Neighbourhood *Watt*ch - Community Based Energy Visualisation For The Home

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ABSTRACT

In this paper we describe an investigation into a social, community-based electricity and waste visualisation. We present a system that, through visualisations suitable for all ages, can display the electricity consumption and waste production of a community. This system, originally deployed online, was analysed during a month-long user study, which found that, although eliciting an initial popular response, was not sufficiently embedded in daily life to have a long term effect. Thus a separate device was prototyped to give the system a permanent, more pervasive presence in a household. Additionally, we argue that such a system could be easily adapted for personalised mobile use, and would benefit from the more frequent interactions with, for example, a user's mobile phone. We also present challenges in producing this interface on a mobile device, and open discussion on how this is best achieved.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: User-centred design—*Input devices and strategies, Interaction Styles, Prototyping*

General Terms

Design, Human Factors

Keywords

Nudge, behaviour, influence, energy, consumption

1. INTRODUCTION

Current scientific reports and investigations into the causes and extent of climate change, such as the IPCC Fourth Assessment Report on Climate Change [8], together with other green issues such as peak oil, rainforest destruction and renewable energy (which received significant investment of over $150 billion in 2008 alone [7])have heightened public interest in environmental issues. This interest is spurred on by increased media coverage and campaigns such as *10:10*[1], which aims to cut 10% of UK emissions in 2010, and the *Prince's Rainforest Project*[2], a campaign spearheaded by HRH The Prince of Wales against rainforest deforestation.

[1]More information available at http://www.1010uk.org/.
[2]Available at http://www.rainforestsos.org/.

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Many systems have been developed to help individuals track their own energy consumption or waste production, as discussed in the next section, but we are unlikely to reduce global energy consumption without working together. We sought to develop a system that a) was accessible to the whole household, and b) places our energy consumption in the context of other people in our communities. The aim is to help households work together, with each other and other households, to reduce global energy consumption. We believe that the implications of adding social awareness and a mobility to household metering has not been properly researched, and that it may have a significant influence on the long term behaviour of users.

In the rest of this paper, we first introduce a system designed to be both accessible to the whole family and socially aware. We then describe a study where this system was deployed within five households for one month. Our findings indicate that although an online social network provides good motivation for change, it is not sufficiently built into daily routine to have a long term benefit. We then describe an initial investigation into a prototype device that places this socially aware system more pervasively into the living space and conclude with our hypothesis that a mobile deployment of this socially aware system will provide a more personalised experience to nudge and influence energy consumption behaviours.

2. BACKGROUND & RELATED WORK

In light of the recent interest in 'green' living, table-top style household electricity monitors have increased in popularity as a method of gathering precise realtime domestic electricity data conveniently, instead of the imprecise data from a typically difficult to access household electricity meter. Installing these monitors is arguably a proven way of reducing a household's consumption- a study for the Department of Environment Farming and Rural Affairs by the University of Oxford identified a saving of 5-15% on average household consumption from the addition of a monitor, as the occupants of the home became more aware of their usage [3]. However, the current range of table-top monitors provide limited feedback to users, usually based on a numerical display which requires knowledge of the units of power - Watts (W), and energy - Kilowatt Hours (kWh), which are used to represent electricity consumption. A notable exception to this is the Wattson device, which glows in different colours depending on the amount of electricity being consumed. In addition to this, despite supporting user experimentation in the home with relation to how differ-

ent devices affect overall household electricity consumption, current monitors feature no further incentive to reduce consumption, and after an initial interest, the energy savings can decrease as the novelty factor of the monitor itself wears off for the occupants of the home [2] in a boomerang effect.

Future visualisations based on the data already available from such commercial monitors could be used to create more engaging and meaningful visualisations for households. Current research is being done into the possibilities of using local household data in new ways, to increase the visibility of such data in everyday lives such as the Weigh Your Waste [6], and WattBot [9]projects. Weigh Your Waste involves an in-home visualisation of the status of a user's rubbish bin, and uses the weight of the waste currently in the bin to calculate the cost of disposal. The WattBot project aims to create an iPhone application that shows a user's home electrical use, broken down by the room or appliance, to indicate where the majority of energy is being consumed, and how different rooms and appliances compare. We believe these systems can be made increasingly effective by the addition of other households' data, providing both a reference point, and a possible goal to aim for. This social side of such a system is ideal for mobile use where comparisons of energy usage, recycling amounts and tips on how to improve could be shared between individuals using mobile devices.

3. NEIGHBOURHOOD WATTCH

Our goal was to design a system that was accessible to the whole family, and so we used the participatory design method [1] to engage with a class of school children to design a suitable visualisation. In this case it was used to form initial ideas regarding the types of visualisation children felt were suitable for showing waste and electricity data in the home. As Druin and colleagues suggest [5], children can offer valuable insight into how they themselves think, what they like and dislike, and what they can relate to.

A group of 10 and 11 year old children in a class at a local primary school took part in a design session, creating ideas to represent both electricity use and waste production. This age group lies on the upper bounds of where children are the most descriptive and self-reflective whilst still lacking pre-conceived ideas and methods, often resulting in truly original ideas [4]. The children were presented with two examples of existing electricity monitors, and then asked to produce one waste and one electricity design to represent the same information through a visualisation.

These visualisations were then analysed for common features, and used as a basis for designing the final visualisation used in the system. The children's designs had a number of popular themes in common, for example the use of colour such as traffic light style devices or lights that lit up in the same green, amber and red colours, which were popular for depicting electricity usage. Other themes included depictions of forests which changed in size, depictions of themselves or people close to them changing in size or getting older and younger, and pictures of rubbish bins that got progressively full of recycling or rubbish. These themes were combined to create the final visualisation used in the system - a house depicts each different household, with rubbish and recycling use mapped to the amount of black bags and recycling bins, and the electricity use mapped to the number of trees and window colours, as can be seen in Figure 1.

The system we developed consisted of this visualisation

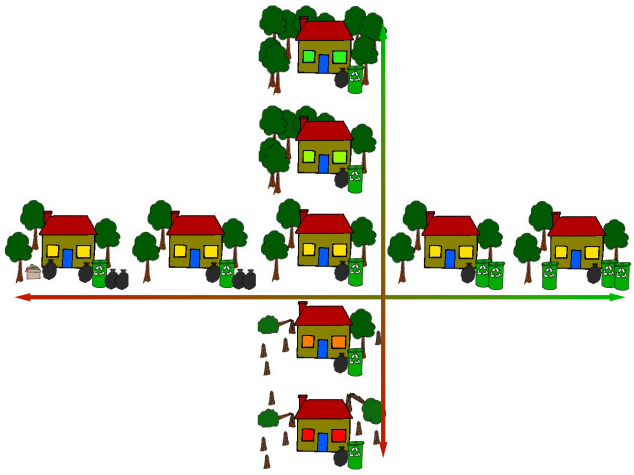

Figure 1: Scale of visualisations through electricity and waste consumption and production.

Figure 2: The visualisation for the community.

implemented through a website as shown in Figure 2. The site took readings of waste and electricity data from each participant, and used this to generate the visualisation along with other statistics, displaying this data when the participant logged in.

4. USER STUDY

A qualitative user study was designed to investigate the impact that the Neighbourhood *Watt*ch system had on a household's perceptions and behaviours regarding their electricity usage and waste production. Further the study recorded their actual usage throughout the month when using a system that visualised multiple households' electricity and waste data alongside the user's own. Finally the study explored the energy usage and waste production of households with young children in general.

The study took place over a period of four weeks. Each participating household was supplied with an electricity monitor, and a set of weighing scales to measuring the weight of rubbish they threw out. In the first stage which lasted one week, participants' daily electricity use, as reported by the monitor, and the weight of their rubbish and recycling, were recorded onto a sheet of paper, to get them used to using the monitoring hardware. The second stage also ran

for one week and involved recording the same data but using the website described previously, however participants could only see their own data. The third and final stage made up the remaining two weeks, and used the same website as in the previous stage, but enabled the community visualisations.

Prospective households were contacted via the class that was involved in the visualisation participatory design exercise. Five households willing to partake in the study were found, each of which had at least one child in their final years (9 and 10 years old) at school. Apart from this similarity other aspects of the households varied, such as the property sizes, attitudes towards the environment and 'green issues'; three of the five households recycled materials such as tin foil, TetraPaks and batteries, which were not collected from the kerb-side and therefore required a separate trip to the municipal site, whilst one reported recycling very little. These different households gave the study a wider scope to investigate the effectiveness of visualisations on households with differing attitudes and behaviours.

5. RESULTS

All participants experimented with the electricity monitor when it was first installed, exploring how much energy different devices use in their homes (which confirmed findings by Darby et al. [3]), and for a number of participants the study served as a constant reminder to be more energy conscious. The community section of the website provoked interest among participants, but the electricity monitor was the primary cause for behaviour change in the households.

Despite the focus on the monitor, participants were still aware of their presence on the website, and how they appeared to other participants. Participants felt guilty when seeing the community page and identifying other people who were using less energy them them; one household, for example, commented: *"I looked at other people's houses online, and saw averages of less than four and I thought ooh oh dear!"*. Another stated: *"We trimmed all the hedges! We should have put that in see, that would have made us better!"*, reaffirming their wish to look good to other people on the community section of the site.

Whilst the system was well received by all participants, a number of common and key issues arose through the study period. Whilst the website received praise from participants regarding its functionality and ease-of-use, when changing from the paper sheet recording to using the website, participants did not record as many readings. When queried, the participants admitted they did not use their computer on a daily basis and turning it on just to enter the reading was considered too time consuming: *"Everyday I noted it down on the calendar usually what it was at the end of the night, but I didn't always have the energy to put it in - I don't always have the computer on everyday."* Another household commented *"It's quite a responsibility doing it every night", "Unless you're in the habit of going on the computer every night for something anyway".*

In addition, the participants did not generally use or explore the website apart from updating readings, thus the main feedback from the electricity use came from the energy monitor itself, with most participants only looking through the community section of the site once or twice during the study.

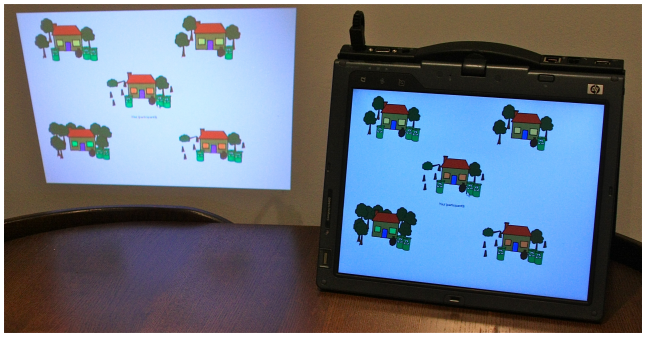

Figure 3: Revised system prototype with projector display, showing the community visualisation.

6. REVISED SYSTEM

Further to these results a refined, more pervasive system was prototyped, designed taking into account the issues that participants had identified with the existing system, and to address these problems it was decided that the refined system must consist of a device similar to the electricity monitor, but be capable of displaying the same information as the website. The table-top electricity monitor was attractive to the households as it required nothing more than a casual glance to assess how much electricity was currently being used. By comparison the website required logging in, and in some cases the additional time of turning the computer on. It was decided the new system would also support automatic updating of waste production, using a method similar to the *Weigh Your Waste* project [6], involving wireless scales fitted to rubbish bins to monitor the weight of the contained waste.

The refined system was prototyped before being presented to the participants of the previous study for feedback in a think aloud session. The new system, shown in Figure 3 was designed to include a table-top display device that would show the community visualisation, whilst automatically recording the electricity and waste use from the household providing a more pervasive interaction than the previous system.

6.1 Reactions

The new system was met with enthusiasm from most participants, with all but one household agreeing that it was better than the first system. This participant liked the refined system, but commented that it wasn't a system they would use in their home, they thought they were as green as they could possibly be: *"It's not for me, as we turn off electricity as much as possible anyway, and we also recycle as much as possible."* They did however state that they would be willing to use such a system for research purposes, to help refine it further.

All other households expressed an interest in the new device, and all said they would use it in their homes. They much preferred the fact that the device provided all the information on its own display and did not require using a computer, for both accessibility and speed reasons – two households stated they thought the new system was easier to use, with the large display being *"Clear and easy to understand"* and *"More user friendly, and I don't need to log in - time efficient."* They also commented that if it was in the

home directly, *"The children would like the interactivity of it"*, and all households stated they would prefer to place this device in the kitchen or dining room, in places they frequent in the home.

6.2 Towards Mobile Device Design

While it is clear that the socially aware aspect had a positive impact on people's energy consumption, the exact form of Neighbourhood *Watt*ch requires additional research. One logical hypothesis is that Neighbourhood *Watt*ch should be deployed on mobile devices, so that it can be integrated even more into daily practices. The revised prototype presented above had the benefit of being better integrated into routine, but several participants were unsure about the use of additional technology in the house to reduce energy consumption. There are several advantages to creating more personalised mobile device applications for Neighbourhood *Watt*ch: 1) many people keep mobile devices on their person throughout the day; 2) it allows the user to keep track of their consumption while out of the house; 3) it allows individuals to track finer-grained physical spaces such as their own room; 4) individuals can have a personalised age-appropriate view of their energy consumption; 5) it allows people to share and compare their energy consumption when visiting others. One downside is that it may be harder for families to engage with the visualisation together. Another is that the physical presence of the monitor in the house is taken away. We would suggest that the presence of Neighbourhood *Watt*ch on a mobile phone should be made permanent by an icon in the corner or an ambient indicator, to capture the same benefits as a permanent installation in the house. These pros and cons should be discussed fully in a workshop environment, to identify if they are valid goals for the technology and gauge wether or not these are features users would want to interact with and use in a mobile context.

The transition from web-based interactions to mobile ones for this technology depends highly on the mobile technology being used. A recent smartphone released in the last couple of years is fully capable of displaying the web interface used in the study, and so are more recent popular form factors such as Apple's iPad. Re-designing the interface into one based in a native application for these devices would increase the speed of determining energy usage, however a different visualisation may be more suitable. Older phones such as one without touch screen or colour display would not support the web interface as is, and would require a redesigned interface specifically for them which we believe would still not provide a compelling and engaging experience due to the hardware limitations of such devices.

Newer devices however present an increased range of possible interactions. GPS and location data available from these newer devices could be used to determine how households in the immediate vicinity of the user compare to their own use, or remind user when they have left their home which appliances have been left on for example. Additionally, the feedback from actuators such as a devices screen brightness, vibration levers or even auditory signals could be used to further nudge and persuade users. As mentioned above, having a mobile display of energy information when visiting friends could also be a conversation point for discussing how savings were made.

The rise of such social tools such as Twitter and Facebook combined with ubiquitous internet connected mobile devices has meant that for a lot of people, they are in constant communication with friends and colleagues. This social network popularity could be exploited with revisions of neighbourhood *Watt*ch into a social service. This would have scope from comparing individuals in a home and how they contribute to the overall energy use, how they compare individually and as a family to other individuals and households, how houses in a street compare in a town, or how towns compare throughout the country, possibly including such motivators as weekly goals, or challenges and leader boards. We believe tight integration with existing social networking services combined with mobile alerts, or notifications of such challenges would highly increase it's effectiveness.

7. CONCLUSIONS

In this paper, we have described an investigation into a system that promotes and facilitates better awareness of energy consumption by placing it in the context of a user's community. Neighbourhood *Watt*ch lets users know not only whether they have reduced their energy consumption, but allows them to see whether or not their consumption is good or bad when compared to other people. While our investigation indicates that social awareness of energy consumption did motivate better energy consumption, the visualisations had to be pervasive and embedded in daily routines to have long term effects. We believe that Neighbourhood *Watt*ch would be better able to nudge and influence behaviour if deployed on users existing mobile-devices, but must maintain permanent presence to be effective.

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