoples calendars into one place and then have a suggested date and time that would work for everyone. | Less Ambiguous | WS2 | P5 |
| 2L21 | Alarm Clock / Peak Hours (Sleep Cycle) | An alarm clock that would ring when you're supposed to be going to sleep because of your sleep cycles when it's the best time for you | Less Ambiguous | WS2 | P5 |
| 2L22 | Get Your Line manager To Set Weekly Totals As Part Of Your Objectives | You could get your line manager to set your weekly usage as part of your objectives | Less Ambiguous | WS2 | P5 |
| 2L23 | Change School Times So Parents Can Use At Cheap Times (Evenings) | Change school hours so that your daily timetable changes and you're around when its free and asleep when its peak time | Less Ambiguous | WS2 | P6 |
| 3M1 | Bus Driver + Different Rate Of Price -> Traffic | I thought about one that wasn't about energy consumption at home.. I thought about the bus driver and the different rate of price and traffic and if the traffic was bad maybe you'd get sharged more if you wanted to use the bus. | More Ambiguous | WS3 | P8 |
| 3M2 | Family /Friends + Police -> Password To Enter The House | And the other one was thinking about families and friends and even police… if they had a password to enter the house it would be a lot more… I'm always forgetting my keys. | More Ambiguous | WS3 | P9 |
| 3M3 | Moods - Colour: Mood Light Settings | moods and colours. I'm quite particular about lighting depending on the time of day and I'd like to have settings rather than adjusting lights and things so it would be just one touch thing for…. | More Ambiguous | WS3 | P9 |
| 3M4 | I Wish My Bedroom Door Understood I Need a Key To Switch My Toaster On For Breakfast | I wish my bedroom door understood I need key to switch my toaster on for my breakfast or something like that | More Ambiguous | WS3 | P9 |
| 3M5 | I Wish When I Sleep My Bills Are Paid & In The Low Rate Of Day My Washing Machine Wash All Things | I wish when I sleep my bills are paid and in the low rate of the energy all the appliance are working without I knew. For example they are intelligent and know which of the rate is the low rate and start the washing | More Ambiguous | WS3 | P8 |
| 3M7 | Money - Consumption Cost Rather Than Units | I took money and circle size/consumption and I thought rather than showing usage… seing it in terms of money… I'd like to know in a smart home if I'm finding out about my usage of different things I'd like to have it in monetary terms rather than you've used X number of units… because I've got my electricity meter and my gas meter and I can take a 6 digit or an 8 digit reading and it doesn't mean anything to me.. | More Ambiguous | WS3 | P7 |
| 3M8 | I Wish My Clothes Work For Me To Say What Is TheTemperature | I wish my clothes would tell me what is the temperature and have some alarm to control the temperature | More Ambiguous | WS3 | P9 |

| | | | | | |
|---|---|---|---|---|---|
| 3M9 | I Wish Politicians Make Energy Free For Me By Some Star Points | I wish politicians make energy free for me by some star points. I mean you get some stars… not stars as are here for days but stars for energy saving and then make your energy free | More Ambiguous | WS3 | P9 |
| 3M10 | I Wish when I Check My Facebook It Post Some Good Words For Saving Energy | I wish when I check my facebook there is a post from the energy that some good words or some gifts for saving my energy | More Ambiguous | WS3 | P7 |
| 3M11 | I Wish There Is A Soap Each Time I Need Ironing Or Washing Machine It Smell Different | I wish there was the soap that each time I'm ironing or washing machine it smells different | More Ambiguous | WS3 | P7 |
| 3M12 | I Wish I Live In Virtual Reality Speak With My Appliance At Home To Know About Them Are They Tired Enjoying Life Need Some Attention | I wish I live in virtual reality and I speak with my appliance at home to knowabout them more… are they tired or enjouying their life or need some attention or some repairs or something | More Ambiguous | WS3 | P9 |
| 3M13 | Architect Makes My Map Changed In A Way I Like | I wish there is an architect in my life that makes my maps change in a way I like | More Ambiguous | WS3 | P9 |
| 3L1 | Habits / Routine Generate KW, Save £ | I wish that my habits and routines could generate energy and save money | Less Ambiguous | WS3 | P7 |
| 3L2 | Laptop Daily Representation In £ | For my laptop it would be useful if I had some indication of how much it cost to run per day, per session | Less Ambiguous | WS3 | P9 |
| 3L3 | There Are Some Email As A Reminder To Control The Time I Should Use Each Device | An email to remind me of the times I should use each device | Less Ambiguous | WS3 | P7 |
| 3L4 | There is a Lock That I Can Set For All Devices That Don't Work In Peak & High Rate | I wish there was a lock I can set for all devices that says they don't work during the peak time and high rate just work in the free time or low rate | Less Ambiguous | WS3 | P8 |
| 3L5 | Email Summary - 'You Used … KW You Spent … ' | An email summary, daily or something that says you used this many KW yesterday and it cost you this much money and said maybe the day before you used this or on the same day last week you used this, just a very brief summary | Less Ambiguous | WS3 | P9 |
| 3L6 | Signs For Different Rates | It would be nice if there was some sign that would indicate when the different rates are so that you could know if you were doing things and be more mindful of your energy usage at that particular time. Lights would turn blue or dark blue to indicate high usage that would be some kind of sign | Less Ambiguous | WS3 | P9 |
| 3L7 | Maps Where Each Appliance Is Located | It would be good if you could have an application checking where all your appliances were that would be useful save you losing the remote control | Less Ambiguous | WS3 | P8 |
| 3L8 | Weather, Clothes, Animate Images | Maybe something that gives you an image of your clothes, of what you've got and what would be appropriate | Less Ambiguous | WS3 | P9 |
| 3L9 | It Was a Device That I Can Use It Even When I Am Out Of House To Control Appliance Based On Rate | A device that I can use even outside of the house to control appliances based on the rate | Less Ambiguous | WS3 | P9 |
| 3L10 | In Free Cost Time Smart Appliance Works When I Sleep | For free cost time a smart appliance works while I'm asleep | Less Ambiguous | WS3 | P7 |
| 3L11 | Use Computer To Set Appliances To Operate At Specific Times | If there was a centralised way of setting appliances to operate at a particular time. Ones that aren't time specific. I need to charge my phone for tomorrow but I don't need to plug it in right now it can wait till 2 o'clock in the morning when it will be much cheaper than it is now. | Less Ambiguous | WS3 | P7 |
| 3L12 | Family & Friends -> Circle Size - Energy Usage -> Money | I share a place with my sister and she turns the TV off and leaves it on standby and it drives me nuts. So if I could show each individuals data, how much energy they use that might be quite useful | Less Ambiguous | WS3 | P8 |
| 3L13 | There Is Some Codes Or Signs To Show The Peak Time & Free Time | Some codes or signs to show the peak time or free time to control my usage of energy, for example some lights or sounds on the appliance or on one device to show you… A sound or sign that showed the most efficient way and time to use energy and it can be set on appliance or maybe on a small device to remind you of efficient time | Less Ambiguous | WS3 | P8 |

| | | | | | |
|---|---|---|---|---|---|
| 3L14 | All The Information Shows On My Refrigerator | And I like to have all this informationand this interface on the refridgerator because I use it more | Less Ambiguous | WS3 | P9 |
| 4M1 | Using The Sun Power As Root To Open Door For Less Energy / Electricity | Use the sun power as a route to open the door for less energy electricity | More Ambiguous | WS4 | P10 |
| 4M2 | I wish Government Use Less Energy From Monday - Thursday Like Weekend | I wish government would give less energy on a Monday to Thursday like a weekend | More Ambiguous | WS4 | P11 |
| 4M5 | 24 Hours In A Day - We Only Use 16 | And the fact that we only use… there's this time we don't use… how to use it better? | More Ambiguous | WS4 | P12 |
| 4M6 | I Wish Parents Would Take Control Of Consumption 24/7 | I wish parents could take control of consumption 24/7 | More Ambiguous | WS4 | P12 |
| 4M7 | Electricity Consumption Like Pentagon Shape Of US Governments | Electricity consumption like a pentagon shape of USA government | More Ambiguous | WS4 | P11 |
| 4M8 | The Banker Would Let Me Borrow Electricity From Cheap Hours | The banker would let you borrow electricity from cheap hours of the day | More Ambiguous | WS4 | P10 |
| 4M9 | The Teacher Makes Sat & Sun Gold Star Days | The teacher makes Saturday and Sundays a gold star day | More Ambiguous | WS4 | P10 |
| 4M10 | Bank The Hours Unused | Can we bank the free hours that we don't use? | More Ambiguous | WS4 | P10 |
| 4M11 | Media -> Sat Sun: Low Cost | Media should tell more about the low cost electricity on Saturday and Sunday. I think most of the people are not aware of this fact | More Ambiguous | WS4 | P10 |
| 4M12 | Teacher -> Amount Explained To The Students | Teachers should educate the students about their energy consumption and where they can spend more consuming less. So we should start the thinking at early stages | More Ambiguous | WS4 | P11 |
| 4M13 | The Police Would Issue warnings To High Users | The police would issue warnings to high users | More Ambiguous | WS4 | P11 |
| 4L1 | Door Open For The Green Dark | Door open for the green dark | Less Ambiguous | WS4 | P10 |
| 4L2 | Police Show A Green Light To Let you Know That It Is Free To Use Any Electricity | Police show you dark green light to let you know it is free to use any electricity | Less Ambiguous | WS4 | P12 |
| 4L3 | School & University Are Close So That The Weekends Is Low Or Free Of Charge | School or university is closed at weekend so its low or free of charge | Less Ambiguous | WS4 | P12 |
| 4L4 | Daily Money Monitor | And daily money monitor. So its something that's telling you how much money your spending which could go alongside your electricity consumption nd that would be a realy clear and bright thing so you could see if you were going above your budget | Less Ambiguous | WS4 | P12 |
| 4L5 | Parents Spend Less On Fridge Because Of Stable Rate | Parents spend less money on fridge consumption because of stable rates | Less Ambiguous | WS4 | P11 |
| 4L6 | Governement Should Make Control Of Energy Consumption On Mon & Tues As Expensive Day | Government should take control of energy consumption on Mondaya and Tuesday as expensive day | Less Ambiguous | WS4 | P11 |
| 4L7 | Using Less Washing Machine By Teacher On Thursday & Sunday | Educating students by teachers using less washing machine on Thursday and Sunday | Less Ambiguous | WS4 | P10 |
| 4L8 | Smiling Sun/Earth Alert | Smiling sun or earth alert another light kind of thing in your house that would tell you it was a good time to use electricity because its cheap | Less Ambiguous | WS4 | P10 |
| 4L9 | Put The Brakes on Consumption Monday & Tuesday | And then put the brakes on consumption on Monday and Tuesday so maybe it would be every day of the week and it would tell you what days you need to put the brakes on | Less Ambiguous | WS4 | P11 |
| 4L10 | Microcontroller To Fridge Energy Consumption | I think we should use microcontroller to control energy consumption of fridge because if you put something in the fridge it doesn't matter if it consumes energy straight away or later because if you turn off the fridge it can stay cold for say 2-3 hours. So if we can put a microcontroller on every fridge it can consume energy at a suitable time when the energy consumption is low. I think it would be better | Less Ambiguous | WS4 | P10 |

| 4L11 | CPU Washing Machine Timing | And same thing is for washing machine. I think it doesn't matter when you wash your clothes so it is better to wash you clothes when energy consumption is low. So I'd like to put some controller inside washing machine so we can turn it on but it will not turn on untill later when the enrgy consumption is low | Less Ambiguous | WS4 | P10 |
|---|---|---|---|---|---|
| 4L12 | Government Charging Based On Income & Consumption | And I wish government impossed variable charging based on your income not only on your consumption - like national insurance - say your repayment is low it doesn't mean you should be out of electricity consumption. So there should be some effort from government on this issue | Less Ambiguous | WS4 | P10 |
| 4L13 | Consumption Police Light | So I had a consumption police light. So you would have a little police man in the corner of your room that would come on if you were going over your… if you were maybe.. So you maybe didn't want to go over £2 a day or something | Less Ambiguous | WS4 | P11 |
| 4L14 | Dark Green Trees = Free Electricity | Dark green trees is a code to free electricity | Less Ambiguous | WS4 | P11 |

# Rating of Ideas Generated in Activity 3

| Ref | Novelty 1 | Novelty 2 | Novelty 3 | Novelty Avg | Useful 1 | Useful 2 | Useful | Useful Avg |
|-----|-----------|-----------|-----------|-------------|----------|----------|--------|------------|
| 1M1 | 4 | 2 | 5 | 3.66666667 | 4 | 2 | 2 | 2.66666667 |
| 1M2 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 |
| 1M3 | 5 | 5 | 4 | 4.66666667 | 4 | 5 | 3 | 4 |
| 1M4 | 3 | 3 | 3 | 3 | 5 | 2 | 3 | 3.33333333 |
| 1M5 | 4 | 3 | 2 | 3 | 1 | 5 | 4 | 3.33333333 |
| 1M6 | 5 | 4 | 5 | 4.66666667 | 3 | 2 | 4 | 3 |
| 1M7 | 5 | 5 | 4 | 4.66666667 | 5 | 1 | 2 | 2.66666667 |
| 1M8 | 3 | 2 | 2 | 2.33333333 | 3 | 1 | 1 | 1.66666667 |
| 1M9 | 2 | 2 | 3 | 2.33333333 | 4 | 2 | 2 | 2.66666667 |
| 1M11 | 3 | 2 | 1 | 2 | 5 | 4 | 4 | 4.33333333 |
| 1M12 | 3 | 1 | 2 | 2 | 5 | 0 | 4 | 3 |
| 1M13 | 2 | 4 | 2 | 2.66666667 | 4 | 3 | 4 | 3.66666667 |
| 1M14 | 5 | 3 | 4 | 4 | 4 | 3 | 3 | 3.33333333 |
| 1M15 | 3 | 2 | 1 | 2 | 5 | 3 | 4 | 4 |
| 1L1 | 3 | 4 | 3 | 3.33333333 | 2 | 5 | 3 | 3.33333333 |
| 1L2 | 2 | 3 | 4 | 3 | 5 | 5 | 3 | 4.33333333 |
| 1L3 | 2 | 3 | 3 | 2.66666667 | 4 | 5 | 4 | 4.33333333 |
| 1L4 | 3 | 2 | 1 | 2 | 4 | 0 | 1 | 1.66666667 |
| 1L5 | 2 | 3 | 3 | 2.66666667 | 3 | 5 | 4 | 4 |
| 1L6 | 5 | 4 | 3 | 4 | 3 | 5 | 3 | 3.66666667 |
| 1L9 | 3 | 3 | 4 | 3.33333333 | 5 | 4 | 4 | 4.33333333 |
| 1L10 | 4 | 5 | 3 | 4 | 1 | 1 | 3 | 1.66666667 |
| 1L11 | 2 | 3 | 4 | 3 | 5 | 4 | 4 | 4.33333333 |
| 1L12 | 3 | 3 | 2 | 2.66666667 | 5 | 2 | 4 | 3.66666667 |
| 1L13 | 4 | 3 | 4 | 3.66666667 | 1 | 5 | 2 | 2.66666667 |
| 1L14 | 3 | 4 | 2 | 3 | 4 | 5 | 4 | 4.33333333 |
| 1L15 | 2 | 0 | 2 | 1.33333333 | 4 | 3 | 4 | 3.66666667 |
| 1L16 | 2 | 2 | 3 | 2.33333333 | 3 | 2 | 3 | 2.66666667 |
| 1L17 | 3 | 4 | 3 | 3.33333333 | 1 | 4 | 3 | 2.66666667 |
| 1L18 | 4 | 4 | 2 | 3.33333333 | 4 | 5 | 4 | 4.33333333 |
| 2M1 | 4 | 3 | 2 | 3 | 1 | 5 | 1 | 2.33333333 |
| 2M2 | 4 | 0 | 3 | 2.33333333 | 2 | 3 | 2 | 2.33333333 |
| 2M3 | 3 | 4 | 3 | 3.33333333 | 3 | 1 | 3 | 2.33333333 |
| 2M4 | 3 | 2 | 4 | 3 | 4 | 4 | 3 | 3.66666667 |
| 2M5 | 5 | 5 | 4 | 4.66666667 | 4 | 2 | 4 | 3.33333333 |
| 2M6 | 5 | 0 | 3 | 2.66666667 | 1 | 0 | 3 | 1.33333333 |
| 2M7 | 4 | 5 | 4 | 4.33333333 | 5 | 4 | 4 | 4.33333333 |
| 2M8 | 0 | 3 | 3 | 2 | 0 | 2 | 3 | 1.66666667 |
| 2M9 | 3 | 5 | 2 | 3.33333333 | 4 | 3 | 2 | 3 |
| 2M10 | 5 | 5 | 5 | 5 | 1 | 1 | 1 | 1 |
| 2M11 | 5 | 5 | 5 | 5 | 1 | 1 | 2 | 1.33333333 |
| 2M12 | 5 | 1 | 1 | 2.33333333 | 2 | 4 | 1 | 2.33333333 |
| 2M13 | 0 | 3 | 2 | 1.66666667 | 0 | 0 | 3 | 1 |
| 2M14 | 3 | 3 | 4 | 3.33333333 | 4 | 4 | 2 | 3.33333333 |
| 2M15 | 3 | 2 | 3 | 2.66666667 | 5 | 3 | 3 | 3.66666667 |
| 2M16 | 3 | 4 | 2 | 3 | 5 | 3 | 3 | 3.66666667 |
| 2M17 | 0 | 5 | 4 | 3 | 0 | 5 | 3 | 2.66666667 |
| 2M18 | 4 | 3 | 3 | 3.33333333 | 4 | 5 | 3 | 4 |
| 2M19 | 4 | 4 | 2 | 3.33333333 | 3 | 5 | 2 | 3.33333333 |
| 2M20 | 4 | 3 | 2 | 3 | 1 | 4 | 1 | 2 |
| 2M21 | 4 | 1 | 1 | 2 | 1 | 0 | 1 | 0.66666667 |
| 2M22 | 4 | 5 | 3 | 4 | 1 | 5 | 1 | 2.33333333 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2M23 | 1 | 5 | 4 | 3.33333333 | 2 | 5 | 1 | 2.66666667 |
| 2M24 | 5 | 5 | 2 | 4 | 1 | 5 | 1 | 2.33333333 |
| 2L1 | 2 | 2 | 2 | 2 | 5 | 5 | 3 | 4.33333333 |
| 2L2 | 3 | 5 | 4 | 4 | 1 | 1 | 3 | 1.66666667 |
| 2L3 | 4 | 5 | 5 | 4.66666667 | 2 | 2 | 4 | 2.66666667 |
| 2L4 | 5 | 1 | 2 | 2.66666667 | 1 | 2 | 1 | 1.33333333 |
| 2L5 | 4 | 4 | 2 | 3.33333333 | 5 | 5 | 3 | 4.33333333 |
| 2L6 | 5 | 5 | 4 | 4.66666667 | 3 | 4 | 2 | 3 |
| 2L7 | 4 | 4 | 2 | 3.33333333 | 4 | 3 | 4 | 3.66666667 |
| 2L8 | 2 | 4 | 3 | 3 | 5 | 4 | 3 | 4 |
| 2L9 | 5 | 2 | 1 | 2.66666667 | 5 | 1 | 1 | 2.33333333 |
| 2L10 | 2 | 0 | 3 | 1.66666667 | 1 | 0 | 2 | 1 |
| 2L11 | 2 | 1 | 1 | 1.33333333 | 2 | 0 | 1 | 1 |
| 2L12 | 4 | 0 | 3 | 2.33333333 | 3 | 1 | 1 | 1.66666667 |
| 2L13 | 2 | 0 | 1 | 1 | 1 | 3 | 1 | 1.66666667 |
| 2L14 | 4 | 3 | 1 | 2.66666667 | 2 | 0 | 1 | 1 |
| 2L15 | 3 | 1 | 4 | 2.66666667 | 1 | 1 | 3 | 1.66666667 |
| 2L16 | 0 | 5 | 3 | 2.66666667 | 0 | 1 | 1 | 0.66666667 |
| 2L17 | 0 | 4 | 3 | 2.33333333 | 0 | 1 | 2 | 1 |
| 2L18 | 2 | 0 | 2 | 1.33333333 | 4 | 0 | 3 | 2.33333333 |
| 2L19 | 2 | 4 | 2 | 2.66666667 | 5 | 3 | 3 | 3.66666667 |
| 2L20 | 3 | 4 | 2 | 3 | 3 | 0 | 1 | 1.33333333 |
| 2L21 | 1 | 0 | 0 | 0.33333333 | 4 | 0 | 0 | 1.33333333 |
| 2L22 | 5 | 5 | 2 | 4 | 1 | 5 | 1 | 2.33333333 |
| 2L23 | 4 | 2 | 4 | 3.33333333 | 2 | 3 | 3 | 2.66666667 |
| 3M1 | 3 | 2 | 1 | 2 | 1 | 0 | 0 | 0.33333333 |
| 3M2 | 4 | 0 | 2 | 2 | 2 | 0 | 3 | 1.66666667 |
| 3M3 | 3 | 0 | 3 | 2 | 1 | 0 | 0 | 0.33333333 |
| 3M4 | 0 | 3 | 4 | 2.33333333 | 0 | 1 | 2 | 1 |
| 3M5 | 4 | 2 | 1 | 2.33333333 | 1 | 4 | 1 | 2 |
| 3M7 | 3 | 2 | 2 | 2.33333333 | 3 | 5 | 4 | 4 |
| 3M8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3M9 | 2 | 3 | 2 | 2.33333333 | 5 | 4 | 2 | 3.66666667 |
| 3M10 | 0 | 2 | 0 | 0.66666667 | 0 | 3 | 0 | 1 |
| 3M11 | 3 | 1 | 2 | 2 | 3 | 5 | 4 | 4 |
| 3M12 | 0 | 3 | 4 | 2.33333333 | 0 | 4 | 3 | 2.33333333 |
| 3M13 | 3 | 0 | 2 | 1.66666667 | 5 | 1 | 2 | 2.66666667 |
| 3L1 | 5 | 0 | 2 | 2.33333333 | 3 | 0 | 3 | 2 |
| 3L2 | 2 | 3 | 4 | 3 | 4 | 5 | 4 | 4.33333333 |
| 3L3 | 3 | 4 | 2 | 3 | 4 | 5 | 4 | 4.33333333 |
| 3L4 | 2 | 3 | 3 | 2.66666667 | 5 | 5 | 3 | 4.33333333 |
| 3L5 | 4 | 2 | 3 | 3 | 5 | 3 | 3 | 3.66666667 |
| 3L6 | 3 | 2 | 2 | 2.33333333 | 2 | 4 | 3 | 3 |
| 3L7 | 2 | 3 | 2 | 2.33333333 | 3 | 5 | 4 | 4 |
| 3L8 | 3 | 3 | 1 | 2.33333333 | 3 | 2 | 3 | 2.66666667 |
| 3L9 | 3 | 3 | 2 | 2.66666667 | 5 | 5 | 2 | 4 |
| 3L10 | 3 | 2 | 2 | 2.33333333 | 3 | 4 | 3 | 3.33333333 |
| 3L11 | 4 | 4 | 3 | 3.66666667 | 5 | 4 | 4 | 4.33333333 |
| 3L12 | 3 | 3 | 2 | 2.66666667 | 1 | 5 | 2 | 2.66666667 |
| 3L13 | 4 | 4 | 2 | 3.33333333 | 2 | 4 | 1 | 2.33333333 |
| 3L14 | 2 | 2 | 3 | 2.33333333 | 5 | 5 | 3 | 4.33333333 |
| 4M1 | 2 | 0 | 3 | 1.66666667 | 2 | 4 | 3 | 3 |
| 4M2 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3.33333333 |
| 4M5 | 4 | 1 | 1 | 2 | 4 | 2 | 1 | 2.33333333 |
| 4M6 | 2 | 2 | 2 | 2 | 5 | 0 | 3 | 2.66666667 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4M7 | 0 | 1 | 3 | 1.33333333 | 0 | 0 | 1 | 0.33333333 |
| 4M8 | 3 | 0 | 1 | 1.33333333 | 4 | 0 | 1 | 1.66666667 |
| 4M9 | 0 | 4 | 0 | 1.33333333 | 0 | 2 | 0 | 0.66666667 |
| 4M10 | 2 | 3 | 2 | 2.33333333 | 4 | 5 | 2 | 3.66666667 |
| 4M11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4M12 | 4 | 4 | 5 | 4.33333333 | 0 | 2 | 3 | 1.66666667 |
| 4M13 | 0 | 0 | 1 | 0.33333333 | 0 | 0 | 0 | 0 |
| 4L1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4L2 | 2 | 0 | 3 | 1.66666667 | 5 | 4 | 4 | 4.33333333 |
| 4L3 | 3 | 3 | 2 | 2.66666667 | 5 | 5 | 4 | 4.66666667 |
| 4L4 | 0 | 5 | 3 | 2.66666667 | 0 | 3 | 3 | 2 |
| 4L5 | 4 | 5 | 4 | 4.33333333 | 3 | 1 | 3 | 2.33333333 |
| 4L6 | 3 | 1 | 1 | 1.66666667 | 3 | 1 | 0 | 1.33333333 |
| 4L7 | 4 | 4 | 3 | 3.66666667 | 5 | 1 | 1 | 2.33333333 |
| 4L8 | 0 | 2 | 1 | 1 | 0 | 3 | 1 | 1.33333333 |
| 4L9 | 2 | 2 | 2 | 2 | 3 | 5 | 4 | 4 |
| 4L10 | 2 | 1 | 1 | 1.33333333 | 3 | 2 | 1 | 2 |
| 4L11 | 4 | 2 | 2 | 2.66666667 | 2 | 0 | 2 | 1.33333333 |
| 4L12 | 0 | 2 | 1 | 1 | 0 | 0 | 1 | 0.33333333 |
| 4L13 | 2 | 4 | 3 | 3 | 3 | 4 | 3 | 3.33333333 |
| 4L14 | 2 | 5 | 2 | 3 | 4 | 3 | 2 | 3 |

# Participant Questionnaire Responses

| Participant | Condition | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 |
|---|---|---|---|---|---|---|---|---|
| P1 | V1 | | 1 | 2 | 2 | 2 | 1 | 3 | 2 |
| P2 | V1 | | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| P3 | V1 | | 1 | 2 | 1 | 2 | 2 | 2 | 2 |
| P4 | V1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| P5 | V1 | | 2 | 2 | 1 | 1 | 3 | 3 | 2 |
| P6 | V1 | | 3 | 3 | 2 | 2 | 2 | 2 | 1 |
| P7 | V1 | | 1 | 2 | 2 | 1 | 1 | 2 | 1 |
| P8 | V1 | | 2 | 2 | 2 | 3 | 2 | 2 | 2 |
| P9 | V1 | | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| P10 | V1 | | 1 | 2 | 3 | 2 | 2 | 1 | 2 |
| P11 | V1 | | 1 | 1 | 1 | 1 | 3 | 3 | 1 |
| P12 | V1 | | 2 | 2 | 1 | 3 | 2 | 2 | 2 |
| P1 | V2 | | 2 | 3 | 2 | 4 | 2 | 3 | 2 |
| P2 | V2 | | 2 | 3 | 3 | 3 | 2 | 5 | 5 |
| P3 | V2 | | 3 | 1 | 1 | 2 | 5 | 5 | 5 |
| P4 | V2 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| P5 | V2 | | 1 | 2 | 1 | 2 | 1 | 1 | 1 |
| P6 | V2 | | 4 | 2 | 3 | 2 | 3 | 5 | 2 |
| P7 | V2 | | 1 | 2 | 2 | 2 | 4 | 4 | 2 |
| P8 | V2 | | 5 | 2 | 2 | 2 | 4 | 5 | 3 |
| P9 | V2 | | 2 | 3 | 2 | 1 | 2 | 3 | 2 |
| P10 | V2 | | 1 | 2 | 4 | 3 | 4 | 4 | 4 |
| P11 | V2 | | 2 | 2 | 1 | 1 | 5 | 5 | 2 |
| P12 | V2 | | 3 | 3 | 1 | 2 | 3 | 4 | 3 |

# Analysis of Post-it Notes Generated in Activity 2

*Workshop 1*

| Less Ambiguous Visualisation: Inspirations | Type |
|---|---|
| 1 Hour Per Circle | Interface Observation |
| KWh Summary Per Day | Interface Observation |
| Household Type | Data Hypothesis |
| Sources Of Energy | Data Hypothesis |
| Explore Personal Habits | Use Observation |
| Understanding Habits | Use Observation |
| Effects Of Different Residents | Use Observation |
| House Sharers | Use Observation |
| Determinants Of Price Range | Data Question |
| Weekends Low Price | Data Insight |
| Hourly Price Ranges | Data Insight |
| Cost Of Using Different Devices | Data Insight |
| Power Consumption | Data Hypothesis |
| Consumption Per Person | Data Hypothesis |
| New £ | Interface Observation |
| Show Energy & Price Together | Interface Observation |

| More Ambiguous Visualisation: Observations | Type |
|---|---|
| Power Consumption | Data Hypothesis |
| Different Energy Types | Data Hypothesis |
| Shape Meaning? | Interface Observation |
| Green Solar Power | Interface Observation |
| A Triangle Is A Year? | Interface Observation |
| Grid = Month | Interface Observation |
| No Sunday | Interface Observation |
| Different People | Data Hypothesis |
| Lots of Houses | Data Hypothesis |
| Amount of Use | Data Hypothesis |
| Blue = Bad | Interface Observation |
| Colour Meaning? | Interface Observation |
| Green = Good | Interface Observation |
| UK Homes | Data Hypothesis |
| Navigation Inconsistent (rubbish!) | Interface Observation |
| Puzzle | Task Observation |
| Days | Data Hypothesis |
| No Key | Interface Observation |
| Inside & Out | Data Hypothesis |
| Thought Grid Was Touchable | Interface Observation |

*Workshop 2*

| Less Ambiguous Visualisation: Inspirations | Type |
|---|---|
| Peak Hours | Data Insight |
| What Are P's? | Interface Observation |
| What Are The Bars? | Interface Observation |
| Evenings Are Expensive | Data Insight |
| Convenience | Interface Observation |
| No Calculator To Sum Up Usage | Interface Observation |
| Money Saving Or Consumption Saving? | Use Observation |
| Only For Monitoring | Use Observation |
| Needs Totals | Interface Observation |
| No Good For Planning | Interface Observation |
| Total Per week | Interface Observation |
| Reflection Rather Than Prediction | Use Observation |
| Suggestion (Box) | Interface Observation |
| Need A Key | Interface Observation |
| Need For Chest Freezer? | Data Insight |
| Nice Colours | Interface Observation |
| Eating Habits | Data Insight |
| Lazy | Data Insight |

| More Ambiguous Visualisation: Inspirations | Type |
|---|---|
| The Bubbles Aren't Interactive | Interface Observation |
| We Can See Where The Peak Hours Are | Data Insight |
| Visualise Rather Than Analyse The Data | Use Observation |
| What Are The Pentagons? Type of Equipment | Interface Observation |
| Reflect Not Calculate (again) | Use Observation |
| Missing Sum Function | Interface Observation |
| Same Thing Presented Differently | Interface Observation |
| All In One View | Interface Observation |
| Colours Are Similar - Could Be Confusing | Interface Observation |
| Delineate Difference In Colours For Pleasure | Interface Observation |
| Visualisation Can't Be Canvas Each Change Of Colour Must Have Meaning | Interface Observation |
| Very Confusing Without Legend | Interface Observation |
| Colours Aren't Logical | Interface Observation |
| Overcomes Some Of The Previous Problems | Interface Observation |
| Overview Easy To Explore | Interface Observation |
| Grid Makes Me Safe | Interface Observation |
| Like Layout More Than Other | Interface Observation |

| | |
|---|---|
| Prefer Other One | Interface Observation |
| 24 Squares 1 Per Hour | Interface Observation |
| Misses Key + Scale | Interface Observation |
| Triangle = Killowatts + Costs | Interface Observation |
| Top Is Total | Data Insight |
| What Are The Stars? 7 = Days Of The Week? | Interface Observation |
| How Are They Supplied In Days? | Data Question |
| Shows Usage As Bubbles In Matrix | Interface Observation |
| Daily Calendar | Interface Observation |

***Workshop 3***

| **Less Ambiguous Visualisation: Inspirations** | **Type** |
|---|---|
| Intuitive | Interface Observation |
| Labels | Interface Observation |
| Day <--> Device | Interface Observation |
| Units Of Usage Shows Different Story | Data Insight |
| Circle Size Energy Usage | Interface Observation |
| When Are Different Rates? | Data Question |
| Animations | Interface Observation |
| Appliance Specific | Data Insight |
| Understandable Interactions | Interface Observation |
| KWH / £ | Interface Observation |
| Free Cost Doesn't Mean No Usage! | Data Insight |
| The Hours Can Be Different Visualisation | Interface Observation |
| Free Energy - Superfluous Indication in £ of Free Energy Use | Interface Observation |
| Obvious | Interface Observation |
| Rating Is Different In Each Day | Data Insight |
| Different Colour Rating Different day | Interface Observation |
| Grey Out High + Peak At Weekend | Interface Observation |
| Daily Representation Only In KW Not £ | Interface Observation |

| **More Ambiguous Visualisation: Inspirations** | **Type** |
|---|---|
| Circles = Consumption | Interface Observation |
| Different Colour | Interface Observation |
| What Do Symbols Mean? | Interface Observation |
| Circle Size Consumption? | Interface Observation |
| Needs Key | Interface Observation |
| Triangle 2 | Interface Description |
| Weekend Are Different | Data Insight |
| Not Obvious | Interface Observation |
| Grid Temporal | Interface Observation |
| Stars - Days? 7 | Interface Observation |
| Pentagons Appliances | Interface Observation |
| Colour Size | Interface Observation |
| Stars -> Rating -> Days | Interface Observation |
| Words + Shape | Interface Observation |
| Not Intuitive | Interface Observation |
| Grid - Hours Of Day? | Interface Observation |
| Some Circles Too Small | Interface Observation |
| 24 / 7 - Number | Interface Observation |
| Different Rate Of Price | Data Insight |

***Workshop 4***

| **Less Ambiguous Visualisation: Inspirations** | **Type** |
|---|---|
| 6am = Low Price More Consumption | Data Insight |
| 6 - 9 = More Consumption With  Higher Price | Data Insight |
| 12 - 9pm Is The Higher Rate Of Spend | Data Insight |
| Thursday & Sunday Using Washing Machine | Data Insight |
| Sat - Sun Low Cost | Data Insight |
| Colour Code: Green To Blue -> Free To Peak | Interface Observation |
| Fridge Is Stable Almost Consumption For Every Day | Data Insight |
| Total Consumption : Highest Consumption At High (16p) | Data Insight |
| Dark Green = Free Electricity | Interface Observation |
| Circles = Not Clear (May Be Consumption) | Interface Observation |
| Weekends = Med Low Or Free! | Data Insight |
| Colours Not Distinct Enough | Interface Observation |
| The Money Visual Could Tell You Total Cost | Interface Observation |
| Mon & Tues = Most Expensive Days | Data Insight |

| **More Ambiguous Visualisation: Inspirations** | **Type** |
|---|---|
| Triangle = Show Amount | Interface Observation |
| Shape | Interface Observation |
| Pentagon Is More Stable | Interface Observation |
| 24 Cube = Hour | Interface Observation |
| 9 Pentagon = Equipment | Interface Observation |
| 7 Star = Week | Interface Observation |
| 2 Triangle = Price | Interface Observation |
| Pentagons 1 = Total Equipment | Interface Observation |
| Pentagon Control The Amount Star Changing The Colour Grid | Interface Observation |
| Sat & Sun Low Cost | Data Insight |
| Monday - Wed Tues - Thur is The Most High Cost | Data Insight |
| When We Figured Out It Was 24 Hours The Rest Of The Pattern Became Obvious | Use Observation |

# Video Transcript: Workshop #2 IV1 (Less)

| Partici | Transcript | Code | | List of codes: |
|---|---|---|---|---|
| P3: | Peak hours? Peak usage? | OU | | DI = Data Insight |
| P1: | Yeah! | MC | | DQ = Data Hypothesis or Question |
| P3: | So we have one for that? | MC | | OU = Observation About Use |
| P1: | Yeah is that what you've written? | MC | | OI = Observation About Interface |
| P3: | Peak hours | OU | | MC = Micellaneous Comment |
| P1: | Specifically like the bubbles? | OI | | |
| | I think that's what this shows? Right? [points at visualization] | | | |
| P3: | When we use it the most. | OI | | |
| | What I don't get is here like, free, medium and it has in | | | |
| P2: | brackets 4p... what is p? | OI | | |
| | Oh that would be pence.... Per kilowatt. It costs more at | | | |
| P1: | peak times | OI | | |
| P1: | So shall we see what the other days are? | MC | | |
| | Well that's interesting, look at the different uses on a | | | |
| P1: | Tuesday. Is everyone out on a Tuesday? | DQ | | |
| P3: | Tuesday? | MC | | |
| | That's Monday. Now Tuesday. What's everyone doing on a | | | |
| P1: | Monday night? | DQ | | |
| P3: | Let's see... | MC | | |
| P3: | Lets see the rest of the days. | MC | | |
| | [interacting with visualization] Oh. Everyone's off on a | | | |
| P1: | Wednesday | DQ | | |
| | So what I'm thinking is like... is it showing like on these | | | |
| | (inaudible) [pointing at visualization] is it intensity of how | | | |
| | much power used or is it how much they charge during | | | |
| P2: | specific.... | OI | | |
| P3: | Say it again. You don't get these? [points to visualization] | OI | | |
| P2: | No, no the bars | OI | | |
| | Oh so I would assume that during the week you have peak | | | |
| | times of use to try and (inaudible) what they do in the week. | | | |
| | And at weekends you don't have peak charges. The highest | | | |
| P1: | cost per unit is medium | DQ | | |
| P2: | What does this scale mean? From 0 to 22? | OI | | |
| | | | | |
| P1: | I think that's the kilowatts... that's just the amount of usage.. | OI | | |
| P2: | OK. | MC | | |
| P1: | So (inaudible) | MC | | |
| P3: | You've also got pounds also... | OI | | |
| P2: | Does something happen if we switch from here to here | OI | | |
| P3: | OK so we can see now in price | OI | | |
| | Sunday is obviously a big day for electricity use... everyone | | | |
| P1: | doing their washing | DQ | | |
| P2: | This scale is from 0 to 7 now... Is that pounds? | OI | | |
| | Yeah. Yeah. Yeah. Now its pounds if we took it back you can | | | |
| | see it in energy amount... and this is how much money it | | | |
| P3: | cost | OI | | |
| P3: | So evenings are expensive | DQ | | |
| P1: | People do a lot of stuff on Monday evening. | DQ | | |
| P2: | So that's interesting | MC | | |
| | They're doing stuff on a Sunday and a Monday... like for | | | |
| | me... so lets look at what machinery... so I would (inaudible) | | | |
| P1: | on a washing machine... | DQ | | |
| | So on a Monday no one uses the washing machine... They're | | | |
| P1: | not using the dishwasher... or the microwave... | DQ | | |
| | No you know actually this isn't many people... this is one | | | |
| P3: | house. | DI | | |
| | Because you see, you can see all the machines are not | | | |
| P3: | housed in the smart home I think. | DQ | | |

| | | |
|---|---|---|
| P1: | Oh I thought it was a consolidation... I thought it was consolidated use | DQ |
| P3: | I think its one house... because these are the.... | DQ |
| P1: | So this particular family are only really ironing on a Monday... Oh no they're using their desktop computers ... | DI |
| P1: | They are using that pretty consistently [interacting with visualization] throughout the week. | DQ |
| P3: | So I guess there is some (inaudible) | MC |
| P1: | yeah in the evenings they're using their desktop computers... but at the weekends they're not really... well no... they are too aren't they | DQ |
| F: | [Facilitator reminds participants of the prompt questions] | MC |
| P3: | Well I think it's very convenient... you can see everything you know... how you use everything... you can plan your expenses better... | OI |
| P2: | Though it doesn't have a summing function for example like all these times of day... here they tell a story but if I want to count up something... I don't know... | OI |
| P1: | Oh yeah like a calculator option | OI |
| P3: | So calculator?... No calculator | OI |
| P2: | Some way of like summing things... or is it already integrated somehow? | OI |
| P3: | You mean like a total consumption... for something? | MC |
| P1: | Because it's just total electricity but you couldn't work out like across... you couldn't do it across the week how much it's going to be | OI |
| P2: | But I think there would be various but I asked more what the scale of this... what is the unit... | OI |
| P1: | Yeah like from 0 to 7 and from 0 to 42 or what.... | OI |
| P2: | Is it like kilowatts? | OI |
| P1: | I suppose its interesting because I'm not sure what the point is but if it its... I mean... it saves people money but it doesn't necessarily save energy consumption because if you use this right you could use more electricity and pay less. | OU |
| P1: | If you timed it right so you're always using your washing machine when it was low you could do 3 times as much washing... 4 times as much washing in the week and still only just hit the same as if you did it once in the high. | OU |
| P1: | So you could actually use more electricity using one of these for a small cost which I imagine... doesn't quite makes sense? | OU |
| P3: | So how do you want to put that down on this? [laughing and holding a pot-it note] | MC |
| P1: | Is it meant to be just a money saving device or is it theoretically meant to be a consumption device? Because you need to be a guilty person for it to work as a pure... if you're trying to cut energy use generally they need to be a person who cares about the environment you know a hero... has to really care about the environment and not really care about their own pocket | OU |
| P2: | I think it's for monitoring mainly it lets you see how you behave because we often don't pay attention. | OU |
| P2: | Or I don't know.... maybe for households which are flat sharers so you can observe how you go together as a group... you know... how you behave and how other people behave | OU |
| P1: | Oh yeah I mean to what end | OU |
| P2: | Like it has some sort of controlling device | OU |
| P2: | You can see each of these devices how much it consumes... you can see for example whether to use less or to use more... I don't know | OI |

| | | |
|---|---|---|
| P3: | I think it should have like a... totals... so you can see the whole usage for the week and then you can go onto each 1 and see where you are using it the most | OI |
| P1: | [shocked] An iron costs more to run than a desktop computer [All talk over each other excitedly - words inaudible] | DI |
| P1: | The iron is massive! | DI |
| P1: | The microwave... | MC |
| P2: | I like the colours | OI |
| P1: | They're very nice colours | OI |
| F: | [Facilitator directs the group to the prompt questions] | MC |
| P3: | What do you think that this is for? | OU |
| P3: | To monitor the house... consumption... energy consumption of the house | OU |
| P1: | Yeah the aim of the device is to do that but I'm not sure what the reason for using the device is... | OU |
| P1: | So the point is that I get this is meant to monitor it... but to what end? | OU |
| P3: | Information. So you know how you're using it | OU |
| P1: | But it's what you do with the information. There's no point in gathering lots of information that you don't really use. | OU |
| P2: | There are 2 motives at least. 1 is like being environmentally friendly the other one is saving money | OU |
| P1: | And depending on which one you come to it with will depend on how you use it | OU |
| P1: | For example if I was really environmentally conscious I might decide that my personal ethics not to use the iron are spot on [laughter] | OU |
| P2: | But if my energy came from an environmentally friendly place that's fine too. | OU |
| P1: | And also who is this person that's doing the ironing at 5am? | DQ |
| P2: | Oh my goodness | MC |
| P2: | Somebody has got insomnia perhaps... | DQ |
| P2: | So why evaluate both the fridge-freezer and chest freezer as separate categories if its turned on all the time? | DQ |
| P3: | Maybe they're 2 different.... | MC |
| P2: | I know that they are physically 2 different devices but I don't know why we're observing these 2 at all actually because they are turned on all the time why would we need to monitor them? | DQ |
| P1: | I suppose you could if you were trying to be really good you could be like ooh look its really using a lot lets get rid of the chest freezer and just use the fridge-freezer | OU |
| P2: | That's a one-time information | OU |
| P1: | I suppose it does contribute to your total level | OU |
| P1: | There's another... if it's just connected to 1 of each of these devices or like for example... | OU |
| P2: | There could be like other static things [inaudible - combination of scaffolders outside and participants mumbling quietly] | OU |
| P3: | That's a lot of TV watching | DQ |
| P3: | What else? | DQ |
| P2: | Saturday and Sunday never have a peak production but what I don't understand is like... when does... OK... | DQ |
| P2: | Are we trying to understand when do they charge more and when do they charge less? ... and I don't quite connect the situation with this time line here and the prices here | DQ |
| P3: | Yeah you can... see... here's the price and then you choose... and you have totals for everything. | DQ |

| | | |
|---|---|---|
| P2: | But here it just seems like... how much its was... for example after 9pm I see that it was less... it was low rather than medium but I don't know what happens for example between 12am and 5am because nobody used it at that time. I don't know how much it would be charged if it was used | OI |
| P1: | So you're kind of saying why isn't there a key for this? So if you click on there and try and work out how much it was... | OI |
| P1: | So you need a key for when what cost is what time | OI |
| P2: | It could be like a table of like when it says like this hour to that hour its medium on Saturdays or something like that | OI |
| P1: | Yes | MC |
| P3: | That doesn't make sense. If the freezer, fridge and chest freezer they're turned on all the time... how come there's no consumption in those hours [pointing at visualization] | OI |
| P1: | Because this is the cost look... so there's consumption but it's free | OI |
| P3: | OK | MC |
| P1: | So yeah we want a key to understand because otherwise I can say to myself... like you say I can say to myself... OK so I want to reduce my ironing costs but unless I know when it's cheap to use my iron how can I? and I just have to keep testing and trying it at different times otherwise, wouldn't I. | OU |
| P3: | So suggestion something? Box? Or suggestion pop-up? | OI |
| P1: | Or its just a case of a key that told you like... free like these hours | OI |
| P2: | Like if you tapped the medium then it says like medium is on Mondays and Thursdays from.... 4... | OI |
| P3: | So lets assume that we're environmentally friendly and we want to see... let me think... when... Oh but then this won't help us actually. If we want to plan when to turn on the dishwasher so we don't use too much energy we can't plan it because this only tells us what we've done. | OU |
| P2: | This is more for reflection than prediction I think | OU |
| P1: | Yeah I'd agree with that 1 | OU |
| P3: | So. Reflection. | OU |
| P2: | rather than prediction | OU |
| P2: | And yet in the end I would like to have an option of saying how much I spent this month when I summarise the amount | OI |
| P1: | Like a totalizer | OI |
| P3: | You can [clicks visualization] Yeah you can actually | MC |
| P1: | No but this is only per day so you can't work per week | OI |
| P3: | So total for week [writing post-it] that would be helpful | OI |
| P3: | I can't believe the iron uses that much energy | DQ |
| P1: | I know that's crazy isn't it | MC |
| P2: | I wonder how often they use the microwave? And not cooking? | DQ |
| P2: | And where is the cooker? They don't have a cooker. | DQ |
| P1: | Maybe it's a gas cooker? | DQ |
| P3: | Oh gas yeah. | MC |
| P2: | So they are eating in a bad way probably during the week rather than the weekend? No | DQ |
| P3: | Not necessarily. You can actually cook vegetables in a microwave | MC |
| P1: | Are you revealing something about your lifestyle choices? [laughter] | MC |
| P3: | Its faster... | MC |
| P1: | So they spent £2.50 on the microwave I bet they thought that was a cheap meal that... I'll just get a microwave meal and they spent £2.50 that day on the microwave | DI |

| | | |
|---|---|---|
| P3: | Well how much energy? | DQ |
| P3: | Oh yeah. Lots of energy and lots of money... that's not good... | DQ |
| P1: | Yeah so they are spending quite a lot on the microwave over the week | DQ |
| P3: | Saturdays and Sundays they don't but they probably eat out those days | DQ |
| P1: | Yeah or they're at home so they've got time to actually cook a meal | DQ |
| P1: | Like they did on Monday | DQ |
| P1: | Wednesday really was a bad day... | DQ |
| P3: | So eating habits also | MC |
| P1: | They use the dishwasher almost every day of the week | DI |
| P3: | So they're lazy as well... [laughter] | DQ |
| P1: | I think it would shock people if they added up how much energy they spent in a week | DI |
| P3: | So it needs another column for the week... not column you know what I mean | OI |
| P1: | Yeah a button or an option | OI |
| P3: | So this actually throws up a [inaudible] energy | MC |
| P3: | Notice how this doesn't change? | OI |
| P3: | I'm guessing that these here [clicking on visualization]... | OI |
| P1: | Oh these are like summary bars aren't they... which area of the day... | OI |
| P3: | So if you switch between price and electricity it doesn't change... it's the same on the day | OI |
| P1: | I'd imagine that this bit is based on percentages. So we know that like say on this one they like 80% of the usage was in that block of time | OI |
| P3: | Yes but you don't know if this is on the energy or on money. If you change it between energy and money it you should be able to see it | OI |
| P1: | But if its percentage of use across the day it doesn't matter if its money or energy | OI |
| P3: | Buts its not look it corresponds with these [points at visualization] prices | OI |
| P3: | These colours here and the way the percentages are arranged they should change... to energy or to price... because they change [using the visualization]... They correspond to the colours of the peak.. you k now peak hours | OI |
| P1: | I see what you mean but if those are like... if those are proportions of use... even though that changes... | OI |

# Video Transcript: Workshop #2 IV2 (More)

| Participant | Transcription | Code | |
|---|---|---|---|
| P1: | OK so lets press buttons | MC | List of codes: |
| P3: | OK what does that mean? | OI | DI = Data Insight |
| P2: | I think these are the days of the week there are 7 stars... or price categories? No I think these are days of the week. | OI | DQ = Data Hypothesis or Question |
| P2: | How many of these? These are 9 and these are 2. These are pounds and kilowatt hours I think... these 2 | OI | OU = Observation About Use |
| P2: | These could be the timelines across here [pointing at visualization] | OI | OI = Observation About Interface |
| P1: | So like 6, 8, 10, 12... 2, 4 , 6, 8, 10... [touching visualization] | OI | MC = Micellaneous Comment |
| P2: | Something like that | MC | |
| P1: | So is it a matrix this time? Rather than a... and these are interactive [touches visualization] | OI | |
| P2: | They just go bump into your face... [laughter, smiling] | OI | |
| P2: | It changes yeah... | OI | |
| P3: | The other ones weren't interactive either... | OI | |
| P1: | No that's true | OI | |
| P2: | Just like a proof of concept thing maybe? Maybe just like an initial structure | OI | |
| P3: | I think it's a different way of displaying the information instead of bars there's... [makes small shape with fingers] | OI | |
| P2: | So 3 scales? 3scales... This one is... this one displays... the right on is the x | OI | |
| P3: | No... these aren't times... because you have one date.... That whole day... what does that mean? [pointing to visualization] | OI | |
| P1: | Oh so what do you think? [pointing at visualization] These are the hours? | OI | |
| P1: | Wooah! Don't think you're meant to do that. | MC | |
| P1: | So are there 24? | OI | |
| P3: | 1, 2, 3, 4, 5, 6... | OI | |
| P1: | Yeah 24 | OI | |
| P3: | So this is a calendar? | OU | |
| P1: | A daily calendar... | OU | |
| P3: | Ahh. I'm really not sure if these are the days... [touching visualization] and how this display is here... I don't get it... I you see the different days you can get different data in it... you see? | OI | |
| P2: | For example if this is Thursday now... | DQ | |
| P3: | So what does that mean? | OI | |
| P2: | So this could... these are probably the timelines... | OI | |
| P1: | So these are the bits of equipment | OI | |
| P2: | Yeah these are the chest freezer and stuff... | OI | |
| P3: | Aahh! [agreement all round] | MC | |
| P3: | So you see you click Mondays... for example this is Monday... and this whole thing is Monday [indicates visualization] | OI | |
| P2: | Yeah... so this is like midnight, 1am, 2am, 3am... and there's 24 hours... | OI | |
| P3: | And these are the different prices | OI | |
| P2: | This shows the consumption... and you know what we had those circles down there by the timeline... these are those circles just put into the matrix now. | OI | |
| P1: | Yeah so this is the bit that changes with consumption or cost. So if we can work out which one the iron is.... [laughter] | OI | |
| P1: | Was it Monday? One of the days she was doing loads of ironing... The person that is... | DQ | |
| P2: | I guess from the top... its like down from top to bottom is Monday to Sunday | OI | |
| P1: | That's the dishwasher because there was only one day in the week when they didn't use the dishwasher [agreement and laughter] | DQ | |
| P3: | I think it's in the same order... so this is total... right?... totals. And then you have... what was the second one? I can't remember. Then the dishwasher. Then microwave. Right? | OI | |

| | | |
|---|---|---|
| P2: | My first thinking was I like this one far better than the first one because you have actually that calendar view and can see very easily when its expensive and when it is not expensive. What it misses is probably a scale or what the purple is... | OI |
| P1: | [laughing] Some sort of information... | OI |
| | | |
| P2: | Yeah. But. If you like know this from before I find this far more pleasurable than the first one, but that's just my personal opinion... | OI |
| P3: | I prefer the other one | OI |
| P2: | I like matrices very much. It gives me like this table view I'm a big fan of tables so if it's in the grid it makes me safe | OI |
| P3: | Safe? | MC |
| P2: | Yeah I feel like I'm... to have an overview and control of this data its easy to explore it, its all in front of you sort of thing? | OI |
| P3: | So we see? What do we see? We see a grid. We see... We think we see... | OI |
| P2: | By these controls on the side you pick a view... basically... | OI |
| P3: | So we think we see the same data presented in a different way? | DQ |
| P2: | Yes?[agreement] | MC |
| P3: | So we see the same data but presented in a different way | DQ |
| P2: | I think it kind of answers some of the visualization inspirations we had before when we were first asked. Some of them. | OU |
| P2: | The previous one there was like... different sorts of bar like up there [motions above head] there was view by day... and here were the bars... and here were the little circles [motioning in front of face]. Here everything is in the overview. I find that like easier | OI |
| P3: | But to me this is very confusing because there is no legend, there is nothing, there is no key... I don't know | OI |
| P2: | I agree a legend would be useful... | OI |
| P3: | I have no idea because you see there are different colours... you see... its like... I mean [interacting with visualization]... like... these colours they don't just merge into another one... you have this colour here and you also have it here and so it doesn't tell me... you know... what that means | OI |
| P2: | Could you expand this idea a bit more? | MC |
| P3: | Like usually this colour might mean for example certain consumption right? So like you have it here the same column, one line it will change, morph into another one. Is it changing... if the consumption is changing or something... I don't understand what... why we have different colours | OI |
| P1: | Yeah because I don't... in my head I suppose I guessed the colours are the peaks. So this is free... and this low, medium... but then its weird that there is randomly this 1 here and there's 3... | OI |
| P3: | Exactly. Exactly what I mean. It's confusing so I don't understand why... | OI |
| P2: | Maybe that's like they calculated the cost for example and this purple one is from 5 to 6 that's when people come home from work they can cook or something like that? That 1 hour... 2 hours actually | DQ |
| P1: | I was going to say... what if you changed the... does it matter what we pick on that? [interacting with visualization] | OI |
| P3: | So then you have different coloured circles also... so what does that mean? Different price or what? | OI |
| | | |
| P2: | No it just means to somehow signal how much consumption there was and it had to be certain colours but these colours are not... the same as like... there is just like... a darker shade of the colour which is behind it... so these colours are just darker shades of what's behind them... no other coding in that on my understanding. | OI |
| P3: | I don't think so... I think if you do visualizations like that it doesn't work like that... | MC |
| | | |
| P2: | I think this is just like... I understand it as a measure of the quantity. The circles. And the colour of it doesn't mean anything its just to make it visible it's a darker shade of a category of price which is... | OI |

| | | |
|---|---|---|
| P3: | Yeah but the colour always means something you know... in visualizations you have a reason for you to... a group of colours for one thing and another for another. | OI |
| P2: | But this is just like darker shades so that its possible to show it because how else would you show it? It could be only black circles everywhere but this way its more pleasurable... you know... to just put darker shades of a colour which is behind it | OI |
| P3: | No, no I don't think this is the case... because you have purple... which day was it that had the different colours? | OI |
| P1: | Any day... Monday to Friday | DQ |
| P2: | This is just like a darker shade... if you're asking me about the colour of the circle... its just a darker shade of this purple thing... and purple is like peak hour or something | OI |
| P1: | Yeah so like this colour only ever appears on purple and this colour only appears on blue and this colour only appears on the pale green | OI |
| P3: | You guys have a case | MC |
| P1: | The circles are just slightly deeper hues of that colour... whether its right or not is up for debate... but that's what it is [laughter] | OI |
| P2: | The colours are very similar so if somebody can't recognise the colours very good can be confused... | OI |
| P1: | Yes. That's a very good point. | MC |
| P2: | My dad would be like crazy with this because he wouldn't recognise reds or something like that... | OI |
| P3: | So you think that he wouldn't be able to see... to see that they were different? | OI |
| P1: | Yeah because actually the green... particularly the 2 greens I would think they're very close. [agreement] | OI |
| P3: | For me I can still... this isn't helpful to plan... to see or to monitor my usage because its just confusing where to see the cost... I prefer the past | OI |
| P2: | I prefer the circles and the calendar here... but I understand why you say that the bars are more intuitive to you... I guess its just up to personal preference | OI |
| P1: | I suppose in our minds we have the bar graphs giving you the cost of wattage and then the bubbles showing you when during the day that's happening whereas with this I suppose you get it all in one... is that why you may like it more than the other one? You have just one graph with both the prices and when. Whereas in the other one you have to get 2 pieces of data and add them together in your head. | OI |
| P2: | You had to like share your view on 3 different parts of the screen whereas here it all in 1 | OI |
| P3: | But I don't think that this says when again... it just says the day. I don't see how this can be turned into time | OI |
| P1: | Oh so this is 12... wooh! [shocked/amused at something in visualization laughter]... 12 - 1, 1 - 2, 2 - 3, 3 - 4, 4 - 5, 5 - 6, 6 - 7, 7 - 8, 8 - 9,  9 - 10 ... | OI |
| P3: | Oh so you think this is like... | MC |
| P1: | 1 hour per box | OI |
| P3: | OK now that makes sense | MC |
| P3: | So then... so this would be 7? | DQ |
| P1: | Yeah 6 - 7 | DQ |
| P3: | 6 - 7... I think that makes sense now | DQ |
| P2: | But still it doesn't carry out a sum function perhaps it still has some of the shortages of... [inaudible as P1 & P3 laugh] | OI |
| P3: | This is the totals... this is the thing that... because the first 1 is also... and then you have usage every hour [indicating in visualization] | OI |
| P2: | But there is no sum of the day or the week or something like that... it just has like... indicating per hour just like it was in the previous visualization... | OI |
| P1: | So you would have to go 1, 2, 3, 4, 5, daytime... | OU |

| | | |
|---|---|---|
| P2: | Its more like again for reflection and not to like actually calculate stuff but more like to have some general idea about how things are consumed | OU |
| P3: | I think that this is more to visualize the data... the other one was more to look at the quantity as well as the... you know... | OU |
| P3: | Here it seems like there's more... because of the circles... | OU |
| P1: | Visualize rather than analyse? | OU |
| P3: | Yeah [general agreement] | OU |
| P3: | With the other 1 you could manually calculate it. With this 1... | OU |
| P1: | Guess work. | OU |
| P3: | Can we see which 1 is the peak hour here? Can we tell? | DQ |
| P1: | So yeah I think anything that's blue or purple are the peak hours | OI |
| P1: | So 1 peak hour in the morning | DI |
| P1: | Oh that is good though... yeah... because that's what we said we wanted wasn't it... to see where the peak hours are | MC |

# Video Transcript: Workshop #4 IV1 (Less)

| Participant | Transcript | Code | |
|---|---|---|---|
| P3: | So there seems to be free, low, medium, high, peak. Is that prices? | OI | List of codes: |
| P3: | So there is a time on there which is actually free. | DQ | DI = Data Insight |
| P3: | Is it electricity? Or is it electricity and gas? | DQ | DQ = Data Hypothesis or Question |
| P1: | It's electricity. | DQ | OU = Observation About Use |
| P1: | It's electricity consumption and what you can see is there is a high value which is this [pointing at the visualization] | DQ | OI = Observation About Interface |
| P1: | OK we should describe every day.... I can see.... | MC | MC = Micellaneous Comment |
| P1: | The medium colour appears for every day. But what we don't have is peak and high colour on Saturday and Sunday. | OI | |
| P2: | All Saturday and Sunday is mostly.... | MC | |
| P3: | What's that dark colour at the weekend? | OI | |
| P2: | Most of it is medium. | OI | |
| P3: | Free? | OI | |
| P3: | So it's actually medium or low. | OI | |
| P1: | This is what it says for the duration of a day, this is for the full week [pointing to aspects in the visualization] and this is describing each day which value you're using | OI | |
| P3: | But what day is this one? Because presumably this changes every day. | OI | |
| P1: | this is according to the circle which is getting bigger. | OI | |
| P3: | Ahh so there is more consumption for the circles. | OI | |
| P3: | So dark green is free | OI | |
| P3: | So is the circles the amount of power used every single day? It's a changing thing the amount of power that's used in a typical day | OI | |
| P3: | So that's a typical day and then that's what happens across the week. | | |
| P3: | That's prices and consumption. | DQ | |
| P3: | The circles equals typical consumption | OI | |
| P1: | This one's not really giving us the information with regards to the kilowatt hours or the prices | OI | |
| P2: | This one's the consumption. | OI | |
| P1: | Consumption. Yeah. | OI | |
| P2: | From 6 to 9 you consume more electricity because you are at home. This shows you at home and then you go to the office. So on the peak scale these are more office hours and then look at PM - at night you go home again | DI | |
| P3: | Why is it coloured? That's what's confusing me | OI | |
| P2: | You will not consume any energy and at that time it is the cheapest | DQ | |
| P3: | OK | MC | |
| P2: | Now if we look and there is more pressure on the system they charge you more | DQ | |
| P3: | When is it actually the most expensive time to use? | DQ | |
| P2: | Midday | DQ | |
| P1: | 6 to 9 pm | DQ | |
| P2: | Most expensive time I think is 5pm to 6pm | DQ | |
| P1: | By why at 6pm is the circle getting bigger? What does that mean? | OI | |
| P2: | More consumption. | OI | |
| P2: | So at around 5 and at around 8 when you are getting home from your office you don't consume too much but they are charging high. At night say 8 pm they are again charging more amount but you are again consuming green amounts. That's what I think. | DI | |
| P3: | The thing we talked about earlier was that the weekends are either medium, low or free. | DQ | |
| P3: | [writing post it] Weekends are low, medium or even free. | MC | |
| P1: | And we could say like Tuesday and Monday is the most consumption... is the most expensive consumption. [Participants start to interact with the visualization rather than point to areas on its default view] | DQ | |
| P1: | So this is the total we were talking about... and you can see each particular equipment...  washing machine which is... dishwasher is... | OI | |
| P2: | Medium.... And normally used in the morning.. | DQ | |
| P1: | Did you write? Dishwasher is..... | MC | |
| P2: | [interacting with visualization] And this is washing machine. What does it look like? And there is nothing.... | DQ | |
| P3: | Oh but that's on a Monday | DQ | |
| P1: | If it's on Tuesday... | DQ | |

| | | |
|---|---|---|
| P1: | Yeah so people doing their.... | MC |
| P3: | So who is doing their washing when? | DQ |
| P1: | On Thursday people are washing their... | DQ |
| P2: | [Going through the days on the visualization] And on Sunday. | DQ |
| P1: | Thursday and Sunday | DQ |
| P3: | Ohhh You never do washing on a Sunday [mock outrage] [laughter] And dishwasher... on Saturday only in the morning ... on Friday.... | MC |
| P2: | Thursday no dishwashers.. and on Wednesday.. | DQ |
| P1: | Its at midnight. | DQ |
| P3: | Oh. Is this one persons consumption? Do you think? Because they didn't do anything on those days. What about fridge-freezer? That one's continually on... So does that one have something on every day? Yes. | DQ |
| P3: | So something like that that's constantly plugged in is running throughout. | DQ |
| P1: | Yes and if we see the fridge... the circles are almost the same | DQ |
| P3: | So this is one person's consumption for a week and that's what the circle stands for. | DI |
| P2: | Iron.... [interacting with visualization] | MC |
| P1: | Yeah. If you can see that for example this desktop computer compared to the fridge... the consumption is different. | DQ |
| P2: | And on Sunday we can say... [interacting with visualization] | MC |
| P3: | So you could use this to look at your own consumption | OU |
| P1: | So we can say that fridge is steady consumption | DI |
| P2: | (inaudible) [demonstrating something to P3] | MC |
| P3: | What is this across the top? These numbers? 0 - 42? Oh its kilowatts... is it? | OI |
| P1: | Yeah kilowatts. | OI |
| P3: | I suppose what you can see is how much it costs [P2 is interacting with the visualization] | OI |
| P1: | Oh you can see the price | OI |
| P1: | So up to now we were looking at kilowatts. I am also curious to see the price. | OI |
| P2: | A little more step by step. So first know everything about total consumption... | MC |
| P1: | Total cost | MC |
| P2: | Total cost and profile and then.... [indicates continuing more with hand] | MC |
| P1: | OK so for midday we would say like... from... at 12 and... 12 am... 9am... 9pm and.... [writing] | MC |
| P3: | Its quite difficult to see what the difference is here... between these... even the blues | OI |
| P1: | So the dark blue is the most expensive time. | OI |
| P2: | Its expensive | OI |
| P3: | [pointing at the visualization] See for a minute there I thought that that was the high but actually you're right it's the peak... and peak is twice as expensive | OI |
| P3: | And yet it's just a shade in blue | OI |
| P3: | So what do we think about the colour of the different... errm? [indicates area of the visualization] | OI |
| P3: | Do you think it would make more sense to have red for the peak so you'd know exactly when it was that your electricity was costing more? | OI |
| P1: | Yeah. | MC |
| P2: | I also think that this dark blue, the peak one, you find you're paying the higher rate but consuming a lower amount | DQ |
| P2: | So when you multiply cost and consumption then the total cost is this [indicates on visualization] | DQ |
| P3: | No but my question is here... just looking at that I thought those 2 circles were high... | OI |
| P2: | So you were considering only 3 circles of peak? [P2 & P3 are pointing to areas on visualization] | OI |
| P3: | No my point is that I thought those were high but they're actually peak because the shading of blue is so close. It's very difficult to distinguish which is peak for me. So my question is do you think it would be useful to actually have that in an easier colour so that you would see at a glance - oh look you've used that. Because its actually twice as expensive as the high rate. So if you want to stop that you might want to identify that quickly. | OI |

| P1: | Yeah | MC |
| | Because its actually... you see that [pointing to visualization] that circle of electricity has cost you just as much as that big circle of high rate but it's | |
| P3: | only half the size | OI |
| | Shall we go to the other [interacting with visualization] I think its... I just | |
| P1: | want to check.... | MC |
| | So the week is not changing if its price or if its kilowatts. What is changing | |
| P1: | is the rate. | OI |

[Final 1 minute 30 seconds missing due to camera failure]

# Video Transcript: Workshop #4 IV2 (More)

| Participant | Transcript | Code | List of codes: |
|---|---|---|---|
| P3: | So what have we got? Stars on one side, hexagons on the other | OI | DI = Data Insight |
| P1: | Shapes | OI | OU = Observation About Use |
| P3: | What happens when you try that? You were going up that one? [pointing at visualization]… You were just going up like this [to P2] | OI | OI = Observation About Interface |
| P3: | So how many? | OI | MC = Micellaneous Comment |
| P1: | It's not really clear | MC | |
| P3: | It's 5 across here, 4 up and down | OI | |
| P2: | [interacting with visualization] These or these? | OI | |
| P1: | Shall I see what this one?…. | OI | |
| P3: | That is… What does it do? | OI | |
| P1: | [interacting with visualization] More circles and less circles….. | OI | |
| P3: | What is changing when you touch those 2 triangles? | OI | |
| P1: | So the colour is the same… colours… yes. Just the amount… the circles | OI | |
| P3: | Do more than 1 change? | OI | |
| P1: | [writing post-it] More circles… It's hard. | MC | |
| P3: | So there's a green up in here and a green down here.. | OI | |
| P1: | Is…. The colours is fixed? | OI | |
| P3: | The grid is… Is it? If you hit the triangle more than once? | OI | |
| P1: | But… what is making a difference is the amount of circles getting bigger and smaller… | OI | |
| P2: | If you try this one [interacts with visulaization] | MC | |
| P1: | So the triangle…. | OI | |
| P2: | Could be 7 days…. | OI | |
| P1: | Shows the amount… There is a difference that I am trying to see… See what is the difference between a star… | OI | |
| P2: | I don't know… | MC | |
| P1: | [interacting with visualization] … click on that… again I want to change… | MC | |
| P3: | 1, 2, 3, 4, 5, 6, 7 So these are days of the week and theses are … 1, 2, 3, 4, No… [pointing at visualization] | OI | |
| P1: | 9 | OI | |
| P3: | 9 and 7 | OI | |
| P1: | 9… 9 and 7… 2 [counting interface elements] | OI | |
| P3: | Is it? Does it? What happens when you touch down there [interacting with the visualization] | OI | |
| P1: | What is changing? I'm trying to see how… OK… If this green changes [interacts with different parts of the visualization]… Oh. It's pretty difficult…I'm going to guess that this pentagon (mumbles) | OI | |
| P3: | There are 9 of them. | OI | |
| P1: | This is number 8 which is having this… almost the same – stable without change [interacting with visualization to test change | OI | |
| P1: | [writing] So what we can see… in pentagon 8… is more stable…. | OI | |
| P1: | So the change is more… I try to see that…. I can see that the changes appear more here than in here [indicating areas of visualization]… basically from here they are more dramatic… change… | OI | |
| P2: | Is this altering the number? And is this altering the size? | OI | |
| P3: | Is it? | MC | |
| P2: | I think … [P2 & P3 are interacting with visualization testing the idea] | MC | |
| P2: | I think | MC | |
| P3: | And then there are these…. | MC | |
| P2: | Only the shades are changing… | OI | |
| P3: | No the numbers are changing as well…. | OI | |
| P3: | Do that again… there's a different number… | OI | |
| P1: | OK. Lets see that…. | MC | |
| P1: | OK. OK. OK. I got it…. Yeah [interacting with visualization] | MC | |
| P1: | what I got from the star is that the colour of the grid is changing [interacts with visualization to indicate]… like… click different things… it's getting… | OI | |
| P1: | So the stars are changing the colour…. | OI | |
| P1: | … and what are the triangles showing? | OI | |
| P3: | [interacting with visualization] Showing the same thing… you get… | OI | |
| P2: | (mumbles inaudible) | MC | |
| P3: | You get… | MC | |
| P2: | Alright… so 1… | MC | |
| P1: | What is changing is this [shows size of circle with fingers] | OI | |
| P3: | And the top row…[P2 & P3 are interacting with visualization and P1 is trying to explain something] | OI | |
| P2: | No… no… the colour maybe… | OI | |
| P1: | No the colour is fixed. | OI | |
| P1: | What is changing… | OI | |
| P2: | But the top row is… | OI | |
| P1: | But its nothing maybe?… It is… | OI | |

| | | |
|---|---|---|
| | You get the top row when you do the… [interacting with visualization]… oh where's it gone… Ahh yeah when you do the yellow on the right hand triangle you get the top row | |
| P3: | [interacts with the visualization testing idea] | OI |
| P1: | So I'm trying to make a difference between this triangle and the pentagon… | OI |
| P3: | Yes lets see what that does. Lets see what it does. | MC |
| P1: | So for that one if…. | MC |
| P3: | OK let me do… [P1 & P2 are interacting with visualization] | MC |
| P3: | Oh it makes a wee change but not the same… It's not like the top row getting set up. | OI |
| P2: | This is altering the top row? | OI |
| P3: | It is in the stars…. | OI |
| P3: | It is in some circumstances… | OI |
| P1: | Its changing here…. But you see… | OI |
| P3: | What could the grid represent? There's empty boxes… is that amount? | OI |
| P1: | [interacting with visualization] OK the top row is changing… | OI |
| P3: | What do you think it's for? [referring to prompt questions][P1 interacts with visualization while P2 & P3 watch] | OU |
| P1: | OK there is a change… a big change here in the first row [indicates area of visualization] | OI |
| P1: | And lets see how many cubes we have 1, 2, 3, 4, 5, 6 [counting columns in visualization grid]…. and 6 by 4 [indicates rows] | OI |
| P3: | Oh! So when did it become 6? I thought it was 5 before. | OI |
| P1: | It's 6 by 4…. 24… yeah | OI |
| P3: | Was it… Is it always 6 across do you know? | OI |
| P1: | 24 cubes | OI |
| P1: | 7 stars | OI |
| P1: | 2 triangles | OI |
| P1: | I'm trying to find a reason… trying to find a relation…. | OI |
| P1: | 24, 9, 7, 2…. So probably…. | OI |
| P3: | What is this… [points to P1's post-it]… oh the 2 triangles. | OI |
| P3: | 2 states | OI |
| P1: | to facilitator] Is it for the…. Is it… energy consumption is it another version of the data visualization or is it something else? | MC |
| F: | It's similar data to before. It's in the same subject. It's energy consumption data [participants had been told this at the start of the activity] | MC |
| P3: | Oh. Is it 24 hours? A day? | OI |
| P2: | Yeah | MC |
| P1: | Yeah | MC |
| P2: | These are the days [indicating on visualization] | OI |
| P1: | 24 hours of the day, 7 days a week… 2 is probably day or night… | OI |
| P2: | What is the 9? | OI |
| P3: | What would it be? | OI |
| P1: | 9 | OI |
| P3: | 2 half hours? No. | OI |
| P3: | 9? | OI |
| P2: | I think maybe there are 9 categories | OI |
| P1: | 9 categories | OI |
| P3: | This is a different cost? [points at visualization] | OI |
| P2: | Maybe 1 is for cooking and consumption? Maybe different items… | OI |
| P1: | So lets see what… [interacts with visualization] | OI |
| P3: | Oh. I see what you're saying. | MC |
| P3: | So this is the cheap time of day [indicates on visualization]. Maybe. And this is the medium time of day. | DQ |
| P2: | So for this type of consumption starting from Monday [interacts with visualization] so… peak… | DQ |
| P3: | So we saw that they used a lot of power on the first days of the week. | DQ |
| P1: | First is the total? | OI |
| P3: | What if we look for something constant? That's the fridge-freezer here. | DQ |
| P2: | Top one is total electricity. | OI |
| P3: | and this is the cost… this errr… | OI |
| P3: | So what do we think about any of this? | MC |
| P1: | What is this 2 triangles? | OI |
| P3: | I only just noticed it was 24. I thought it was…. | OI |
| P2: | One is kilowatt hours another was price.. | OI |
| P1: | Price. Yeah. | OI |
| P3: | You think? | MC |
| P2: | Because I think this one is kilowatt hour so you are using this kilowatt hour at this time but it is not charging you anything. This hour is free. | DQ |
| P3: | Yes that's fine. That would make sense there are two things there | OI |
| P2: | I think the green 1 is free | OI |
| P3: | So the thing that I found across it was that I didn't see this was 24 hours I thought it was 20 in the box. I kept saying it was 5 by 4. | OI |
| P2: | 24 hours [indicates area of visualization] so… this is kilowatt-hours… | OI |
| P1: | So we can say Monday is the most consumption again [13:30] | DQ |
| P2: | Where is Monday? … You said Monday?... | MC |
| P2: | So this should be Saturday… Sunday… | MC |

| | | |
|---|---|---|
| P2: | Saturday, Sunday low cost? | DQ |
| P1: | Low cost … yes. | DQ |
| P3: | yes its got different colours. | OI |
| P2: | Monday… and this is… these are peak hours there are two peak hours? | DQ |
| P3: | Yes | MC |
| P2: | It almost the same kind of profile for (inaudible) [interacting with visualization] | DQ |
| P1: | Monday, Wednesday, Tuesday… Thursday… is the most [writing post-it] | MC |

# 13 Case Study: E.ON

This section contains the following examples of evaluation data collected during the study reported in Chapter 5 of the main body of this thesis:

1. Examples of the final ides outputs from Activity 5
2. Examples of the outputs from Activity 1
3. Listing of ideas and insights from Activity 2
4. Analysis of participants' responses to Reflection Prompt #1
5. Analysis of participants' responses to Reflection Prompt #2
6. Analysis of participants' responses to Reflection Prompt #3

Figure 48: A final design idea output from Activity 5 from Chapter 5 Case Study: E.ON

Figure 49: A final design idea output from Activity 5 from Chapter 5 Case Study: E.ON

Figure 50: A final design idea output from Activity 5 from Chapter 5 Case Study: E.ON

Figure 51: A final design idea output from Activity 5 from Chapter 5 Case Study: E.ON

Figure 52: An example output from Activity 1 from Chapter 5 Case Study: E.ON
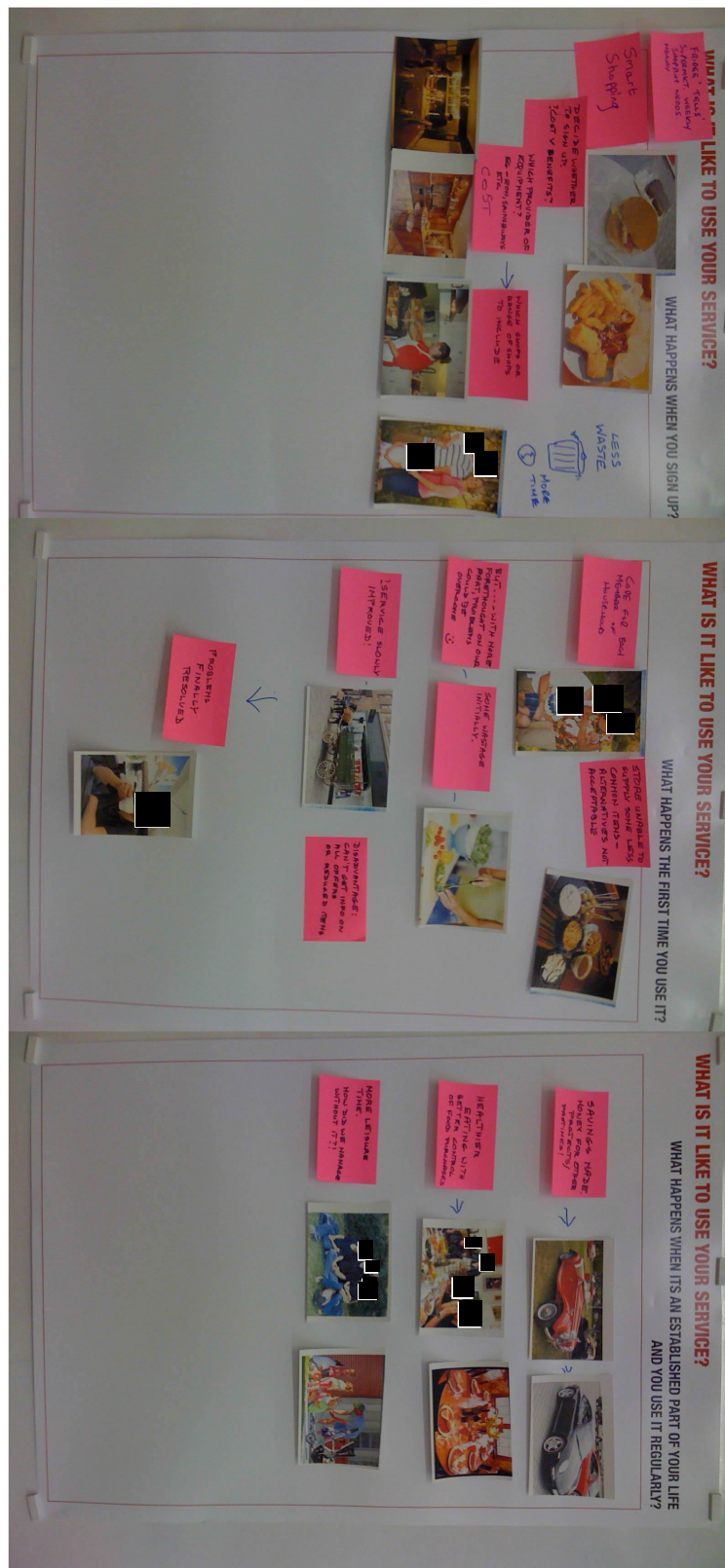
Figure 53: An example output from Activity 1 from Chapter 5 Case Study: E.ON

Figure 54: An example output from Activity 1 from Chapter 5 Case Study: E.ON

Figure 55: An example output from Activity 1 from Chapter 5 Case Study: E.ON

# Co-designers Reflection Postcard #1 Responses

| Participant | Transcript | Engagement | Collaboration |
|---|---|---|---|
| 1 | Our group was engaged and excited. We really used the tech to answer the Q's although I questioned if all groups were the same. | Totally Positive | Totally Positive |
| 2 | I fully immersed myself in the activity and felt able to be heard but being bossy I am not sure and gave a quieter member of the group so much of a chance. The technology was extremely useful and very interactive. | Totally Positive | Totally Positive |
| 3 | The activities were interesting and engaging. I think we worked well within the team and the technology was a help but would have liked longer to analyze trends. | Totally Positive | Partially Positive |
| 4 | Generally felt quite interested in the tasks as they were quite fun, I worked quite well with my team and the tech made it a lot easier to look through the data. | Partially Positive | Partially Positive |
| 5 | Interesting exercise. Engaged well with other members of the team. Technology information useful. | Totally Positive | Totally Positive |
| 6 | Very engaged, worked well with the other team members. Writing on the screen could have been longer. Takes me longer to work things out than other people. Tech was a bit fiddly, finger went on wrong buttons. | Totally Positive | Totally Positive |
| 7 | It was easy to work with the group, we were open to each others opinions. Technology was useful for us to investigate our views and to help discussion. The display of the information was interpreted differently by others but this helped with discussion. | Totally Positive | Totally Positive |
| 8 | I think the exercise was quite engaging and I was quite engaged during it. It was very comfortable working with the other members. The technology was helpful to understand but I think one iPad between three on a round table was a bit difficult as it was a bit difficult to see data without standing and bending. | Partially Positive | Partially Positive |
| 10 | I felt that we worked well as a team and found it interesting to decide on the type of family and their possible activities. The iPad was useful in deciding the uses the family made of possible equipment they had. | Totally Positive | Totally Positive |

| # | Statement | | |
|---|-----------|---|---|
| 11 | Engagement 7 out of 10 (10 = high), distraction 3 out of 10. Needed some thinking and focus in order to make good suggestions. Found technology useful and display information wasn't a distraction, but it didn't really help find answers. Quite a lot of own knowledge/experience was used. | Partially Positive | No Response |
| 12 | I was very involved in the discussions. I found working with the team easy. I did have to concentrate on the technology with which I am not familiar. | Partially Positive | Partially Positive |
| 13 | I felt engaged all the time; found it easy to concentrate and time passed quickly. Worked easily with other team members. Technology helped but with only one iPad it was difficult to analyse all the data in the time allowed. I felt engaged and absorbed with the tasks and comfortable working with the other members. | Totally Positive | Partially Positive |
| 14 | Some of the information in task 1 was a little overwhelming. The technology was very useful. | Partially Positive | Totally Positive |

# Co-designers Reflection Postcard #2 Responses

| Participant | Transcription | Patterns & Relationships | Overview |
|---|---|---|---|
| 1 | Usage, timelines and others quickly. Yes it clearly helped you to understand patterns. Definitely. You had a broad overview and you could drill down to get clearer answers. This interactivity flowed very well and really demonstrated well how | Totally Positive | Totally Positive |
| 2 | this family behaved. | Totally Positive | Totally Positive |
| 3 | the greenwaves one. Some patterns but some was contradictory. Unable to see a clear pattern. Liked the visualisation better than | Partially Positive | Partially Negative |
| 4 | about it. It was easy to get an overview about each group of data due to how it was laid out and that made it very easy to compare the data and come to assumptions | Totally Positive | Totally Positive |
| 5 | iPad data was useful and I saw the energy use patterns and visualisations clearly. Yes, I could gain an overview of the data, it just took me a while to look at all the info and out a picture together - longer than others. I could find patterns and relationships - its what I've been doing for the last | Totally Positive | Totally Positive |
| 6 | 9 months or so! It was difficult to form an overview as there seemed little consistency in the data. If I knew the household this would be ok. Very hard without some more | Partially Positive | Partially Positive |
| 7 | information. | Totally Negative | Totally Negative |

There were patterns in the data for some activities but for a couple of them it was a bit inconsistent. However I managed to find some patterns to work out

| No. | Comment | | |
|---|---|---|---|
| 8 | the type of family and their energy use. Yes we were able to interpret the information. Yes there were factors which could be followed and in | Partially Positive | Partially Positive |
| 10 | time used to our advantage. Found the way data was presented quite easy to understand. Colours were useful, although not sure why not red and green. Didn't really contribute to | Partially Positive | Partially Positive |
| 11 | ideas. Pricing was very confusing. A bit difficult to get the info from the iPad. So some of | Partially Positive | Partially Negative |
| 12 | the patterns were not too easy to appreciate. It was possible to gain an overview and find patterns but having more time would have made the | Partially Negative | Partially Negative |
| 13 | visualisation more useful and constructive. Managed to gain an overview of the iPad data although the cards and associated input I found a bit overwhelming although this did prompt new ideas. | Partially Positive | Partially Positive |
| 14 | would have helped. Maybe a longer pre-amble about the boxed info | Partially Positive | Partially Positive |

# Co-designers Reflection Postcard #3 Responses

| Participant | Transcript | Generate Ideas | Explore Options | Incorporate Knowledge |
|---|---|---|---|---|
| 1 | Very helpful. Couldn't do it without. Some minor improvements (red for bad?). Took knowledge to use it. May be difficult for non-expert. | Totally Positive | Totally Positive | Totally Positive |
| 2 | The data really helped to paint a picture of our family and the materials helped to demonstrate the vision. Because I use the greenwave Eon app but the one we used today was better and informative. | Totally Positive | Totally Positive | Totally Positive |
| 3 | To an extent, not having full greenwave socket data on major appliances. Much of it was a "guesstimate". | Partially Positive | Partially Positive | Partially Positive |
| 4 | The iPad data visualisation was very useful as it made it surprisingly easy to look at each piece of data and also caused the data to be better laid out. I could also use it with my own knowledge which I had to do for the first task. | Totally Positive | Totally Positive | Totally Positive |
| 5 | I have not used an iPad before but soon saw the data visualisation displayed. Saw that my existing knowledge could coincide with the iPad data. | No Response | Totally Positive | Totally Positive |
| 6 | Easy to imagine the type of people in the house. My existing knowledge fitted well with the issues raised by the data. The knowledge we had from the Eon trial was useful. I think there is too much information on the display. If this format was used without significant 'education' I think it would be very confusing. Once we found our way around the interface it was | Totally Positive | Totally Positive | Totally Positive |
| 7 | easy to dig deeper to answer questions. | Partially Positive | Partially Positive | Partially Positive |

It wasn't easy to start with as we have to have some
assumptions but later on it became easier to do the exercise
from data available. I certainly could use my experience and

8 knowledge for the activities.
It was interesting working out the use of energy. We were able
to share our interpretation of the energy usage. Yes we used the

10 information for the competition.
Needed to focus back on house and empathise what they were

11 like. iPad data didn't really contribute to ideas.
Did use prior knowledge and so did other team members.

12 get used to it!!
Not too easy to explore the ideas suggested by the iPad, but I did

Having only one iPad made it harder to explore ideas in time
available. Knowledge gained from Thinking Energy project

13 helped with analysis of information.
The iPad was easy to use and helped with data visualisation
although the day views were good a week overview would have
helped. It was easy to incorporate this data with existing

14 knowledge.

| | | | |
|---|---|---|---|
| 8 | Partially Positive | Partially Positive | Totally Positive |
| 10 | Totally Positive | Totally Positive | Totally Positive |
| 11 | Partially Negative | Neutral | Totally Positive |
| 12 | Partially Negative | Partially Negative | Totally Positive |
| 13 | Partially Negative | Partially Negative | Partially Positive |
| 14 | Partially Positive | Partially Positive | Totally Positive |

# 14 Case Study: MIRROR

This section contains the following examples of evaluation data collected during the study reported in Chapter 6 of the main body of this thesis:

1. Analysis of participants' responses to Reflection Prompt #1
2. Analysis of participants' responses to Reflection Prompt #2
3. Analysis of participants' responses to Reflection Prompt #3
4. A listing of the connections between existing MIRROR apps that were captured in the map
5. A listing of ideas for new apps or uses of the data generated within the MIRROR project.

## Co-designers Reflection Postcard #1 Responses

| Participant | Transcript | Increased Understanding | How Represented |
|---|---|---|---|
| 1 | Yes, especially on certain apps. The connection and recombination of the available data gave valuable insights. Representation in the map: partially. The information and data are named in the map but there is no detailed description of the data and its technical (like formats)... | Totally Positive | Partially Positive |
| 2 | Yes, indeed. Although we have heard what different apps do in the past 2.5 years, I only now realised some new aspects of various apps that I didn't know. The map is good although it is increasingly more difficult to get a sense of connections the more ribbons & labels are included | Totally Positive | Partially Positive |
| 3 | Yes! I learnt quite a bit about what some of the apps I am less familiar with do. I understood my own contributions to the map when I made them, and also those of others while they were explaining them but I'm afraid it will be hard to remember all this! | Totally Positive | Partially Positive |
| 4 | Yes, I learned more about other apps and their similarities. I believe it is hard to understand the map afterwards, especially alone. It is probably very good if the group meets again | Totally Positive | Partially Negative |
| 5 | Yes it has increased my understanding of the data (and the apps as a whole) of the apps that I am not familiar with: yes-> of the apps that I have tested: no really increased understanding Yes it does give a good representation of the data used / recorded / stored by the Apps | Totally Positive | No Response |
| 6 | Unfortunately we do not have all the apps (data) represented. So would be good to complete the picture | Totally Positive | Partially Negative |

| # | Response | Rating |
|---|---|---|
| | There are slight new insights, although I had a good understanding of the data being generated before the project The map represents this understanding, although it is a little bit | Partially Positive |
| 7 | messy to analyse the relationships | Partially Positive |
| | Yes! Yes! Though the map got a bit confusing at the end, which is basically awesome, because that means that we did (good) work :) Personally I suggest to write down the newly created | Totally Positive |
| 8 | knowledge of the map in an organised, structured textual way It definitely increased my understanding. I'm quite new in MIRROR and had only a rough idea about what apps exist and what they do. Today I got a great overview about some of the MIRROR apps and what kind of data they collect / generate. To be honest I think there is more knowledge in the map than in my | Partially Positive |
| 9 | head ;-) But I think it represents my understanding well Increased my understanding a bit, but not all tools are | Totally Positive |
| 10 | represented. I think there is at least an overlap between my understanding and what is in the map | Partially Positive |

# Co-designers Reflection Postcard #2 Responses

| Participant | Transcript | New Ideas | How Represented |
|---|---|---|---|
| 1 | Yes I was able to contribute a couple of ideas I had thought about in the past and set them into the right context. The mapping attempt in the workshop helped explaining and even brought up new ideas | Totally Positive | Totally Positive |
| 2 | Mostly yes new ideas were integrated and used in the map | Partially Positive | Totally Positive |
| 3 | Yes – I had plenty of opportunity to contribute both to the hexagons we made in groups, and to the map we made all together. I was a bit sad the session for generating new ideas didn't go on far longer | Totally Positive | Totally Positive |
| 4 | Yes I could contribute Towards the end it was a bit too much so I focused on understanding the others | Totally Positive | Partially Negative |
| 5 | Yes, I think that a testbed view really added to the information (how is it used) and by the (hexagon) presentations of the apps and data you suddenly realised there are some connections that can be useful | Totally Positive | Totally Positive |
| 6 | Yes, but as mentioned we should also work at this from a business / personal objective to be accomplished. So if a connecting App and creates new one, we could select with which objective do we want to solve in a specific case | Partially Positive | No Response |
| 7 | Yes I was able to contribute new ideas and they were reflected in the map | Totally Positive | Totally Positive |

8 Yes, I hope so. Yes, they were
I could contribute new ideas or prompt new ideas
through questions mainly in the first part, where
we created the first sheets. All ideas were reflected

Totally Positive

Totally Positive

9 in the map

Totally Positive

Totally Positive

10 Yes. Yes

Totally Positive

Totally Positive

# Co-designers Reflection Postcard #3 Responses

| Participant | Transcript | Express Perspective | How Represented |
|---|---|---|---|
| 1 | Yes, as far as the data created in our apps is concerned. I think the perspective of all the participating partners broadened and we all gained new ideas of how close our attempts in app development are actually related | Totally Positive | Totally Positive |
| 2 | A more situation-driven approach could have worked better, i.e. what is the situation a carer encounters, then decide the data needed to assist them | Partially Negative | No Response |
| 3 | I'm not sure I have a particular perspective on any of the data I was just trying to understand what there is and how it's used | Neutral | No Response |
| 4 | I feel that we lost the data perspective in the end. We talked about new apps and interconnecting processes instead However the important points are in the map. The discussion went into a different direction. I am not sure how to continue | Partially Negative | Partially Positive |
| 5 | Yes I think we could have done some more by placing hexagons next to each other randomly and see what it would do / give us new ideas | Totally Positive | Partially Positive |
| 6 | Yes, but pity not all apps / data were represented. | Partially Positive | No Response |
| 7 | I think that I was able to enhance the understanding of my perspective, although I guess that I was not able to make it fully clear Though, it was satisfactorily represented in the map | Partially Positive | Totally Positive |

Yes! It's interesting that there are that many different views on the project. Actually I wasn't aware that fact. At least I did not know about all of them What may have been a good point on the agenda: evaluating each new 'connection' in terms of a) applicability, b) cost (how much time is needed to implement it), c) usefulness, d) exploitability… in order to get some

8  sort of prioritisation

I think I could express my perspective and everything

9  is perfectly represented in the map

Yes but not on issues of the totality (e.g. what type of data are we gathering in MIRROR, all in all & what can we do with it). (Why collect data and how they benefit reflective learning is a key issue in the project). In this workshop we have focused on specific apps, but that is also ok. Being concrete tends to inspire more

10  general thinking

Totally Positive        Neutral

Totally Positive        Totally Positive

Partially Positive      Totally Positive

# Connections Between MIRROR Apps and Data Captured in the Map

| ID | What is the data? | Where is it going to be used? | When is it going to be used? | Why is it going to be useful? | How is it going to be used? | Who is going to use it? | Connection |
|---|---|---|---|---|---|---|---|
| N1 | Data on episodes (moods... & notes) resulting from individual & collaborative reflectios | | Feed into Carer; use Carer as support for the reflection session | Utilise carer for reflection and utilise recorded as an input to Carer | | | Yammer & Carer |
| N2 | Data from an episode (user initiated gathering) including who were there (proximity | Collaborative reflection during debriefing at coordination centre | | Help include the right people with the right data to reflect on episodes where they were all involved | Sharing individual experiences and People 'on the floor' basis for discussion coordination / (emergency or care!) & managers / coordinators | | Sensor data & WATCHiT timeline |
| N3 | <id1, id2, time> + <text, time> Remarks on Yammer categorised as moods (energy / positive /negative) | | | Sensor gives you connections between carer and resident. Yammer can give you data about what happened during an interaction | Select a node in CareReflect Yammer automatically looks up date/time to provide content | | Sensor data & Yammer |
| N4 | | | Use Yammer to reflect (on moods) in meeting compare with moods later | | I think it already exists without moods in conference tools | | Yammer & Mood Map |
| N5 | Situation and who is near by and moods of those nearby Anomolies registered & timestamped / tagged by CareReflect, WATCHiT, KnowSelf | Team reflection. Managers identifying problematic issues | Management / team meetings | Stimulate refelction Understand challenging situations better by analysing proximity & mood map data | As a basis for critical problem-solving | Project groups | Sensor data & Mood Map |
| N6 | | mobile | prompts activity / checks | See what is important | suggest an app/data to look at Application profile for process or project. Profile <-> timestamp. | individual worker | WATCHiT, CareReflect & KnowSelf |
| N7 | Applications in use and timestamp + Mood and timestamps | | | | Broadoverview. Connection timestamp and process Profile <-> process, Mood <-> timestamp | | KnowSelf, IMA & Mood Map |
| N8 | Use tags to intrconnect information | Various apps with suggestions e.g. IMA, Yammer, DoWeKnow app | Context based during reflection | New connection -> new knowledge. Connecting existing information | Suggest related data | Background process. Automatically | All apps |
| N9 | Case base of: issues, solutions, best practice, feedback, new solutions | | | Support browsing data | Suggest helpful information & connections | Users of IAA & IMA | IAA/IMA & Carer |

# New Ideas Added to the Map

| ID | What is the data? | Where is it going to be used? | When is it going to be used? | Why is it going to be useful? | How is it going to be used? | Who is going to use it? | Connection |
|---|---|---|---|---|---|---|---|
| N1 | Data on episodes (moods.... & notes) resulting from individual & collaborative reflectios | | Feed into Carer; use Carer as support for the reflection session | Utilise carer for reflection and utilise recorded as an input to Carer | | | Yammer & Carer |
| N2 | Data from an episode (user initiated gathering) including who were there (proximity | Collaborative reflection during debriefing at coordination centre | Help include the right people with the right data to reflect on episodes where they were all involved | | Sharing individual experiences and basis for discussion coordination / collaboration | People 'on the floor' / (emergency or care!) & managers / coordinators | Sensor data & WaTCHiT timeline |
| N3 | <id1, id2, time> + <text, time> Remarks on Yammer categorised as moods (energy / positive /negative) | | Use Yammer to reflect (on moods) in meeting compare with moods later | Sensor gives you connections between carer and resident. Yammer can give you data about what happened during an interaction | Select a node in CareReflect Yammer automatically looks up date/time to provide content | | Sensor data & Yammer |
| N4 | | | | Stimulate refelction | I think it already exists without moods in conference tools | Project groups | Yammer & Mood Map |
| N5 | Situation and who is near by and moods of those nearby Anomolies registered & timestamped / tagged by CareReflect, WaTCHiT, KnowSelf | Team reflection. Managers identifying problematic issues | Management / team meetings | Understand challenging situations better by analysing proximity & mood map data | As a basis for critical problem-solving | | Sensor data & Mood Map |
| N6 | | mobile | prompts activity / checks | See what is important | suggest an app/data to look at Application profile for process or project. Profile <-> process, Mood <-> timestamp | individual worker | WaTCHiT, CareReflect & KnowSelf |
| N7 | Applications in use and timestamp + Mood and timestamps | | | Broadoverview. Connection timestamp and process | Profile <-> process, Mood <-> timestamp timestamp | | KnowSelf, IMA & Mood Map |
| N8 | Use tags to intrconnect information | Various apps with suggestions e.g. IMA, Yammer, DoWeKnow app | Context based during reflection | New connection -> new knowledge. Connecting existing information | Suggest related data | Background process. Automatically | All apps |
| N9 | Case base of: issues, solutions, best practice, feedback, new solutions | | | Support browsing data | Suggest helpful information & connections | Users of IAA & IMA | IAA/IMA & Carer |

# 15 Analytical & Intuitive Creativity

This section contains the following examples of evaluation data collected during the study reported in Chapter 6 of the main body of this thesis:

1. Details of the Creativity Support Index scores and analysis for each participant
2. A listing of all the ideas generated during Activity 3 in each of the workshops in which participants were given an interface visualizing smart energy data
3. A listing of all the ideas generated during Activity 3 in each of the workshops in which participants were given an interface visualizing Flickr photographs
4. A listing of all the ideas generated during Activity 3 in each of the workshops in which participants were given reports outlining changes in energy consumption
5. A listing of all the ideas generated during Activity 3 in each of the workshops in the control condition
6. A transcript of each of the design concepts generated during Activity 4
7. A listing of each participant's rating for each of the final ideas developed, excluding the idea developed in their own workshop
8. Example transcription, taken from the video recording of Workshop #5, demonstrating how ideas emerged from interaction with the interface visualizing Flickr photographs
9. Example transcription, taken from the video recording of Workshop #6, demonstrating how ideas emerged from interaction with the interface visualizing smart energy data

# CSI Scores and Analysis

| Participant | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 |
|---|---|---|---|---|---|---|---|---|---|
| Condition | Photo | Photo | Photo | Report | Report | Report | InfoVis | InfoVis | InfoVis |
| Q1 | 2 | 2 | 5 | 5 | 6 | 6 | 8 | 9 | 8 |
| Q2 | 1 | 3 | 5 | 6 | 6 | 6 | 6 | 6 | 7 |
| Q3 | 2 | 2 | 5 | 8 | 8 | 6 | 6 | 5 | 9 |
| Q4 | 3 | 3 | 5 | 5 | 8 | 8 | 6 | 6 | 9 |
| Q5 | 4 | 5 | 5 | 4 | 6 | 8 | 6 | 7 | 5 |
| Q6 | 9 | 5 | 5 | 8 | 8 | 6 | 9 | 6 | 9 |
| Q7 | 4 | 3 | 5 | 7 | 8 | 6 | 5 | 7 | 8 |
| Q8 | 1 | 2 | 5 | 5 | 8 | 5 | 6 | 5 | 9 |
| Q9 | 5 | 5 | 5 | 9 | 8 | 6 | 8 | 8 | 7 |
| Q10 | 4 | 1 | 5 | 4 | 5 | 5 | 4 | 5 | 9 |
| Q11 | 4 | 2 | 5 | 8 | 5 | 6 | 2 | 6 | 7 |
| Q12 | 9 | 8 | 5 | 9 | 8 | 8 | 9 | 8 | 9 |
| RWE | 3.5 | 3.5 | 5 | 7 | 7 | 6 | 6 | 8.5 | 8.5 |
| Exploration | 1 | 2.5 | 5 | 5.5 | 6 | 5.5 | 5.5 | 5.5 | 7 |
| Collaboration | 3 | 2 | 5 | 8 | 6.5 | 6 | 6.5 | 5.5 | 8 |
| Enjoyment | 3.5 | 3 | 5 | 6 | 8 | 7 | 5.5 | 6.5 | 9 |
| Expressivene | 4 | 3 | 5 | 4 | 5.5 | 5.5 | 3.5 | 6 | 6 |
| Immersion | 9 | 6.5 | 5 | 8.5 | 8 | 8 | 9 | 6.5 | 8.5 |
| RWECount | 2 | 0 | 2 | 3 | 5 | 0 | 3 | 5 | 2 |
| ExplorCount | 5 | 5 | 4 | 2 | 3 | 4 | 4 | 4 | 5 |
| CollabCount | 3 | 2 | 5 | 4 | 4 | 2 | 3 | 3 | 4 |
| EnjoyCount | 0 | 4 | 0 | 0 | 1 | 4 | 0 | 0 | 1 |
| ExpressCount | 3 | 1 | 2 | 4 | 0 | 0 | 2 | 0 | 3 |
| ImmersCount | 2 | 3 | 2 | 2 | 2 | 1 | 3 | 1 | 0 |
| CSI | 37.7777778 | 37.7777778 | 55.5555556 | 71.8518519 | 76.2962963 | 68.1481481 | 69.2592593 | 73.7037037 | 82.2222222 |

| | Participant | #13 | #14 | #15 | #16 | #17 | #18 | #19 | #20 | #21 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Condition | Photo | Photo | Photo | InfoVis | InfoVis | InfoVis | Report | Report | Report |
| | Q1 | 2 | 4 | 4 | 9 | 9 | 7 | 3 | 8 | 8 |
| | Q2 | 2 | 3 | 4 | 9 | 9 | 7 | 2 | 6 | 4 |
| | Q3 | 1 | 3 | 4 | 9 | 9 | 9 | 3 | 8 | 5 |
| | Q4 | 2 | 1 | 7 | 9 | 9 | 8 | 3 | 7 | 1 |
| | Q5 | 2 | 2 | 4 | 9 | 9 | 6 | 3 | 3 | 3 |
| | Q6 | 6 | 8 | 4 | 6 | 6 | 6 | 5 | 9 | 9 |
| | Q7 | 5 | 2 | 4 | 8 | 9 | 8 | 2 | 4 | 4 |
| | Q8 | 4 | 3 | 3 | 8 | 9 | 6 | 2 | 5 | 4 |
| | Q9 | 3 | 2 | 4 | 6 | 9 | 6 | 3 | 3 | 7 |
| | Q10 | 2 | 2 | 4 | 9 | 9 | 8 | 2 | 5 | 2 |
| | Q11 | 1 | 2 | 4 | 9 | 9 | 9 | 3 | 2 | 2 |
| | Q12 | 2 | 7 | 3 | 9 | 8 | 7 | 3 | 9 | 8 |
| | RWE | 2.5 | 3 | 4 | 9 | 9 | 6.5 | 3 | 6.5 | 7.5 |
| | Exploration | 3 | 3 | 4 | 9 | 9 | 6.5 | 2 | 4.5 | 4 |
| | Collaboratior | 1 | 2.5 | 4 | 9 | 9 | 9 | 3 | 6.5 | 3.5 |
| | Enjoyment | 3.5 | 1.5 | 4 | 9 | 7.5 | 8 | 2.5 | 6 | 2.5 |
| | Expressivene | 2 | 2 | 4 | 9 | 9 | 7 | 2.5 | 2.5 | 2.5 |
| | Immersion | 4 | 7.5 | 3.5 | 7.5 | 8.5 | 6.5 | 4 | 9 | 8.5 |
| | RWECount | 0 | 3 | 2 | 2 | 3 | 1 | 1 | 2 | 5 |
| | ExplorCount | 5 | 5 | 4 | 2 | 5 | 3 | 4 | 4 | 3 |
| | CollabCount | 2 | 3 | 4 | 4 | 1 | 4 | 5 | 2 | 3 |
| | EnjoyCount | 3 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | ExpressCoun | 4 | 1 | 3 | 4 | 3 | 4 | 2 | 5 | 3 |
| | ImmersCoun | 1 | 3 | 1 | 2 | 3 | 3 | 3 | 2 | 1 |
| | CSI | 29.2592593 | 41.4814815 | 44.0740741 | 96.6666667 | 98.8888889 | 81.1111111 | 31.8518519 | 55.1851852 | 56.2962963 |

# Listing of Divergent Ideas Using InfoVis Interface

WS 3
Wonder woman
Shower timer
1-9 web
Cook & freeze

Monthly community blackout
Usage meter
Put fines
Britain's reading hour (blank the TV)
Washing machine timer
More sensitive light switch

Stop using tumble dryer
Efficient use of kettle (educate the people)
individuals

Educate kids
X-ray
LED lamps e.g. in shower encourage the use of
smart LED lamps

Self reporting devices
Smart grids
Store energy in other format (e.g. heat / cold)

Viral advertising / educational campaign

Leaflets with hints
Visualise current consumption

Smart appliances that talk to the grid

Switching between office hours

WS 6
Timer setting on appliances
Satelite dish combo with solar panel
Use old machines to create new ones
Ease / Not challenging
If you save certain amount of $ on your energy
you get a grocery voucher
Financial incentives
Tells meter
Washing machines - Dryers - Ironging
24 hour service - book online
Pay more to use during peak hours
Target high consumers. Reduce or buy this
panel!
Central heating system (flats). (District heating)
Heats the air for dryers
Limit the amount of energy each household is
allowed to use each month
Communal gardens for drying

Washing service / truck = convenience
Ban items that use more energy (a la plasma
TVs)
Households who consume too much get one
Communal space for hanging clothes to dry
No standby modes for appliances that are only
on a few hours a day (e.g. dishwasher)
Greenhouse laundry system. Drying on the roof
with kenetic and heating energy used
Desktop has a battery like a laptop
Limit time you can use appliances or oven /
stove
Solar panels on each house (use it for free) TV
has used 60%
Switch off all standby items with one button

# Listing of Divergent Ideas Using Flickr Interface

WS 1
More efficient batteries for mobile phones & laptop
Dirty is cool
Reminder of light left on when leaving
Community incentives
Energy saving smart light path tracks
Crystal piezo walking electricity

Miniature mechaninal meters
Smart outlet
Scheduling washing machine scheduling dishwasher use at non peak hours
Monthly electrical bundle by price -> choose when to use
RFID senses you leave -> turns off stuff
Lights flicker during peak

Mirrors to carry 1 bulbs light to many rooms
Prisms
Fading light path
Time shower & time water
Static electricity switch - rub - zap on
Cost per gadget

Glass walls
Bio flourescent light thing
Smart chargers
Incentivise usage during non-peak hours
Tiered fridge
Mag charging surface
Mechanical generator
static electricity storage
Rain water harvesting
Capturing sunlight for later use
Moving usage to one room
Bio energy
Refrigerator with separate power for different compartment for fridges
Scalable piezo pieces
Devices that use low grade heat
Shame your neighbours
Community energy website / app
Fridge cold @ night & off @ day
Usage states
Hot water scheduling
Rechargable house battery
Community grids (smaller grids)
Work towards goals
Devices that share water
Electric santa Good vs Bad
Look up new devices - see cost and tips
Smart gadgets
Low grade heat of refrigerator
Stop incandescent lamp
Solar heating and electricity with solar
Change TV show  times
Light indicate and EZ on/off switch
Use low grade heat
Wanna watch TV & not enough electricity please turn off X items
Penalty for using energy during peak hours e.g. football

WS 5
Hot water
Heating
Change lifestyle
Energy assessment
Use our waste to generate electricity
Improve building insulation
Live information on consumption (e.g. in the last hour you just spent £5)
Individual room heating
Select how much money you want to spend on your shower
Switch off campaign
Standby devices
Solar panels
Easy ways to track consumption. Competition with friend?
Incentives for appliance manufacturers
Light sensors
Accumulate electricity from movement/exercise
Supply national grid with extra electricity
Our own electricity generators
Collective use of appliances (e.g. gatherings for watching TV)
Customised incentives

# Listing of Divergent Ideas Using Reports

**WS 2**

1 day boot camp

Counter -use -visual -money

Compromise decrease use of x so you can increase your use of y

Capped' allowance

A battery for every home

Digital price tags

Smart home green labels

Shift routine e.g. shower in the evening -washing at night

Info graphic portrait

Encourage planning: reward people clearly who choose to be off-peak

Make it cool to be energy conscious e.g visualise implications

Automatic switch off - 'override'

Save-a-thon 24 hour comp. Massive prize. Most energy saved is rewarded

Automatic timing of appliance activity

Energy reps - visit each home & dispense advice

Tiny Habits (e.g. B.J. Fogg. Attach new habit to existing one(s)

Hotel card system

App - allows energy consumption monitoring

Perceptual trickery. Warm vs cold. Lighting context based

Wash rota

Re-circulation of heated material

Green Light' -> OK to use product? Ideal hours of use

Education (student accomodation. House is gamified. Reward is reduced energy bill)

Visualise impact. AR / texts / emails

Discounted off-peak rates -> incentives

Virtual pet (represents house). Must be looked after in order to keep alive

Personal space heater

Comp game be as inefficient as possible

Real-time evidence and visualization

Compare usage -> social proof (esp. communities)

Opt-in strategy shows energy heroes

Send around people to hug / congratulate savers

Insulation

Weather

Time of day

Work routine / shifts

# of family, household members

Being aware / conscious of use

Budget

House structure

Seasons

Meal times

Social time

Habits e.g. shower in morning

Flat rates 'get the most out of it'

**WS 7**

Appliances that draw energy @ off peak times and store it for use @ peak times

Bulk cooking @ off peak time

TV Licence fee changes according to the time you use it

Rewards scheme for using power overnight (like Boots points)

Cheap cost of timers (or free)

Charging overnight (laptops, phones) (Campaign)

Campaigns to encourage adults to get off their TV watching / Game playing arses

Use celebrities in campaigns

App / device / service to make you aware of when peak / off peak times are

Billboards showing energy consumption (real time)

Awareness of peak & off-peak hours (app / alert)

TV ads

Device which monitors your usage and displays it with history function to see over time

Info about demand / consumption readily available e.g via council website

Campaigns to encourage kids to play fewer games & watch less TV - outdoor analog play

Money saved C.O.2 saved

Buildings that allow more daylight or effective use of light

App to program devices to switch on / off @ right time

Champions

League tables local & national

Community device that allows you to charge for free during off peak times

Investment from energy companies based on savings made

Cost incentives for off-peak usage -> obvious -> large

Support small businesses for domestic purposes

# Listing of Divergent Ideas in Control Condition

| WS 4 | WS 8 |
|---|---|
| Device to pre-programme appliances to work in off peak hours | Creating times for appliances |
| Insulation | Promote manual devices |
| Points on off-peak usage (as with rewards) | Deactivate sockets totally when not in use |
| Overview of usage in the bills & online | Promote bicycle usage operated devices like TV etc. e.g ride stationary bike to run TV |
| Its like a fridge for foods that go bad | Software / charger that intelligently draws power during off-peak hours |
| Like a big battery charger | People energy' capture energy from everyday activity e.g. football |
| Card? | Electricity usage of individual appliances - peak / off-peak |
| Personal behaviour (off peak time) | App giving statistical info raise awareness |
| Heat system. All house external internal | Other novelty activities. Giant wheel in public place - turn it to generate electricity. Creates awareness as well |
| New domestic systems (PLC?) All house | Stationary bicycles in public places which people can cycle as a novelty to generate electricity & awareness |
| Incentives for more bioclimatic building | Work from home -> cloud computing makes commuting unnecesary -> less pressure on public tech -> comfortable incentive -> less pressure on resources -> rewards |
| Sleep patterns (user group) | Companies given incentives for allowing employees to work from home |
| Houses store power for later at off-peak | Devices must idle after a period of non-use |
| Delegating into other time zones | Bikes tell you how much energy you contributed: gives "credits" |
| Incentives from government requires specific policy | Charge devices off Boris bikes |
| Device that tells consumers of energy usage at specific times in community | Plug stored energy back into grid (at home) -> reduced from bill -> hybrid car -> unused off-peak energy |
| Accumulation of energy | Introducing batteries in households and offices. Carge in off-peak and utilize in off-peak |
| | Subsidise dynamic demand devices |
| | Create incentives for using electricity off peak usage & avoiding peak usage |
| | Billing - clearly indicate peak / off-peak use "you saved…. " "You could have saved" |
| | Power storage during off-peak, used during peak |
| | Heat / charge / collection thingy (or train) |
| | Free sensors for the people |
| | When incentives are introduced - they should be in the news to inform more people! |

# AAR!

AAR! is the product of an information rich environment. It includes smart appliances that report their actual consumption and that can be controlled from a mobile phone. AAR! Provides users with data visualizations to make them aware of their electricity consumption and incorporates figures reported from the national grid. AAR! Also incorporates a social media element enabling comparison, competition and games with friends and family. Examples of such games might include:

"Who can keep the T.V. switched off the longest?" – A challenge sent from one user to selected friends who would then switch off their T.V.

"Anyone fancy power saving mode?" – A challenge to see who amongst a group of friends could use the least energy between say 8pm, when the initiator arrives home, and midnight.

"Who can use their washing machine when demand is lowest?" – A monthly competition that would encourage people to learn about the best times to use their appliances.

## How does your idea work?

AAR! Includes a smart grid and smart appliances which beam information to laptops, smart phones and tablets. It includes a social app that encourages games and competitions between friends, neighbours and people who are similar. Competition losers will be sent educational information about how to use less energy. AAR! also includes data visualizations showing the electricity consumption of a household, it's individual devices and the national grid

## Who is your idea aimed at?

AAR! is aimed at every household, although it may appeal more to younger generations of user who are more likely to use mobile technologies.

## What type of energy consumption will it move?

AAR! will use competitions to reduce and move peak hours energy consumption. This may include switching off the T.V. or using a timer to select the optimum time to use the washing machine

## Where does the magic happen?

The magic of AAR! is in the social nature of the idea and in the simple, achievable challenges that are set. People always like to compare themselves to others and a challenge that asks you to switch off your T.V. for 10 minutes is more likely to be taken up than one that asks users to change behaviour for six months.

## When will consumers use it?

The information features of AAR! will be available twenty-four seven. Data from appliances will be recorded all the time and people can monitor this whenever they want to. The important part may be the games and social element, which are aimed at consumers when they are at home during peak hours.

## Why will consumers use it?

Consumers will use AAR! because they will save money. Data visualization will increase awareness and encourage smart decision-making. Consumers will use AAR! on their own mobile devices reducing the need for hardware, whilst games will keep consumers engaged.

# Battery Power for Peak Hours

With Battery Power for Peak Hours each home will have a battery that charges during off-peak time and is available for use during peak time. Individuals will also be able to take a small plug-in battery with them during the day, which will generate electricity from activities such as riding a bike or walking. This energy can then be used to top up the home battery or to feed back into the national grid for a reduction to bills. In addition, Battery Power for Peak Hours will also include an app to tell you your energy use and give you local or national statistics from the grid.

## How does your idea work?

With Battery Power for Peak Hours your battery will be charged off-peak. This will use dynamic demand data to prevent it charging during peak times. Energy that is stored during off-peak hours or generated whilst cycling or walking can be used during peak hours or sold back to the grid for rewards. An app will monitor the consumption of your devices and provide national or local statistics regarding the national grid. When a consumer receives their bill they will be clearly told about their peak and off-peak use. Bills will tell consumers how much they have saved by using off-peak energy.

## Who is your idea aimed at?

Battery Power for Peak Hours is aimed at all households connected to the national grid.

## What type of energy consumption will it move?

Battery Power for Peak Hours will shift the energy used during peak hours by replacing it with the power from batteries that have been charged off-peak.

## Where does the magic happen?

The magic with Battery Power for Peak Hours happens when the stored off-peak electricity is used during peak times and rewards are given for the subsequent reductions in peak use. It happens in an application that details the power consumption of all the devices at home. Power generated when riding bikes or walking can be sold back to suppliers for a reduction on the next bill. The Battery Power for Peak Hours battery will only charge when demand on the grid is low, never during high demand.

## When will consumers use it?

The Battery Power for Peak Hours battery will charge during off-peak times. The application that monitors devices is always available and energy can be drawn from the battery when needed. Power will be drawn from the grid when the

battery is drained. Additional energy can be generated during daytime activities to supplement the battery or be sold back to suppliers.

## Why will consumers use it?

Consumers will use Battery Power for Peak Hours because it will save them money. Clearly marked bills will highlight the immediate savings they have made and show rewards for less peak time use.

# Beat the Clock

Beat the Clock is a national campaign to encourage behaviour change in domestic energy consumers. The kinds of behaviour change that Beat the Clock will encourage include shifting the times that people use their laundry appliances; when and how much they watch T.V. or play video games; when they charge their personal devices; and when they do their cooking.

## How does your idea work?

Beat the Clock is a national campaign to raise awareness about how much electricity is being used at different times. It will use different communication channels including social media, display outlets, websites, apps and devices for showing energy consumption in the house. There would be lots of information going out about consumption; incentives would be used to encourage people to change their energy behaviour and rewards given for using electricity off-peak. There will be different levels to the campaign from individual households, through local communities up to a national level. League tables will make it fun and competitive, showing the amount of money saved or the reduction in carbon emissions. Free timers will be given out to people who take part, helping them use their appliances at the right time.

## Who is your idea aimed at?

Beat the Clock is aimed at individual households and the individuals who live in them. It will include local communities, small local businesses and run right up to a national level. Beat the Clock will aim to engage every member of society.

## What type of energy consumption will it move?

Beat the Clock is a national campaign to encourage changes in domestic electricity consumption. The areas it will target include laundry appliances, T.V. watching and video game use, charging personal devices and cooking.

## Where does the magic happen?

With Beat the Clock the magic will happen everywhere. It is between individuals, inside households, within communities and between communities. Beat the Clock will be the whole nation.

## When will consumers use it?

Beat the Clock will be a campaign that is constant but one that evolves and always stays fresh. It will have different phases depending on the current season and so it won't just be a campaign that starts off and then ends after 3 months because everyone knows what it is.

## Why will consumers use it?

Consumers will become part of Beat the Clock because of the incentives such as reward points or reductions in the T.V. licence. The rewards scheme will provide consumers with discounts to their bills. For example reducing the amount of peak-time T.V. watched might lead to a reduction in the T.V. licence. The Beat the Clock campaign will also provide consumers with free timers so that, for example, washing machines might be used in the middle of the night or to use when charging personal devices. Beat the Clock will also encourage the energy companies to invest savings into local community projects and provide an hour of free electricity for them to use. Consumers will be engaged by the competitions and league tables, with everyone wanting to look good and competing against each other. They will also be attracted by ethical elements, seeing the reductions in their carbon emissions and the effect that would have on the world at large.

# Community Wash

The focus of Community Wash will be to shift the energy consumed when washing and drying laundry from peak to off-peak times. This will be achieved through a service that collects dirty laundry; then washes, dries and irons it before returning it in a convenient manner. Community Wash will offer a financial incentive for community members to turn in their existing washing machines and dryers. These will then be repaired, recycled and re-used by Community Wash. Community Wash will offer employment opportunities to the unemployed and to teenagers looking for their first job.

## How does your idea work?

Community Wash is a local communal washing service with pick-up and drop-off facilities. It will offer incentives to users by taking away their existing washing machines and clothes driers in return for Community Wash subscriptions. These machines will then be used within the Community Wash facility, if they are new and efficient, and repaired or recycled if they are not. The Community Wash service will do the washing overnight and only use electricity off-peak.

## Who is your idea aimed at?

Everyone! But in particular Community Wash will target busy individuals who currently use their washing machines during peak hours when they get home from work. Each Community Wash service will cover a particular neighbourhood or local community.

## What type of energy consumption will it move?

Community Wash will move all the electricity consumption related to washing, drying and ironing laundry from every individual household included in their local scheme. The Community Wash service will use electricity during off-peak hours unless there is an emergency need, in which case the charge for washing will be increased.

## Where does the magic happen?

Community Wash will use old machines to create new ones by recycling, repairing and reusing their parts. Community Wash will mean that no one has the hassle of doing washing anymore and it will reduce the amount of electricity used during the day by running an overnight service. Community Wash will also increase employment opportunities in the local area and offer skills and training for the unemployed.

## When will consumers use it?

Community Wash will offer a 24-hour service. Pick-up and drop off will be arranged at times convenient for the user both before and after work. The service will incorporate both telephone and online booking. Alternatively, community members will be able to visit their local Community Wash facility and do their washing for free.

## Why will consumers use it?

Consumers will use Community Wash because it is a service that saves them lots of time. There will be no more need for washing, drying or ironing at home. It will be good for the environment, as it will use less electricity and water. Community Wash offer a financial incentive to turn in your current washing machine and provide a 24-hour service with access at all times.

# EC4U: Energy Consumption For You

EC4U tracks electricity consumption data on an individual per-household basis. This is then uploaded to a website, which acts as a forum for discussion, a repository of ideas for how you can reduce energy usage and a place where users can compete against friends or people from other areas.

## How does your idea work?

EC4U will track the electricity consumption of individual households. This data will be uploaded to a website where consumers will be able to compare their own consumption with that of their friends or of similar people in other areas. Users will use this comparison data to compete with each other and reduce their own consumption. This website would also be a resource where ideas for how to reduce energy consumption and techniques for energy optimisation can be shared and discussed.

## Who is your idea aimed at?

EC4U is aimed at You! Individual households can get involved in competitions between communities and towns; and companies can compete with each other.

## What type of energy consumption will it move?

EC4U will change people's habits, helping to reduce power consumption by making them aware of how they currently use electricity and how they can reduce their consumption. Consumption will be shifted towards night time use with cheaper night time electricity prices.

## Where does the magic happen?

With EC4U a device will be attached to consumers' electricity meters to automatically track and upload their consumption data. The magic of EC4U will be the lower energy bills that are obtained through consumers' efforts.

## When will consumers use it?

Once consumers have signed up to EC4U it will become a twenty-four seven service. Data will be automatically uploaded at different intervals allowing users to track their personal trends.

## Why will consumers use it?

Consumers will use EC4U to lower their electricity bills. There will also be eco-friendly prizes for the individuals, households or towns that reduce their energy use. In addition, some fraction of the savings made could go into charities working in the local community.

# Energy Camel: It saves you in the energy desert

Energy Camel accumulates power and energy when users are awake or asleep. It is a solution for individual households like a big battery charger that includes an electronic device with a user interface or card and communication with a central system giving data on peak times. Energy Camel will give users a happy face when they save energy, making them feel better and providing a discount on their accounts. Energy Camel is good for the earth, good for the health and good for the wealth.

## How does your idea work?

Energy Camel is like a big battery charger with an electronic device that communicates with a central system, regulated by a policy maker, that has data about peak times. It takes account of the supply and demand for the consumer's house

## Who is your idea aimed at?

Energy Camel is aimed at You!

## What type of energy consumption will it move?

Energy Camel will move the entire individual household's energy consumption.

## Where does the magic happen?

The magic of Energy Camel is that it happens in the background. This means that the user's behaviour doesn't change. Energy Camel has no effect on the consumer's daily routines. It is like a big battery charger. An analogy for how it works would be a fridge. We have a fridge so that we can store food and not have to shop for groceries every day. With Energy Camel you store all your energy and you use it when it is convenient.

## When will consumers use it?

Once Energy Camel has been set up it accumulates energy in off-peak times that can be used during peak hours.

## Why will consumers use it?

Consumers will use Energy Camel because it is cost effective and environmentally friendly and because it will leave them feeling self-satisfied. They will use it because there is no change to their daily routine and saves them money on their bills. It is feel good machine. Also if there are electricity cuts or an emergency, consumers won't have to worry as Energy Camel provides them with a back-up plan.

# Off Peak Gain

Off Peak Gain will smooth out electricity consumption at peak times. It is a simple idea that starts with reduced prices for off-peak electricity consumption. Consumers will then be provided with information about these peak and off peak times via a monitor at home and an online service that can be can be accessed with a laptop or smart phone. This enables them to see when electricity is charged at discount rates, how much that discount is and what they are able to earn by smartly adapting their use of household appliances

## How does your idea work?

Off Peak Gain provides reduced prices for off-peak energy use. It is a system that raises awareness of peak and off-peak electricity consumption times. It enables and encourages off-peak use and improves decision making by providing information that is accessible through a variety of devices, for example smart phones, or via an in-house monitor.

## Who is your idea aimed at?

Off Peak Gain is aimed at anybody who is in control of using household appliances.

## What type of energy consumption will it move?

Off Peak Gain will reduce the energy consumption of household appliances currently used at peak times. It will move the consumption of energy by appliances that don't need to be on all the time or at specific times and can therefore be scheduled, such as a dishwasher or washing machine.

## Where does the magic happen?

The magic of Off Peak Gain happens when you realise that you are saving money and saving the planet by making simple and easy changes, to your routine use of household appliances, enabled by the feeling of being in control that Off Peak Gain provides.

## When will consumers use it?

Consumers will use Off Peak Gain at their convenience. Access to information regarding peak and off-peak times and electricity pricing is available anytime day and night, whether they are at home or on the go. This enables consumers to make informed decisions whether to use an appliance or not.

## Why will consumers use it?

Consumers will use Off Peak Gain because it will enable them to save money by using their domestic appliances at off peak-times.

# Piezo Active!

Piezo Active! is a small device the size of a pound coin that is used to generate electricity from movement. It is based on piezoelectric crystals and so anywhere there is movement the crystals can be used to generate electricity. The potential of Piezo Active! can be utilised in all everyday applications.

## How does your idea work?

Piezoelectric crystals produce energy from movement. Their small size allows scalability so that Piezo Active! can be used anywhere from keyboards to stairs or in floors etc.

## Who is your idea aimed at?

Piezo Active! is universal. Everyone in the world can use it. It is very small, it doesn't require any behaviour change and yet users will get the warm fuzzy feeling that they have changed the world.

## What type of energy consumption will it move?

Piezo Active! is the anti-consumption. It is the generation of electricity from the natural actions and movements undertaken in households. This can be used to power portable devices and lighting. It can be put in floorboards, in a computer's keyboard, in a mobile phone or in a remote control. The potential of the piezoelectric crystal can be harvested anywhere there is movement.

## Where does the magic happen?

Piezo Active! is really small, the size of a one pound coin, which means it can work anywhere. Impact on Piezo Active! generates electricity. It works for an individual device, it can contribute energy for the immediate vicinity and it can give energy back to the grid. It can happen in a keyboard, under a baby's mat, in the floorboards, in a pathway down the hall or in the door when it is slammed shut. It can work in all sorts of fantastic places, even on the red carpet with all the heels.

## When will consumers use it?

Consumers can use Piezo Active! all the time. Wherever they choose to put a Piezo Active! device it will enable the environment to generate electricity through movement. This could be at home, in an office or in public buildings.

## Why will consumers use it?

Consumers will use Piezo Active! because it does not require any additional effort. There is no behaviour change, consumers do not need to do anything

extra or add anything to their lives in order to use Piezo Active! In addition, Piezo Active! can produce extra electricity to support the national grid and so potentially, if users are generating more electricity than they actually need for their individual devices, it can be put back into the grid for somebody else to use.

# Participants' Rating of Other Groups Ideas

| Idea / WS | P1 | | | P2 | | | P3 | | | P4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Creativity | Novelty | Usefulness | Creativity | Novelty | Usefulness | Creativity | Novelty | Usefulness | Creativity | Novelty | Usefulness |
| AAR / Workshop #3 | 3 | 4 | 3 | 3 | 2 | 2 | 1 | 1 | 0 | 2 | 2 | 1 |
| BPPH / Workshop #8 | 2 | 3 | 2 | 4 | 3 | 3 | 0 | 0 | 0 | 3 | 4 | 3 |
| BtC / Workshop #7 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | 3 | 2 | 2 |
| CW / Workshop #6 | 4 | 4 | 3 | 4 | 2 | 4 | 0 | 0 | 4 | 4 | 4 | 3 |
| EC / Workshop #4 | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 2 | 3 | 4 | 3 | 4 |
| EC4U / Workshop #5 | 1 | 2 | 1 | 2 | 2 | 4 | 1 | 1 | 0 | 1 | 2 | 2 |
| OPG / Workshop #2 | 3 | 4 | 3 | 1 | 1 | 3 | 2 | 2 | 4 | 5 | 5 | 4 |
| PA / Workshop #1 | . | . | . | . | . | . | . | . | . | . | . | . |

| Idea / WS | P5 | | | P6 | | | P7 | | | P8 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Creativity | Novelty | Usefulness | Creativity | Novelty | Usefulness | Creativity | Novelty | Usefulness | Creativity | Novelty | Usefulness |
| AAR / Workshop #3 | 1 | 1 | 2 | 3 | 2 | 4 | 3 | 3 | 2 | 3 | 3 | 2 |
| BPPH / Workshop #8 | 3 | 3 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| BtC / Workshop #7 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 2 | 2 | 0 |
| CW / Workshop #6 | 3 | 3 | 2 | 3 | 4 | 2 | 2 | 2 | 2 | 4 | 4 | 4 |
| EC / Workshop #4 | 3 | 3 | 2 | 4 | 4 | 4 | 3 | 3 | 0 | 3 | 3 | 3 |
| EC4U / Workshop #5 | 2 | 1 | 2 | 2 | 2 | 3 | 4 | 4 | 3 | 5 | 5 | 4 |
| OPG / Workshop #2 | 3 | 2 | 0 | 4 | 4 | 4 | 0 | 0 | 0 | 2 | 2 | 2 |
| PA / Workshop #1 | . | . | . | . | . | . | . | . | . | 5 | 5 | 5 |

| Idea / WS | P9 | | | P10 | | | P11 | | | P12 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Creativity | Novelty | Usefulness | Creativity | Novelty | Usefulness | Creativity | Novelty | Usefulness | Creativity | Novelty | Usefulness |
| AAR / Workshop #3 | 1 | 4 | 4 | 4 | 4 | 3 | 2 | 2 | 5 | 3 | 3 | 1 |
| BPPH / Workshop #8 | 1 | 1 | 2 | 4 | 3 | 2 | 1 | 1 | 5 | 4 | 4 | 3 |
| BtC / Workshop #7 | 3 | 3 | 1 | 1 | 4 | 4 | 4 | 3 | 5 | 2 | 2 | 2 |
| CW / Workshop #6 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 5 | . | . | . |
| EC / Workshop #4 | 1 | 1 | 3 | . | . | . | . | . | . | 3 | 5 | 1 |
| EC4U / Workshop #5 | 2 | 2 | 4 | 4 | 3 | 1 | 1 | 2 | 5 | 4 | 2 | 2 |
| OPG / Workshop #2 | . | . | . | 4 | 3 | 2 | 1 | 1 | 5 | 5 | 5 | 3 |
| PA / Workshop #1 | 3 | 4 | 1 | 4 | 3 | 4 | 4 | 2 | 5 | . | . | . |

| Idea / WS | P13 | | | P14 | | | P15 | | | P16 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Creativity | Novelty | Usefulness | Creativity | Novelty | Usefulness | Creativity | Novelty | Usefulness | Creativity | Novelty | Usefulness |
| AAR / Workshop #3 | 3 | 1 | 0 | 1 | 1 | 3 | 3 | 2 | 5 | 3 | 1 | 1 |
| BPPH / Workshop #8 | 1 | 1 | 0 | 1 | 0 | 3 | 4 | 2 | 5 | 4 | 3 | 3 |
| BtC / Workshop #7 | 3 | 3 | 2 | 3 | 4 | 3 | 4 | 3 | 5 | 2 | 2 | 2 |
| CW / Workshop #6 | 3 | 3 | 2 | 3 | 1 | 2 | 4 | 3 | 5 | 1 | 1 | 1 |
| EC / Workshop #4 | 1 | 1 | 0 | . | . | . | . | . | . | . | . | . |
| EC4U / Workshop #5 | 2 | 2 | 3 | 3 | 2 | 4 | 1 | 4 | 5 | 2 | 2 | 3 |
| OPG / Workshop #2 | 1 | 1 | 2 | 4 | 3 | 2 | 4 | 4 | 5 | 3 | 3 | 3 |
| PA / Workshop #1 | 3 | 4 | 1 | 4 | 3 | 1 | 4 | 3 | 4 | 4 | 4 | 2 |

## P17 – P20

| Workshop | P17 Creativity | P17 Novelty | P17 Usefulness | P18 Creativity | P18 Novelty | P18 Usefulness | P19 Creativity | P19 Novelty | P19 Usefulness | P20 Creativity | P20 Novelty | P20 Usefulness |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AAR / Workshop #3 | 3 | 3 | 4 | 3 | 4 | 5 | 3 | 3 | 4 | 4 | 3 | 4 |
| BPPH / Workshop #8 | 2 | 2 | 3 | 4 | 3 | 1 | 4 | 5 | 5 | 3 | 5 | 4 |
| BtC / Workshop #7 | 3 | 3 | 2 | 4 | 4 | 3 | 2 | 3 | 3 | 4 | 2 | 2 |
| CW / Workshop #6 | · | · | · | 3 | 2 | 2 | 1 | 2 | · | · | · | · |
| EC / Workshop #4 | 4 | 4 | 5 | 4 | 4 | 3 | 2 | 3 | 2 | 4 | 3 | · |
| EC4U / Workshop #5 | 2 | 1 | 2 | 3 | · | · | · | · | 1 | 1 | 1 | 2 |
| OPG / Workshop #2 | 2 | · | 3 | 4 | 2 | 4 | 3 | 4 | 1 | 1 | 2 | 2 |
| PA / Workshop #1 | 4 | 3 | 3 | 5 | 5 | 5 | · | 5 | 5 | 5 | 5 | 5 |

## P21 – P24

| Workshop | P21 Creativity | P21 Novelty | P21 Usefulness | P22 Creativity | P22 Novelty | P22 Usefulness | P23 Creativity | P23 Novelty | P23 Usefulness | P24 Creativity | P24 Novelty | P24 Usefulness |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AAR / Workshop #3 | 5 | 5 | 4 | 2 | 3 | 4 | 3 | 3 | 2 | 4 | 4 | 3 |
| BPPH / Workshop #8 | 3 | 3 | 2· | · | · | · | · | · | · | · | · | · |
| BtC / Workshop #7 | · | · | · | 1 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |
| CW / Workshop #6 | 3 | 4 | 5 | 4 | 4 | 1 | 1 | 1 | 1 | 4 | 4 | 1 |
| EC / Workshop #4 | 4 | 4 | 3 | 3 | 3 | 5 | 4 | 3 | 4 | 3 | 3 | 4 |
| EC4U / Workshop #5 | 4 | 3 | 4 | 3 | 3 | 5 | 3 | 3 | 4 | 2 | 2 | 2 |
| OPG / Workshop #2 | 3 | 4 | 5 | 5 | 5 | 3 | 3 | 3 | 4 | 1 | 1 | 1 |
| PA / Workshop #1 | 3 | 5 | 4 | 4 | 5 | 3 | 3 | 3 | 2 | 4 | 4 | 4 |

# Transcript of Workshop 5 Idea Generation

| Time | Participant | Speech | Action |
|---|---|---|---|
| 29 min | All | | Participants are not communicating or writing and it seems a little awkward. |
| 29 min 5 sec | 13 | "What's this?" | Leans in and taps the iPad |
| 29 min 8 sec | 14 & 15 | | Lean in to look at iPad. |
| 29 min 10 sec | 13 | "Oops. Sorry" | Taps the screen. Taps the screen again |
| 29 min 11 sec | 14 | "I don't think it stops." | Flicks the screen as if to clear an image |
| | All | | Lean again in and look more closely |
| 29 min 14 sec | 13 | "I think science fiction" | Looking at the iPad |
| 29 min 17 sec | 13 | "Oh science fiction!" | Sitting back down into her seat |
| 29 min 22 sec | 13 | "So, in an imaginary scene..." | |
| 29 min 26 sec | 14 | "We'd have our own nuclear reactors in our basements and all our electricity would be free" | |
| 29 min 34 sec | 13 | "Our own electricity generators". | Writing a post-it |
| 29 min 38 sec | 15 | "Like in 'Back to the Future' when they use the waste to power..." | |
| 29 min 44 sec | 14 | "Oh yes. Drop a banana into your ..." | |
| | 14 & 15 | | Laughing |
| 29 min 46 sec | 13 | "Sorry?" | Looks up from writing |
| 29 min 47 sec | 15 | "We used waste to power our vehicle." | |
| 29 min 54 sec: | 15 | "Put your rubbish into a.... umm... power point". | |
| 29 min 59 sec: | 13 | "Use our waste to generate electricity" | Writing another post-it note |
| 30 min 11 sec: | 14 | "The unfortunate thing is you can't really burn a lot of stuff because of the gas would be poisonous" | Speaking to 15 |

# Transcript of Workshop 6 Idea Generation

| Time | Participant | Speech | Action |
|---|---|---|---|
| 21 min 12 sec | 16 | "Maybe the dryer is something we can probably change more? But there's the washing machine that doesn't drain as much as the dryer." | Points to the details of energy consumption for wet goods on the interface. Taps interface buttons to change household demographic |
| 21 min 18 sec | 16 | | Swipes interface screen three times |
| 21 min 21 sec | 17 & 18 | | Looking at interface following [16]'s lead |
| 21 min 21 sec | 17 | "So what about the…" | Moves to point at the interface screen with pen |
| | 18 | "But only in the summer. There's winter and summer. Big difference. The clothes dryer is being used more in the winter" | Taps interface buttons to switch back and forth between summer and winter |
| 21 min 30 sec | 17 | | Points towards the interface with a pen, circling an area to highlight it and direct others |
| | 17 | "OK but its still the same machine so what if there were like on the machine… I know there's one on mine that says 'Eco' or something like that. And maybe it uses less energy but what if it were to be set on a timer? And if I don't really mind when my… maybe clothes is different because if they sit in the wash for a long time they smell but maybe the dishwasher? If I don't care what time its on maybe I'll put it on Eco and it will run in the non-peak hours." | |
| 21 min 34 sec | 17 | | Looking at [17] as she introduces her idea |
| 21 min 35 sec | 18 | | looking at [17] as she introduces her idea, nods in agreement |
| 21 min 35 sec | 16 | | Points towards the interface again with her finger highlighting and directing others |
| 21 min 45 sec | 17 | | Looking at interface following [17]'s lead |
| | 16 & 18 | | Leans in to look at something in the interface |
| 21 min 55 sec | 16 | "Just one potential observation" | |
| 22 min | 17 | "Go ahead write it down. Put timed setting or something" | |
| 22 min 5 sec | 18 | | Writes post-it note for the idea being discussed *'Timer setting on appliances'* |
| 22 min 15 sec | 16 | "What uses more energy? Steam? Or just running hot water?" | |
| | 17 | | |

# 16 Case Study: One Small Change

This section contains the following examples of evaluation data collected during the study reported in Chapter 6 of the main body of this thesis:

1. Details of the Creativity Support Index scores and analysis for each participant, in each workshop
2. Details of the responses to the questionnaire's additional questions for each participant, in each workshop
3. Details for each participant's self-reported ratings for important aspects of domain knowledge at each of three stages
4. Analysis of participants' responses to the Reflection Prompt after day 1 of the workshop
5. Analysis of participants' responses to the Reflection Prompt after day 2 of the workshop
6. Analysis of participants' responses to the follow up questionnaire
7. Details of the evaluation provided by independent domain experts for the problem statement that was the output of day 1 of the workshop, and the proposed solution that was the output of day2 of the workshop

# CSI Data & Analysis

## Workshop Day 1

| Participant | Q1 | Q9 | RWECount | RWE Score | Q2 | Q8 | ExplorCount | Explore Score | Q3 | Q11 | CollabCount | Collaboration | Q4 | Q7 | EnjoyCount | Enjoyment Sc | Q5 | Q10 | ExpressCount | Expressivene | Q6 | Q12 | ImmersCount | Immersion Sc | Total | CSI Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6 | 6 | 4 | 24 | 5 | 6 | 5 | 27.5 | 8 | 8 | 2 | 16 | 3 | 5 | 0 | 0 | 4 | 4 | 3 | 12 | 7 | 1 | 1 | 4 | 83.5 | 61.85185119 |
| 2 | 7 | 8 | 1 | 7 | 7 | 7 | 5 | 35 | 7 | 8 | 4 | 28 | 7 | 6 | 1 | 6.5 | 7 | 7 | 2 | 7 | 8 | 9 | 2 | 18 | 101.5 | 75.18518852 |
| 3 | 8 | 8 | 2 | 16 | 8 | 8 | 5 | 40 | 8 | 8 | 3 | 22.5 | 8 | 8 | 0 | 0 | 7 | 7 | 4 | 26 | 8 | 8 | 1 | 8 | 112.5 | 83.33333333 |
| 4 | 7 | 8 | 1 | 7 | 7 | 6 | 5 | 32.5 | 8 | 9 | 0 | 0 | 7 | 9 | 4 | 32 | 6 | 6 | 2 | 13 | 6 | 8 | 3 | 21 | 105.5 | 78.14814481 |
| 5 | 6 | 8 | 1 | 7 | 8 | 8 | 4 | 32 | 7 | 9 | 5 | 40 | 8 | 8 | 0 | 0 | 9 | 8 | 2 | 17 | 7 | 9 | 3 | 24 | 120 | 88.8888889 |
| 6 | 9 | 9 | 0 | 0 | 9 | 9 | 4 | 36 | 9 | 9 | 4 | 36 | 9 | 9 | 1 | 9 | 9 | 9 | 4 | 36 | 9 | 8 | 2 | 17 | 134 | 99.25925993 |

## Workshop Day 2

| Participant | Q1 | Q9 | RWECount | RWE Score | Q2 | Q8 | ExplorCount | Explore Score | Q3 | Q11 | CollabCount | Collaboration | Q4 | Q7 | EnjoyCount | Enjoyment Sc | Q5 | Q10 | ExpressCount | Expressivene | Q6 | Q12 | ImmersCount | Immersion Sc | Total | CSI Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 5 | 5 | 25 | 4 | 5 | 4 | 18 | 5 | 5 | 3 | 15 | 6 | 6 | 0 | 0 | 5 | 5 | 1 | 5 | 5 | 4 | 2 | 9 | 72 | 53.33333333 |
| 2 | 7 | 9 | 3 | 24 | 8 | 8 | 5 | 40 | 9 | 9 | 4 | 36 | 7 | 7 | 1 | 7 | 7 | 7 | 2 | 14 | 6 | 6 | 0 | 0 | 121 | 89.62962963 |
| 3 | 8 | 7 | 1 | 14 | 6 | 5 | 4 | 32 | 7 | 8 | 2 | 15 | 8 | 8 | 0 | 0 | 7 | 7 | 3 | 35 | 7 | 8 | 2 | 15 | 111 | 82.22222222 |
| 4 | 9 | 7 | 1 | 7.5 | 6 | 5 | 5 | 27.5 | 7 | 7 | 0 | 0 | 9 | 7 | 3 | 24 | 9 | 5 | 3 | 15 | 8 | 8 | 3 | 24 | 98 | 72.59259259 |
| 5 | 9 | 9 | 2 | 18 | 9 | 8 | 2 | 16 | 9 | 8 | 5 | 42.5 | 9 | 8 | 0 | 0 | 8 | 8 | 2 | 16 | 7 | 7 | 4 | 30 | 122.5 | 90.74074074 |
| 6 | 9 | 9 | 1 | 9 | 9 | 9 | 4 | 36 | 9 | 9 | 3 | 27 | 9 | 9 | 1 | 9 | 9 | 9 | 1 | 9 | 8 | 5 | 2 | 14 | 104 | 77.03703704 |

# Participant Responses to Additional Questions

| Participant | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|
| 1 | 6 | 8 | 7 | 7 |
| 2 | 8 | 8 | 5 | 9 |
| 3 | 8 | 8 | 7 | 6 |
| 4 | 7 | 9 | 7 | 8 |
| 5 | 8 | 8 | 8 | 8 |
| 6 | 8 | 6 | 7 | 9 |

| Participant | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|
| 1 | 3 | 5 | 3 | 3 |
| 2 | 7 | 9 | 7 | 7 |
| 3 | 8 | 8 | 7 | 8 |
| 4 | 6 | 9 | 4 | 8 |
| 5 | 8 | 8 | 8 | 7 |
| 6 | 9 | 9 | 8 | 9 |

# Importance of Different Aspects of the Workshop

| Particpant | Individual Thinking | Discussion | Expertise of Group | Activities with InfoVis | Facilitation |
|---|---|---|---|---|---|
| 1 | 6 | 7 | 6 | 3 | 6 |
| 2 | 7 | 6 | 7 | 5 | 6 |
| 3 | 6 | 6 | 5 | 5 | 5 |
| 4 | 7 | 7 | 7 | 5 | 7 |
| 5 | 7 | 7 | 6 | 7 | 7 |
| 6 | 7 | 7 | 1 | 7 | 7 |
| | 40 | 40 | 32 | 32 | 38 |

# Participant Responses on Reflection Postcard Day 1

| Participant | Transcript | Improvement | Reasons |
|---|---|---|---|
| #1 | I gained a better understanding of the mechanics / politics of waste management at City. The data visualization played a part, but it was mainly down to the group interaction | Totally positive | Visualized Data - Group Discussion |
| #2 | It was nice to listen to other peoples' ideas after doing the task about problems and possible solutions. My understanding of the subject matter has increased and this was due to: a) listening to other peoples' ideas; b) using the iPad visualizations - helped us to understand the barriers / motivations people associate with recycling and they acted as foundations for pinpointing problems or finding possible solutions. However actually interacting with the visualization was a bit confusing at first but after an explanation, it became clearer how to use it. | Totally positive | Visualized Data - Group Discussion |
| #3 | The iPad visualization allowed me to see how a different combination of aspects affected peoples' involvement in recycling. Also hearing other peoples' experiences improved my understanding of some of the issues. The discussions were insightful. There were things I wasn't aware of because I didn't use certain facilities in City and was introduced to these facilities through other peoples' stories. | Totally positive | Visualized Data - Group Discussion |
| #4 | My knowledge of the subject matter has increased, mainly because I was sitting next to someone from the environment team who told me all about it. I never really understood you could 'contaminate' general waste - contaminate is probably the wrong word though | Totally positive | Group Discussion |
| #5 | The visualization on the iPad provided insight on what are critically damaging to the process of effective recycling. Miscommunication between students, staff and PAF on how to solve problems is a problem. More cooperation is needed | Totally positive | Visualized data |
| #6 | Today's session was an eye-opener for me. As a member of the environment team, I had not realised how difficult we make an easy task like recycling. The discussions and collaborative working were really useful. Some of the issues discussed were triggered by the fact that I saw data I had previously looked at being displayed in a different way. Great workshop :) | Totally positive | Visualized Data - Group Discussion |

# Participant Responses on Reflection Postcard Day 2

| Participant | Transcript | Improvement | Reasons |
|---|---|---|---|
| #1 | The greatest way in which my understanding increased was by gaining insight into the different perspectives of the other participants | Positive improvement | Group Discussion |
| #2 | My knowledge of the possible solutions to the problem of general waste bins has been increased. I feel that listening to other peoples' ideas and writing them all down on the posters on the wall helped me this most. Individual thinking and group discussion helped me the most. The iPad info helped in telling us 'why' these solutions may be useful but I felt that group discussions were more helpful in creating ideas and exploring them. | Positive improvement | Visualized Data - Group Discussion - Individual Thinking |
| #3 | When all the ideas from the previous workshop were compiled it allowed me to see that the group had similar ideas. It helped me to understand that there are clear issues that most people believe needs to be addressed when it comes to sustainability / recycling. The idea that lack of information may be an important factor that stops people from recycling was interesting. | Positive improvement | Workshop Outputs |
| #4 | My understanding increased. Being around people who know about this stuff and being able to talk to them helped most. | Positive improvement | Group Discussion |
| #5 | My knowledge has increased on how to appropriately investigate bin usage by large populations of students. The limitations and positive aspects of implementing the recycling bins usage will help me better understand how recycling bins need to be used. :) Thanks again!! | Positive improvement | No Response |
| #6 | My understanding of what we can do to address the subject matter has definitely improved and increased. The collaboration really helps. Also because we had the same data, it enabled us to focus on the problem better and come up with solutions. | Positive improvement | Visualized Data - Group Discussion |

# Responses to Follow Up Questionnaire

## Q1. To what extent did the information visualizations *stimulate* and *focus the group discussions you had?*

## Q2. To what extent did the information visualizations *stimulate* and *focus your individual thinking?*

**Participant**

**1** The information visualizations stimulated and focussed the group discussions to what I would describe as "A moderate extent". They allowed us to draw inferences as a group which otherwise may have been more contentious, so there was a greater degree of accord amongst the group on what exactly the situation was. These visualizations allowed us to bypass the step of discussing WHAT the problem was and to move directly to the step of discussing HOW to solve it.

**Partially Positive**

The information visualizations largely reinforced my gut feeling on this particular matter – they did not have a substantial effect in stimulating or focussing my original thinking, but they did allow me more easily to draw attention to specific ideas by pointing to the visualization rather than needing to communicate and explain in great detail.

**Partially Negative**

**2** In the second workshop, when trying to come up with the different ideas to put on the wall in the different categories, I feel that the visualisation helped spark ideas and perhaps answer 'why' certain ideas may work since they provide reasons and show which barriers and motivations were most prevalent. Also, when doing the task on the hexagon sheet of paper, the visualisations helped for mostly the same reasons. This helped me especially when working in pairs since it gave me something to look at in order to spark and guide my thoughts. I am not sure to what extent the group discussions were stimulated by the visualisations, but I feel that the visualisations were there to spark ideas which were used in the discussion. Certain chunks of info were taken and used at certain points of the discussion to provide possible reasons for potential solutions. In this way, it could be seen that they focused the discussions at certain points.

**Partially Positive**

I think the barriers and motivations for green behaviour listed on the info visualisation helped to spark some of my ideas during both workshops especially when my mind went a bit blank and I looked at the info visualisation tool for a bit of inspiration, or to link certain ideas and add to a good idea to use it during the second workshop when trying to understand how to reduce the use of the general bin.

**Totally Positive**

3 The information visualisations stimulated and focused the group discussions we had because it gave us a foundation to start conversation. We were able to compare information collected about different groups easily and the visualisations were very interactive. Often when meeting new people it can be hard finding a common ground as you are unaware of peoples knowledge and points of view. I believe the information visualisations kind of act as this common ground.

Totally Positive

The information visualisations stimulated and focused my individual thinking by providing me with information I was not previously aware of. I had an insight of where a range of people stand in terms of sustainability and also part of what City does. The visualisations made me questions some of my own ideas.

Totally Positive

4 It wasn't immediately clear what the visualisation was showing, which in some ways made it difficult to focus, but in other ways stimulated debate and group problem solving around the visualisation. Whilst the visualisation did stimulate group discussions, I think focus would have been better gained just with simple statements, for example, saying x% of general waste bins are contaminated, and an explanation of what contamination was in this context. The visualisation contained almost too much information that wasn't required for the type of discussion - e.g. it was broken down by month etc which I don't think was really necessary and didn't seem to feature in any discussions.

Partially Negative

Initially it took some time to work out what the visualisation was saying. It stimulated thinking in that it presented questions to be asked and I suppose focus was provided in the scope of what was contained in the data. But as I said before, I thought there was perhaps too much information for what was required in the task and so in that way it felt unfocused at times. Focus could perhaps have been better achieved with a staged and guided approach to presentation of the data - starting off with a little bit of information to stimulate questions then gradually adding further complexity to focus in on different areas of the wider problem. E.g. start with general waste and contamination at a high level, discuss it, then add in the months to ask questions about what that might mean, then add in location to ask what that might mean. It might have created more use of all the data presented.

Partially Negative

5 The information visualizations (IVS) stimulated the group discussion as we tried to understand how to interpret the information provided through the graphs. The IVS helped focus the group discussions by helping us to discuss the reasons why people were less inclined to recycle regardless of their age and gender.

Totally Positive

The IVS stimulated my thinking by remembering the instances of which city university students and staff would not recycle. It also helped me to present ideas that gave reason for why people may not recycle. The IVS helped centralized my thinking by giving me ways to approach the discussion, which were focused on proactive responses to the recycling dilemma at City University.

Totally Positive

6 The visualizations allowed the group to ask specific questions about trends that were noticed and created a level playing field where everyone could contribute to the discussion without feeling like they were not experts. Generally facts and figures are seen as "belonging" to experts but having the information presented in this way took that away and made discussing the usually "boring" numbers a fun and engaging experience. Anyone could walk into the room be given the iPad and then be able to contribute to the discussion. The visualizations also helped create a link between the 2 sets of data and thus allowed us to be able to come up with and discuss solutions specific to the challenges we identified. Though we dealt with the specific challenges, it did not feel as though we were limited in our creativity. In fact, I think we had more ideas than we would have if we came together to just discuss what to do to increase the recycling rate! I think all the ideas were great and relevant and if it were possible for all to be implemented then that would be awesome. I also noticed that the ideas that were put forward as solutions were generally on a large scale (i.e. people did not limit their thinking to just solving the problem here at City but there were also some ideas that involved engaging with people beyond the University)

The information visualizations helped give a clear picture of what was going on with the data in a way that the usual graphs and bar charts do not normally allow. As someone who was somewhat familiar with the data, the visualizations made the data come alive and mean something (before this all it was, was figures in a spreadsheet). The visualizations helped identify areas to focus on and also triggered other ideas that I had not previously thought of. For example, it emerged from the discussions that the term "general waste" could potentially be misleading. Prior to this we thought the issue we needed to address was to ensure all bins were labelled. Perhaps the more important thing here is the wording in the labels and how can use visual aids to clarify what the label requires people to do!

Totally Positive

# Expert Ratings for Workshop Outputs

| | Problem Statement | | | | Proposed Solution | | Additional Comments |
|---|---|---|---|---|---|---|---|
| | Importance | Novelty | Creativity | Effectiveness | Novelty | Creativity | |
| E1 | 5 | 2 | 3 | 4 | 2 | 3 | In conjunction with making the general waste bin the 'bin of last resort' you should ensure that the recycling bins have clear messaging about what materials are acceptable and what are contaminants. These could also feature data on recycling rates. You are right to try and prevent waste in the first place, such as encouraging people to use their own mugs, food containers etc. A new scheme called 'simply cups' was launched in August 2014 – this collects and recycled coffee cups. A proper waste analysis/audit would help you identify what material is going in your general waste bins that could potentially be recycled/prevented. You could look at procurement of materials/packaging bought and disposed of on site, to see if there are opportunities to procure more sustainable/recyclable materials. Having fewer general waste bins and more recycling bins may help with shifting away from general waste being the default bin. Positioning of bins is important. If food contamination is an issue, having a separate food waste collection could be a solution. |
| E2 | 4 | 4 | 4 | 4 | 5 | 5 | The problem identified in the workshops (how to make general waste for incineration the bin of last resort) is certainly an important one and quite relevant for us at City. The proposed solution to this particular problem is quite novel and creative and has the potential to be quite effective. I would be interested to see how you propose to evaluate the prototypes to measure how effective they are in changing behaviour and reducing the use of the general waste bins while improving recycling rates. The proposed budget for implementing the prototypes is quite low; I assume this would only cover initial prototypes. If successful, a much larger budget would be required to implement the programme across the University. Reducing the number of general waste bins is just part of the actual problem at City. The other equally important problem is that people tend to contaminate the recycling bins with food/liquid waste. Cross-contamination seems to be rampant even when recycling bins are located next to general wasste collection could be a solution. |
| E3 | 5 | 4 | 4 | 5 | 5 | 4 | Simple and very effective! Another thing would probably be to reduce the number of bins for general waste for incineration and mainly have recycling bins available around the campus |