Wattsup?: Motivating reductions in domestic energy consumption using social networks

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ABSTRACT

This paper reports on the design, deployment and evaluation of "Wattsup", an innovative application which displays live autonomously logged data from the Wattson energy monitor, allowing users to compare domestic energy consumption on Facebook. Discussions and sketches from a workshop with Facebook users were used to develop a final design implemented using the Facebook API. Wattson energy monitors and the Wattsup app were deployed and trialled in eight homes over an eighteen day period in two conditions. In the first condition participants could only access their personal energy data, whilst in the second they could access each others' data to make comparisons. A significant reduction in energy was observed in the socially enabled condition. Comments on discussion boards and semi-structured interviews with the participants indicated that the element of competition helped motivate energy savings. The paper argues that socially-mediated banter and competition made for a more enjoyable user experience.

Author Keywords

Sustainability, Persuasive Technology, Social Networking, Competitive Energy Saving, User Experience

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

It is generally acknowledged amongst scientists and, increasingly, politicians and corporations that current levels of energy consumption are not sustainable [25]. Many people already know very well that they consume too much energy at home and fly too often. And yet they do next to nothing to change this. Indeed a recent article in the Ecologist on unnecessary travel was written on board a transatlantic Boeing 747 flight [30]. At the moment we want to cut carbon emissions without changing our lifestyles; we do not want sustainable technologies but perhaps we want to want them. How then can technologies designed to change behaviour become compelling, desirable and enjoyable?

It is increasingly recognised that interaction design must address issues of sustainability, e.g. [4, 24, 33]. There has been much work in HCI in the past decade on persuasive technology, e.g. [9, 18, 23]. However Fogg recently pointed out that persuasive technologies very often fail and urged practitioners to think small [19]. Monitoring technologies alone (e.g. pedometers) are often not enough to make meaningful changes in behaviour. This paper draws on previous work on persuasive technologies, e.g. [18, 19] in order to address environmental concerns over domestic energy consumption.

Households are responsible for 30% of the UK's total energy use [12]. Since 1970, household energy demands have grown by 32% [29] and still continue to grow. Energy demands have grown because of increases in home temperature and the proliferation of consumer electronics [14]. Ulrick Beck identifies increasingly individualized forms of living such as: "living alone, single parenthood, non-marital cohabitation, childless marriage, serial marriage" and "living apart together", where partners live in separate dwellings" [2]. The impacts of these trends are social but also environmental in that one person living alone uses more energy than two in the same household [3]. Rising energy consumption currently means increased CO_2 emissions so domestic energy consumption is very much a world problem e.g. [20, 46].

This paper reports on the design, deployment and evaluation of a Facebook application which aimed to encourage energy saving by using live and historical energy feedback in a social-normative context.

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BACKGROUND

Numerous studies have demonstrated that energy usage falls when people know it is being monitored [46]. Studies in Environmental Psychology have shown that feedback on energy consumption can achieve behavioural change though it is not necessarily sustained without timely reminders [11, 16]. The goal of this project therefore, was not just to effect behavioural change but to demonstrate larger reductions in energy consumption through the addition of a social aspect in monitoring energy usage.

The desire to belong and willingness to adapt behaviour to follow what others are doing has been seen as a fundamental motivator [1]. Social norms such as peer pressure have also been seen as a means of changing behaviour to align with the ideas or beliefs of groups [41]. It has been argued that computers now operate as social actors designed to influence our behaviour, filling the roles of teachers, sales people and health agents and [17, 18]. Computers have, for example, been shown to help people overcome their fear of public speaking [43]. Recent work on persuasive technology has argued that reciprocal interaction through instant messaging and "pokes" can be effective strategies for persuasion [47]. Whilst there is insufficient space to give a full account of the psychological theories of social motivation, effecting behavioural change through computer mediated social networks seems promising.

Energy Monitors

In many homes, electricity meters are often difficult to access (located in cupboards or corners) and usually difficult to read. Energy measurements in kilowatts are difficult to make sense of either in terms of finance or ecological impact [8]. Dynamically updating kilowatt readings are however much more understandable [48]. Studies of paper electricity bills have also shown that awareness and understanding can be increased through graphical representations of financial and normative comparisons [10]. However bills do not provide frequent feedback and a recent study found that continuous feedback over a long period is the best means of changing patterns of energy consumption [16]. The importance of raising awareness about patterns of consumption can be illustrated with reference to still widely held but mistaken beliefs about domestic appliances. One study of mistaken folk theories of energy consumption found that there was still credence given to such myths as - turning a thermostat up higher than necessary heats a room up quicker, and - leaving computers and lights on consumes less energy than turning them on and off frequently [28].

The Wattson home energy monitor is a standalone device which is designed to raise awareness of domestic energy consumption. It is an off the shelf technology which takes readings from electricity metres and displays the information as real-time energy usage data. It has a light system that provides ambient feedback as well as a numerical display that can show units like watts and pounds sterling.

Figure 1: The Wattson energy monitor from DIY Kyoto

Smart monitors such as the Wattson are increasingly common and The UK government has committed to replacing all current electricity metres with smart metres by 2020. This is no guarantee that it will happen of course, but it indicates that the availability of such devices is likely to increase.

Facebook

The social networking site Facebook now has over 250 million active users [15]. If the site were a country its population would be greater than that of Russia. Studies of Facebook have demonstrated that users read other people's postings, play games, upload comments on photographs and add to their own 'profile' many times daily [27]. These sites provide a powerful means of delivering small, asynchronous applications to peer groups of likeminded real-world friends in a manageable and pleasant way. There may then be potential in leveraging the engaging power of small applications, offering rich social interactive features to change behaviour.

Feedback Studies

In recent years there have been many studies of innovative ways of displaying energy consumption. The "power aware cord" offers per-appliance feedback in the form of a glowing power cord but does not indicate energy used or cost [21]. The use of portable and stationary, minimalist direct displays for the home was investigated in another recent study [48]. This found that occupants would move around the house turning appliances on and off to monitor the change of feedback on the portable display they carried and enjoyed this playful approach (*ibid*). The Phillips iCat study used a robot with happy or sad facial expressions corresponding to low or high energy use scenarios in a lab [37]. Although the study was limited to the lab and involved the use of a very expensive robot it indicated that participants responded more positively to the playful expression of the cat rather than a bar chart [22].

The two previously discussed studies did not employ the use of any normative feedback, social or otherwise. But some work has been carried out in using social platforms to motivate people to reduce their ecological impact. Mankoff

[34] proposed the use of web widgets like "badges" showing carbon footprints which could be incorporated on platforms like MySpace but the proposed implementation relied on users self-reporting their energy information.

A recent study used a large situated display to compare energy consumption between dormitories of a university campus showing expenditure by both halls and individuals. The display was only updated bi-weekly yet resulted in massive reductions in electricity and water [36]. A Facebook group was created for the study but did not have a high uptake. A Facebook group network can only be fed updates in the form of self-reported textual or static image posts with little guided or sophisticated interaction. Facebook applications provide a more personalised experience through access to the users profile, profile actions and news feed. A Facebook application displaying personal student energy usage tied into each student's unique Facebook account profile may have been more effective.

This study aimed to address a gap in current work on leveraging social platforms by embedding live, continuous energy data into a fully interactive socially-enabled energy application. Using the Facebook Developers Kit (FDK) API, Wattson devices were linked to Facebook allowing us to investigate whether sharing such information between friends might make for further reductions in energy consumption.

DESIGN PROCESS

Focus groups were conducted with a convenience sample [40] of four Facebook users aged between twenty three and thirty eight. There were three males and one female and all were responsible for paying the energy bills in their homes. Discussions took place in a home lab on campus at a university and helped the participants focus on the home as a design space. It should be noted that as the participants were students on a Masters course in HCI they were more sensitive to issues of interface design than other groups might be.

Participants were shown the Wattson monitor and a selection of YouTube videos related to energy consumption. One video featured a Wattson monitor over a period of a few minutes displaying live home energy readings, from low to high when a cooker is switched on; simultaneously, a "Nabaztag" outputs a vocal message that a lot of energy is being used at that moment and flashes its lights.

Figure 2: WattsOn and Nabaztag YouTube Video

Participants commented on the comic potential of the device and the possibility of fun, playful interactions. This generated general discussions around the concept design of a socially enabled home energy monitor and what that might look like.

Pencils, coloured pens, scissors and other craft materials were also provided allowing participants to create their own interface elements.

Figure 3: Initial Sketches developed in focus group

A large number of ideas were generated and discussed. Various graphical metaphors were suggested such as a mouse running in a cage turning faster or slower depending on energy consumption, balloons with user's faces on them were pictured being inflated larger or smaller and floating higher or lower to indicate ranked consumption rates (see figure 3. There were a number of interesting suggestions. For instance: "*a digital photo frame, if you aren't using much energy then you see pictures of beautiful scenery or if you're using a lot some stark scenery, almost like a piece of art that changes over time*". Smiley and sad faces were also suggested as simple but very easily understood graphical elements (see Figure 5).

The participants were then given a paper materials pack containing various paper interface elements such as user avatar icons, energy icons and CO_2 icons to help create prototype interfaces. Plain interface template cards were added to the pack enabling the participants to place the interface elements on the blank interface templates.

Figure 4: Interface elements given to participants

Much of the discussion revolved around the difficulty of relating to the kilowatt as a unit of energy measurement. "*Kilowatts, watts, I don't want to see any of that, money yes.*" There were interesting debates about whether financial representations were more powerful than ecological ones "*I'm thinking a kind of erm some form of visual presentation....you'll see more trees over time in an image if you use less energy, see trees knocked down if you use more*" There were also interesting general discussions of issues such as privacy when sharing data raising concerns such as: "*The risk of failure in front of your friends.*" However it was generally agreed that introducing a competitive element between friends who were free to opt in or out of the group might help drive a reduction in consumption.

IMPLEMENTATION

Moving on from the conceptual design stage was made relatively straight forward due to the high quality of the user generated designs. Following discussions in the focus group it was decided that the main interface attributes for displaying energy would be expressed in Watts and pounds sterling (£) as well as CO_2 emissions measured by weight. In addition to numerical representations, a graphical representation was selected to display alongside both numerical values for energy and Co2 emissions in the form of the happy/sad face theme as previously discussed.

Three core interfaces were developed to provide an engaging user experience: **My Energy, Friends** and **Rankings**. The My Energy screen would show energy consumption with a dial visualisation and a seven day history bar chart.

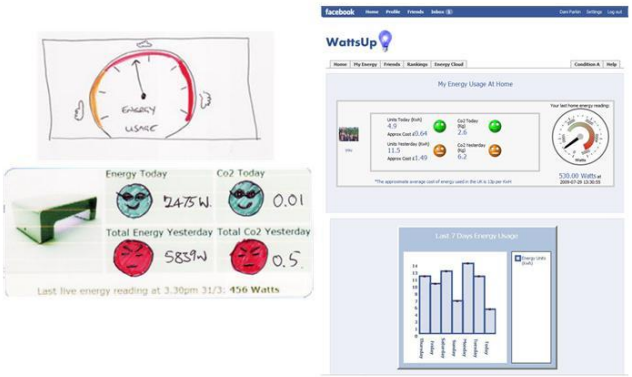

Figure 5: My Energy: Workshop sketches and final design

Sketches developed in the workshop (see the left hand side of figure 5) were developed into final designs (see the right hand side of figure 5). Workshop comments also informed the design e.g.: "*What the dials can do is give you a comparison, although they are very abstract, I can still tell if I have used loads of energy today.*" The final design then related quite directly to initial discussions.

The **Friends** screen would display personal energy consumption against selected friends.

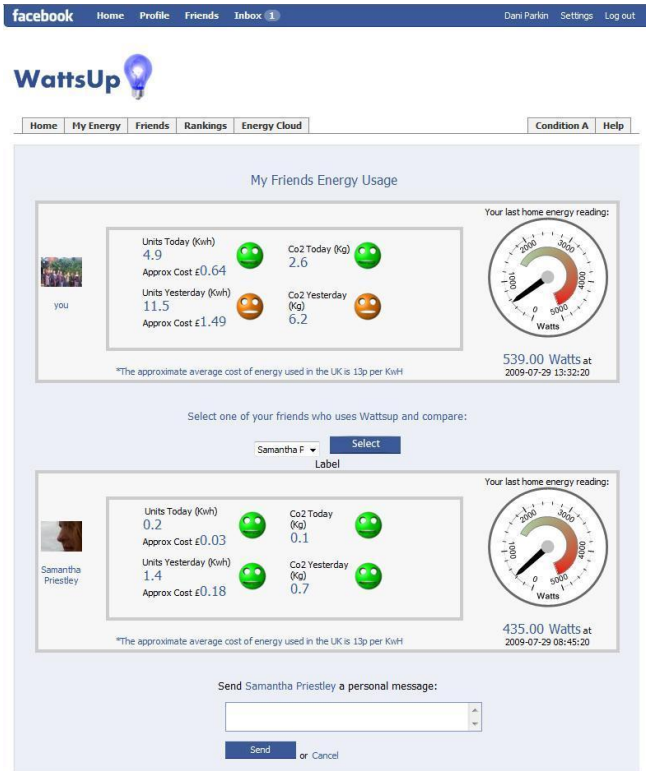

Figure 6: "Friends" screen final design

Again this final design built directly on ideas and comments from the workshop "*I can see it working amongst a group of friends, but finding a way to notify users of the group of whats happening*"'.

The **Rankings** screen would show a table of highest and lowest energy users of the application.

Figure 7; Rankings Screen, Initial workshops sketches and final design.

Again there was a very direct link between the final design and workshop suggestions such as "'*I thought about a leagues table based on points, slightly competitive but not with pressure and a bit where people can discuss it*'" and rough sketches such as those on the left hand side of Figure 7. The ranked pyramid of the heaviest consumers suggested in the workshop (see the bottom left hand side of Figure7) was simplified to a ranking table similar to that imagined in another workshop sketch (top left hand side of Figure 7).

Another important interface element was the integration of a comments board. The rankings table would allow users to visualise what their standing was against others but it would not facilitate friends commenting on personal or others' energy consumption. This feature was added following discussions of the importance of interacting with friends through such an application. A cloud tag feature was also added where users could note the devices they thought were high energy users.

As with any prototype design, choices were limited by time and material constraints. A number of interesting concepts were generated in the workshop which were not feasible within the scope of the project. As is well documented in the participatory design literature, the sketching process was invaluable not only in generating the final designs but also in recognizing a wider design space e.g. [6].

DEPLOYMENT

The application was developed using ASP.NET, Microsoft C#, HTML/CSS, XML, MySQL, Facebook Markup Language, and the FDK API. When completed it was deployed to the Facebook application platform.

To afford the functionality displaying live and recent energy data within a Facebook application, an elaborate application framework was designed and implemented as seen in Figure 8.

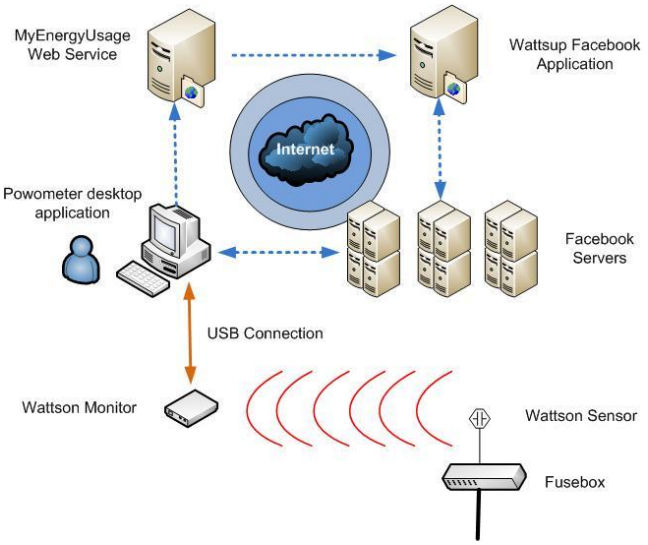

Figure 8: Technical Design Overview

The diagram illustrates the Wattson sensor at the householders fuse box sending the current energy reading by radio signal to the Wattson energy monitor which stores the data in its 30 day dedicated memory. The Wattson is physically attached to a PC via a USB cable which transports the energy data from the Wattson to the PC via the desktop "Powometer" application where it is stored in a local SQL mobile database. At configured intervals Powometer sends the stored energy data to the myenergyusage.org service via the internet where it is stored in multiple MySQL databases for redundancy. Once the energy data is stored on the myenergyusage.org databases it is then presentable to authorised applications to make use of it. The Wattsup technical design and implementation tasks were approached using Evolutionary Prototyping [38].

EXPERIMENTAL METHOD

Aim

The aim of the study was to see if energy savings could be increased by the addition of a social element to monitoring. As it is already known that monitoring can reduce energy consumption the focus was on the social element and we did not consider households without any energy monitors of any kind. To this end, we made a socially enabled version of the Wattson energy monitor via Facebook. The hypothesis was that less energy would be used whilst the Wattson was socially enabled than when it was not socially enabled.

Participants

Eight households were recruited to trial the prototype with each participant being the person responsible for paying the electricity bill. The number of participating households was limited by the number of devices available to the researchers. Selection of the participants followed a purposive sampling method [40]. The criteria for

recruitment were that the lead participant in each household must be responsible for paying their household electricity bill and be a daily user of the Facebook website. None of the households had owned any type of energy monitor prior to the study.

Participant	Profession	Age	No. Household Members
Diane	Nurse	26	2
Alice	Nurse	23	2
Rachael	Office Admin	49	2
Christopher	Programmer	32	2
Robert	School Teacher	41	2
David	Student	31	2
Richard	Student	20	4
Shirley	Writer	40	4

Table 1: Wattsup participant demographics

The participants were also recruited in 4 pairs who resembled one another in circumstances as much as possible. For example if a participant belonged to a family of four then another participant belonging to a family of four was recruited. In total the participants belonged to households with 6 couples and 2 families of four, so twenty people in all were involved in this study. The lead participants had all been regular users of Facebook for at least one year and were all friends who were on one another's Facebook friends list. Additional demographical information on the participants is detailed in Table 1 with pseudonyms used in place of the participant's real names.

Design

The experiment followed a within subjects design [7] with each participant taking part in two conditions or social modes. In condition A the Wattsup application was socially enabled, i.e. users could see their friends' data as well as their own, in condition B the Wattsup application was manipulated so that there were no social features i.e. users could only see their own energy usage.

The households were divided into matched groups and the conditions were counterbalanced between the groups to avoid ordering effects [7]. Group 1 started in condition A, group 2 in condition B and the groups switched conditions halfway through.

The independent variable was therefore the Facebook application's social mode, either enabled or disabled. The dependent variable was the energy used in Kilowatt Hour units with a total measurement being taken in each condition for each household.

Procedure

The experiment required hardware in the form of a Wattson energy monitor and a Windows based PC running the Powometer desktop software available from www.myenergyusage.org to collect energy data from the Wattson monitor. The Wattson monitor was installed along with the required desktop software one week before the experiment officially began. This was done to assist in reducing any effects on participants' energy usage by initially using the Wattson on its own, as it was likely to receive attention as a new gadget in the house (and, as previously noted, decrease energy consumption).

Each participant gave their informed consent and carried out the experiment in their own home. The experiment took place over a period of 18 days with 9 days in each condition. Half of the participants started in condition A with the other half starting in condition B, after 9 days the participants were sent an email through Facebook informing them of the changeover of conditions. The applications were then reprogrammed to perform in the alternative conditions with the relevant participants.

Data was collected in the Wattson device itself, a MS SQL mobile database using the installed desktop software and the myenergyusage.org web service via a MySQL database. The Google analytics service was also used to record the number of Facebook application page views for each interface.

RESULTS

The energy usage, in kWH, in both conditions for each household is summarised in Figure 9.

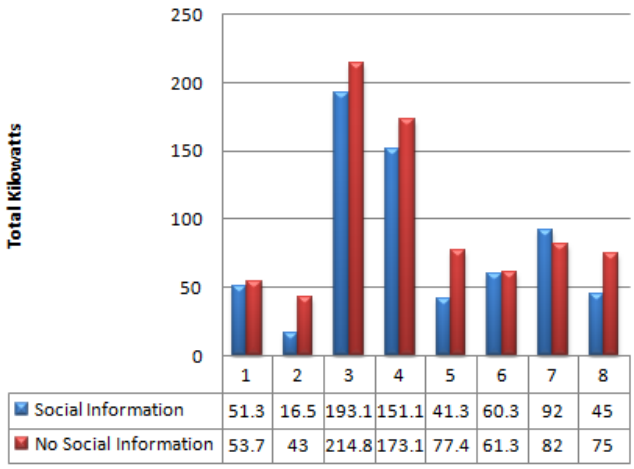

Figure 9: Wattsup participant energy usage in each condition

A Wilcoxon test, for comparing repeated measures of non-parametric data, showed that energy consumption was significantly lower when using the socially enabled application ($Z= -2.1$, $N=8$, $p=0.036$).

A total of 130Kw units of energy saved by the participants in condition A as opposed to condition B. This amount of energy would be expended by leaving a 60W bulb on for 9 days and result in Co2 emissions similar to those produced by driving an average-sized UK petrol car for 399Km.

Additional data collected from Google Analytics highlighted the differences in user interaction activity between both conditions. In terms of the number of times

the participants visited Wattsup, condition A was significantly more popular than condition B with a total of 263 versus 51 page views respectively. The number of visits to the Facebook application then showed a fivefold increase in the social condition. Participants spent most time on the rankings interface viewing and commenting on the rankings table. It can be assumed that participants enjoyed this feature the most due to the collective amount of page views for rankings as well as the average time spent viewing it

However with such a low number of participants it is worth exploring the result further by analysing the qualitative data collected.

QUALITATIVE DATA

In addition to the descriptive and inferential statistics qualitative data analysis was undertaken on the comments board and on semi structured interviews following the trial.

Comments board

The comments board proved to be a popular feature with participants and comments were analysed using a small scale grounded theory approach [44]. Three main categories of comment emerged: **banter, engagement** and **competition**. Banter included teasing such as "*how come you are at the top, cut down drastically on your cups of tea?"* And gloating "*good to see I'm higher in the table then you rob ha ha*" as well as provocations such as ""*energy vampire...you clearly are!!""*. This kind of banter extended to joking exchanges such as:

> Diane: "*I've turned my washing machine settings down as this uses loads...no pun intended*"
>
> Alice: "*I once turned down a washing machine. Wasn't pretty. It went into a cycle of depression and self-loathing before finally giving me my socks back*"

Engagement included disclosure of information such as "*Left my main PC on the last two nights. Made a massive difference to my scores*." And disbelief about energy usage "*gone down in the rankings? I´m in Spain :S*" Engagement could indicate enjoyment "*Woohooo, looking good today!"* but sometimes also mixed feelings of guilt and disinclination to change "*I NEED TO STOP PLAYING PUTER! (idontwanttoidontwanttoidontwantto*)".

Other comments indicated pleasure in the competitive aspect of the rankings "*Take's the top spot: D*" this seemed enjoyable even to those who were not necessarily winning "*I've been usurped*". This competitive element occasionally led to questions "*hey [name omitted] what's your secret? your energy rating is pretty good...*". Comments were made when participants moved both up and down the ranking table indicating engagement in the process throughout.

Semi-Structured Interviews

Participants took part in semi structured interviews about their experience with the set uy when the Wattson device was collected from their homes at the end of the study. They were asked: which condition they preferred and why, whether they had any problems using Wattsup and whether they would use it or something similar over a longer period of time.

All of the participants preferred the socially enabled condition "*I preferred the second one (socially) because I am quite competitive, it gave me further incentive. I think putting a bit of fun in it is quite important.".* All of the participants said they would be very interested in using the system over a longer period of time. With regard to problems using the device some suggested a more visual representation of Co2 emissions.

As with other energy reduction systems participants found monitoring itself quite enjoyable:

> "*Well, this morning we unplugged EVERYTHING one by one, room by room. The reading on the wattson went down by around 450 to 970 watts. Ha, we actually enjoyed investigating this though ;)"*

Although financial and ecological concerns may also be important factors this and other studies clearly indicate that fun should be taken seriously, eg [5].

DISCUSSION

One UK study claimed that sustained behavioural change with domestic energy consumption was unlikely to alter until more than 3 months had elapsed [11]. However, the energy feedback in that study was not delivered within a socially enabled context; therefore it is possible that the claim of 3 months minimum for energy usage behaviour change may not hold when a social platform is used to deliver the feedback. Due to time constraints and resources available this project could not address the experiment duration issue for sustained behaviour change. These findings then may be viewed as a pilot study potentially leading onto a larger and longer term study.

But the approach may be criticised more generally. It could be argued, for instance, that computers are part of the problem and not the solution. Part of the reason for the massive increases in domestic energy consumption is the proliferation of computers and other energy intensive devices. In 1995 29% of the UK population owned a PC, in 2006 this had more than doubled to 65% [35]. The power supply of today's computers is around 300w and growing as technology progresses, significantly more than computers of the 1990s [39]. Increasingly sophisticated components such as graphics cards and processors are using more energy with each subsequent generation.

It is difficult to find reliable figures estimating the carbon footprint of an entity like Facebook. Some estimates place

the number of servers necessary as 10,000 with an additional 300,000 user PCs connected at any one time [32, 42]. While all carbon footprint estimates are disputable the footprint of Facebook and its users is clearly large, perhaps, as some claim, the equivalent of a major city. The number of Facebook users is often compared to the populations of nations. If Facebook is a country you need a computer to live in it. Using Facebook to reduce energy consumption then may be rather like eating more pies in order to lose weight.

However there may be a value to endeavours such as this beyond an immediate and measurable net reduction of personal energy consumption. Such studies cannot help but raise awareness of energy consumption if only because of the Hawthorne effect. For ecological change to take place there must also be ideological change. This study generated a considerable amount of press interest [e.g. 45] which indicates that sustainability is now a very real concern of users. That said, the focus on individuals and personal energy consumption must not detract from larger political interventions. As Paul Dourish has argued we must raise awareness not just of the ecological consequences of leaving the lights on but the consequences of our decisions at the ballot box [13].

It has been argued that in an age of potential ecological catastrophe user centred design is no longer appropriate [e.g. 4]. The user's needs and preferences should not take precedent over the impact of their technologies on the environment. However this is to configure the user solely as a consumer. Users may also be considered as citizens. Although some scientists continue to doubt that global warming can be attributed to human activity it is clear that a great many users / citizens are now entirely persuaded and want to do something about it. The impact of our technologies is a real concern at the level of user experience. User experience is already broadly conceived in terms of social and psychological perspectives, it is becoming clear that it must be conceived in still wider terms to address the ecological challenges of the coming years.

Slavoj Zizek has argued that enjoyment is a political factor in any social structure, even, or especially if it is extremely repressive. The jokes and private satires against the party in communist states were no threat to the regime, indeed they were entirely necessary for its smooth running [49]. Lovelock has argued that if we were to take the ecological challenges that we face seriously then we would adopt systems of rationing much harsher than those of the second world war [31]. Even if the cataclysmic predictions of climate change are wrong it is clear that the way we consume energy must change. If harsh measures are to be endured then perhaps we must find ways to enjoy them.

CONCLUSION

The paper has described the design, deployment and evaluation of a Facebook application designed to allow friends to compare their domestic energy consumption.

The quantitative and qualitative analysis of the data collected from participants in this study suggests that social networking sites may be able to play a role in reducing energy consumption in the home by making monitoring more enjoyable.

This was a small scale study and only a larger investigation could conclusively determine how effective such applications may be. However, these results are encouraging. Competitive carbon counting appears to be both more enjoyable and more effective than individual monitoring.

The limits of how much any individual can achieve by changing their own lifestyles are often pointed out. But collective behaviour change even on a small scale is increasingly recognized as a key to tackling global warming. The International Energy Agency, for instance, estimate that devices on standby cause a full one percent of world greenhouse emissions, this is nearly equal to that of the entire aviation industry[46].

Social networking sites like Facebook and Twitter are increasingly being appropriated by users for political and social ends. Facebook is of course primarily for fun but it may be that the enjoyable aspects of the service make for effective platforms for persuasive technologies.

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REFERENCES

1. Baumeister, R.F., and Leary, M.R.: The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin 117* (1995), 497–529.
2. Beck U. *Individualisation: institutionalized individualism and its social and political consequences*. Sage London UK, 2002
3. BERR, *Energy consumption in the United Kingdom – BERR*. http://www.berr.gov.uk/files/file11250.pdf
4. Blevis E. Sustainable Interaction Design: Invention and Disposal, Renewal and Reuse. In *Proc. CHI 2007*, ACM Press (2007), 502-512

5. Blythe, M.A., Overbeeke, K., Monk, A.F. and Wright, P.C. *Funology: from usability to enjoyment.* Kluwer Academic Publishers, Dordrecht, Germany, 2003
6. Buxton B. *Sketching the User Experience: Getting the Design Right and the Right Design.* Morgan Kaufman. Amsterdam, Holland, 2007
7. Cairns, P., and Cox, A.L *Research Methods for Human-Computer Interaction*. Cambridge University Press, Cambridge, UK, 2008.
8. Chetty, M., Tran, D., and Grinter, R. E. Getting to green: understanding resource consumption in the home. In *Proc. UbiComp 2008,* vol. 344. ACM Press (2008), 242-251.
9. Consolvo, S., Everitt, K., Smith, I., and Landay, J. A. Design requirements for technologies that encourage physical activity. In *Proc CHI 2006*, ACM Press (2006), 457-466.
10. CSE, Consumer Preferences for Improving Energy Consumption Feedback. http://www.cse.org.uk/pdf/pub1033.pdf
11. Darby, S. *The effectiveness of feedback on energy consumption: A review for DEFRA of the literature on metering, billing and direct displays*, Environmental Change Institute, University of Oxford, Oxford, 2006.
12. Defra, Department for Environment, Food and Rural Affairs: Autumn Performance Report 2006. http://www.defra.gov.uk/corporate/apr/apr2006.pdf
13. Dourish P., Print This Paper, Kill A Tree: Environmental Sustainability as a Research Topic for Human – Computer Interaction. Working paper from the Laboratory for Ubiquitous Computing and Interaction at UC Irvine, n.d.
14. EST, Energy Saving Trust's Response to the DTI Energy Review Consultation. http://www.berr.gov.uk/files/file31091.pdf
15. Facebook, Facebook | Statistics http://www.Facebook.com/press/info.php?statistics
16. Fischer, C. Feedback on household electricity consumption: a tool for saving energy? *Energy Efficiency 1,* 1 (2008), 79-104
17. Fogg, B. J. and Nass, C. Silicon sycophants: the effects of computers that flatter. *Int. J. Hum.-Comput. Stud. 46* (1997), 551-561.
18. Fogg, B.J. *Persuasive Technology – Using Computers to Change What We Think and Do*. Morgan Kaufmann, San Francisco, 2003.
19. Fogg, B. Three possible futures for persuasive technology. In *Proc. Persuasive 2009*, ACM Press (2009)
20. Francis, P. *The impact of UK households on the environment through direct and indirect generation of greenhouse gases*. Office for National Statistics, London, UK 2004
21. Gustafsson, A. and Gyllenswärd, M. The power-aware cord: energy awareness through ambient information display. *Ext. Abstracts CHI 2005*. ACM Press (2005), 1423-1426.
22. Ham, J. and Midden, C. A robot that says bad!: using negative and positive social feedback from a robotic agent to save energy. In *Proc.* HRI 2009. ACM Press (2009), 265-266.
23. Ham, J., Midden, C., and Beute, F. Can ambient persuasive technology persuade unconsciously?: using subliminal feedback to influence energy consumption ratings of household appliances. In *Proc. Persuasive 2009*, vol. 350. ACM Press (2009)
24. Huang E., & Truong K. Breaking the Disposable Technology Paradigm: Opportunities for Sustainable Interaction Design for Mobile Phones. In *Proc. CHI 2008*, ACM Press (2008), 323-332
25. IPCC, IPCC Fourth Assessment Report: Working Group I Report "The Physical Science Basis" http://www.ipcc.ch/ipccreports/ar4-syr.htm
26. James, N., & Desai, P. A Study into the Development of Sustainability Rating for Homes. Advisory Committee on Consumer Products and the Environment Bio-Regional Development Group. http://www.defra.gov.uk/environment/consumerprod/accpe/research/pdf/accpe_final030711.pdf
27. Joinson, A. N. Looking at, looking up or keeping up with people?: motives and use of Facebook. In *Proc. CHI 2008*. ACM Press (2008), 1027-1036.
28. Kempton, W. Two Theories of Home Heat Control, *Cognitive Science 10* (1986), 75-90
29. Kinver, M. Saving Energy on the Home Front (BBC News – 23/10/06) http://news.bbc.co.uk/1/hi/sci/tech/6056398.stm
30. Lee M. How Do You Define Unnecessary Travel. *The Ecologist*. June 2009, 71-72
31. Lovelock, J. *The Revenge of Gaia*. Basic Books, 2006
32. Malik O. Facebook's Insatiatible Hunger for Hardware. Gigacom. http://gigaom.com/2008/04/25/Facebooks-insatiable-hunger-for-hardware/
33. Mankoff, J., Blevis, E., Borning, A., Friedman, B., Fussell, S., Hasbrouck, J., Woodruff , A., and Sengers, P. Environmental Sustainability and Interaction. In *Proc. CHI 2007*, ACM Press (2007), 2121-2124.
34. Mankoff, J., Matthews, D., Fussell, S. R., and Johnson, M. Leveraging Social Networks To Motivate Individuals to Reduce their Ecological Footprints. In *Proc. HICSS, 2007,* IEEE, London, 87a
35. National Statistics, National Statistics Online http://www.statistics.gov.uk/cci/nugget.asp?id=1710

36. Odom, W., Pierce, J., and Roedl, D. Social Incentive & Eco-Visualization Displays: Toward Persuading Greater Change in Dormitory Communities. In *Proc. of Public and Situated Displays to Support Communities*. Workshop at *OZCHI 2008*.

37. Philips, *iCat* http://www.hitech-projects.com/icat/

38. Pressman, R.S *Software Engineering: A Practitioner's Approach, 6th edn.* McGraw Hill, New York, 2005.

39. Przybyla, D. and Pegah, M. Dealing with the veiled devil: eco-responsible computing strategy. In *Prco. SIGUCCS,* ACM Press (2007), 296-301.

40. Robson, C. *Real World Research, 2nd edn*. Blackwell Publishing, Malden MA, 1993.

41. Schultz, P.W., Nolan, J.M., Cialdini, R.B., Goldsteing, N.J., and Griskevicius, V. The Constructive, Destructive and Reconstructive Power of Social Norms. *Psychological Science, 18,* 5 (2007), 429-434.

42. Sen A. 10 Billion Facebook Photos – Is That Ecologically Sustainable? *Trendspotting Blog.* http://www.trendsspotting.com/blog/?p=487

43. Slater, M., Pertaub, D-P., and Steed, A. An Experiment on Public Speaking Anxiety in Response to Three Different Types of Virtual Audience. *Presence* 11, 1 (2002), 68-78

44. Strauss A. and Corbin J. *Basics of Qualitative Research: techniques and procedures for developing grounded theory*. Sage Publications, London, 1998.

45. Thompson, R (2009) Facebook App Measures Your Carbon Footprint. *Computer Weekly*, August, 2009.

46. Walker G., and King D. *The Hot Topic: How to Tackle Global Warming and Still Keep the Lights on.* Bloomsbury, London, 2008.

47. Weiksner, M. and Fogg, B.J. Liu: Six Patterns for Persuasion in Online Social Networks. In *Proc. Persuasive 2008,* pp151-163

48. Yun, T. Investigating the impact of a minimalist in-home energy consumption display. In *Ext. Abstracts CHI 2009*. ACM Press (2009), 4417-4422.

49. Zizek S. (2008) *For They Know Not What They Do: Enjoyment as a Political Factor.* Verso, London, 2008