Beyond demand management: The value of sharing electricity information

Stephen Snow
Queensland University of Technology
2 George St, Brisbane 4000, Australia
steve.snow@qut.edu.au

Margot Brereton
Queensland University of Technology
2 George St, Brisbane 4000, Australia
m.brereton@qut.edu.au

Technologies such as smart meters and electricity feedback are becoming an increasingly compelling focus for HCI researchers in light of rising power prices and peak demand. We argue, however, that a pre-occupation with the goal of demand management has limited the scope of design for these technologies. In this paper we present our work-in-progress investigating the potential value of socially sharing electricity information as a means of broadening the scope of design for these devices. This paper outlines some preliminary findings gathered from a design workshop and a series of qualitative interviews with householders in Brisbane, Australia, regarding their attitudes towards electricity feedback and sharing consumption information. Preliminary findings suggest that; (1) the social sharing of electricity feedback information has the potential to be of value in better informing consumption decisions, however; (2) the potential for sharing may be constrained by attitudes towards privacy, trust and the possibility of misinformation being shared. We conclude by outlining ideas for our future research on this topic and invite comments on these ideas.

Keywords: Electricity, smart meter, sharing, interaction, privacy, design thinking

1. INTRODUCTION

Australia uses 22% more electricity per capita than the OECD average and produces 95% of its electricity from non-renewable sources (Garnaut et al. 2008). Attempts by policymakers to address Australia's energy consumption are well justified. Recent years have seen a rapid growth in interest towards technologies aimed at encouraging households to modify or reduce their electricity consumption. These technologies include advanced metering infrastructure such as smart meters as well as various interactive or passive technologies which provide feedback on different aspects of energy consumption (Darby 2010).

We accept that these technologies represent valuable instruments for policymakers wishing to reduce or modify domestic electricity demand (Faruqui et al. 2010). However, whilst attempts to modify domestic demand are justified in order to preserve the efficiency of electricity supply and distribution infrastructure, we consider that a pre-occupation with this single goal may serve to limit the potential for innovation in the design of smart metering and electricity feedback systems. This paper suggests a means of redefining and expanding the role of these instruments beyond

their current function, in particular, outlining the potential value of households sharing their electricity information in a social capacity.

We approach this study from the viewpoint that household electricity consumption occurs in a social frame of reference (Colley et al. 2011, Strengers 2008) and that as such, economic approaches to modifying demand do not always align with everyday practice. Our research draws on the tradition of design thinking. Schön considers that design work should be equally concerned with defining a given problem as about actually solving it (Schön 1990). Here we do not argue that researchers have been addressing the wrong problem, but suggest that designing primarily for demand management may serve to limit the scope for design.

This paper documents our work in progress towards a more holistic problem definition in this design space, providing a basis for further work where we hope to explore alternative roles for feedback and smart metering systems. The paper begins with examples from the literature supporting the argument that rationales for smart metering and electricity feedback tend to focus on demand management more than user empowerment. We

then present suggestions for how and in which direction these rationales could be expanded through inspiration and preliminary findings from our work in progress. Initially we gathered inspiration for our design direction through a short workshop, where discussions produced novel ideas for user empowerment through electricity information sharing. We are now in the process of balancing these ambitious ideas with more grassroots accounts of how households currently represent and share information related to their electricity consumption.

2. EXPANDING THE RATIONALES FOR SMART METERING AND ELECTRICITY FEEDBACK

Smart metering and electricity feedback technology provide designers with many opportunities to invent novel approaches to smarter energy use. Smart meters represent replacements for the conventional household electricity meter, capable of two way communication with the electricity utility and the provision of alternative tariffs (Darby 2010).

HCI literature outlines significant potential for smart meters to empower households in regard to their electricity use, in terms of fostering closer relationships between electricity providers and consumers; businesses model creation, social data sharing and better integration with electricity feedback (Quinn 2009, Darby 2010). Despite these considerable design opportunities, there is little evidence to suggest that current rationales for smart meter deployment extend far beyond their ability to facilitate alternative tariffs and improve demand management (Red Jelly 2008). Previous market research into smart metering in Australia for instance, explained the “overall rationale” behind smart metering to focus-group participants simply as “managing load” (Red Jelly 2008, p.8). There is thus a discrepancy between the potential roles of smart metering programs envisaged by designers and those implemented by policymakers. This discrepancy highlights many opportunities for HCI designers to further explore the benefits offered by smart metering.

Householders (smart metered or not) can now receive near real-time feedback on their electricity consumption through interfaces such as portable energy monitors, in-home displays and PC or web-based applications (Petkov et al. 2011). Consistent throughout the majority of the rich literature on electricity use feedback is the finding that the provision of feedback creates an energy saving effect of between 5% and 15% (Faruqui et al. 2010, Fischer 2008). Equally consistent however, is the prevalence of “energy savings” as the primary measurement of the “success” of these feedback trials. As a result, design implications tend to focus on how feedback can be designed “in order to

achieve optimum results” (Fischer 2008, p.80). Here we are certainly not suggesting that feedback should not aim to modify or reduce electricity demand, but argue instead that this narrow definition of “success” may be limiting the scope and opportunities for electricity feedback design.

Already HCI has made significant progress in broadening the study of electricity feedback beyond merely energy saving potential. This includes exploring tangible and artistic visualisations of electricity consumption (Pierce et al. 2008), work into the effect of placement and aesthetic aspects on the acceptance of feedback into the household (Riche et al. 2010) and an analysis of the desirable attributes of electricity feedback (Karjalainen 2011). Despite this, few contributions explore the potential role of feedback beyond the walls of the individual dwelling (Colley et al. 2011, Petkov et al. 2011).

Investigating the influence of feedback beyond the single dwelling represents an exciting means of extending the rationales of electricity feedback and smart metering technology. Our research intends to build on these existing HCI contributions by investigating the sharing of electricity information in a social capacity. By this we mean exploring the value of the conversations, stories and advice shared between households in regard to their consumption. Accordingly, the main research questions associated with this study are:

- To what extent can feedback and smart meter systems foster the sociable sharing of electricity information?
- What value is this sharing in empowering households towards more informed consumption decisions?

3. GATHERING DESIGN INSPIRATION

The first step in our design process was to seek the help of fellow designers in exploring the limits of how electricity information could be shared and what value this information might be to different stakeholders. As part of the Participatory Innovation Conference (see www.pin-c2012.org), we ran a short workshop titled “Beyond the tariff: exploring the values of smart metered information”. In the workshop, three tables of 5-6 participants were given a number of picture cards, post-it notes, pens and paper on which to arrange the materials on and draw as they wished (refer Figures 1 and 2). The cards represented depictions of generic smart metering stakeholders (households, businesses, utilities etc) with many cards left blank to allow participants to illustrate their own ideas. The intention of the workshop was for each group to collaborate in designing mock-up models for alternative information, cost and value flows between different smart meter stakeholders. Most

participants had experience in design and none considered themselves experts in matters of domestic electricity. As such, the workshop represented an exercise in gathering design inspiration rather than an attempt at engaging smart meter stakeholders.

3.2 Social sharing of electricity consumption: how far can we take it?

While discussion was initially limited to the values of smart metered information to businesses and electricity utilities, in time conversations diverged into more alternative explorations of electricity information, particularly the role of sharing. It was considered that sharing smart metered information socially might stimulate interest in electricity consumption and foster greater levels of energy-literacy. It was thought however, that this sharing would be unpopular unless it took place through existing communication channels.

One group considered many people publish personal information on social media (i.e Twitter, Facebook) which they would be unlikely to share through other mediums and whether social media's ability to transcend barriers to disclosure could be utilised in the context of sharing smart metered information. Another group considered social media to be an ideal platform on which to share electricity information due to the system of "friends" better enabling people to choose who they shared their information with.

Of the two groups who discussed aspects of control over data, both agreed that the control of smart metered data should ultimately be in the hands of the user. It was considered that sharing information of this nature would be unpopular unless it occurred through existing communications channels and people had control over who it was shared with.

Figure 1: One group at work

Ideas generated during the workshop build on the potential benefits of smart meters outlined thus far in the literature (Quinn 2009, Darby 2010) and suggest much potential for an expansion of the role

of smart meters and their interfaces beyond their current roles. The workshop served to both inspire and inform our research direction towards (1) the potential to empower households through the sociable sharing of electricity information and (2) the consideration of factors which might potentially constrain this.

Figure 2: A finished product

On the other hand, the workshop did not bring us any closer to determining whether people are likely to be willing to share their smart metered information in the first place and if so, with whom. Furthermore, many of the ideas generated during the workshop depend on smart metering or at least some means of regular electricity feedback being installed. At present smart metering is implemented in only one state of Australia and real-time electricity feedback remains relatively uncommon.

As such, in further work towards a more comprehensive problem definition, we now aim to balance our research with grassroots accounts from householders about their attitudes towards sharing information of this nature and if, why and when they already share it. We expect these accounts to form a first step into determining the potential value and feasibility of electricity information sharing.

4. BRINGING IT BACK HOME: ATTITUDES TOWARD SHARING ELECTRICITY

We are currently in the process of conducting qualitative interviews with householders in Brisbane, Australia. Our sample group consists of adult household members who identify themselves as playing a meaningful role in the daily operation of the home and in household finances. Of an expected 20 interviews in total, we have conducted 14. The interviews involve a brief energy audit of the dwelling, followed by questions regarding their

current practices and attitudes towards electricity feedback and sharing electricity information. The ideas generated during the workshop regarding control over electricity information served to focus the questions on sharing towards participants' practices and attitudes regarding sharing: Firstly, what aspects of their electricity consumption do they already share- and with whom? Secondly, if they were to have access to more detailed or disaggregated consumption information through improved feedback; would they feel comfortable sharing this? Being a work in progress, the findings we present here are very preliminary in nature and we do not wish to make too many claims regarding the applicability of our findings to a wider sample.

4.1 Representations of electricity in the home: electricity feedback

The quarterly electricity bill has represented the primary source of electricity feedback to all participants, often producing some trepidation around its arrival. Additionally 11 of the 14 participants received a simple wireless energy monitor through a government initiative that displays aggregate kW/h and \$/h on its default screen. For the majority of participants both with and without a monitor, electricity was conceptualised more as an "amount" to pay quarterly, rather than a culmination of individual actions and appliances. Few of those with energy monitors demonstrated a comprehensive understanding of their monitor, with the options for seven-day comparisons of kWh and tonnes of CO₂ being completely unutilised. Additionally three monitors were placed out of sight or obstructed by objects at the time of the interview and a further two had been affected by the installation of solar panels, leading to incorrect readings. Despite this, many of the participants who had received the energy monitors claimed to have drawn benefit from the feedback at some point. This benefit however tended to reduce over time, often as tacit knowledge grew, leading to less interest, while in other cases the monitor malfunctioned.

Almost all participants expressed a desire to receive more feedback on their electricity consumption, though very few participants were able to provide explanations about what form this improved feedback should take without being prompted. When prompted, static feedback mediums such as LCD screens located in a public space in the house (often the kitchen) were outlined as the most desirable. In terms of the type of feedback these displays should provide, appliance specificity, monthly usage comparisons and comparison to a suburb-average were the most popular. Interestingly, very few participants expressed a desire to receive comparisons to their neighbours or their street, instead desiring a comparison to a wider suburb or city average.

4.2 Electricity consumption: social or private?

In seeking personal accounts of sharing electricity information, we are interested in why, how, when and with whom people discuss a range of topics directly and indirectly related to electricity consumption, including appliance purchase, usage, tips on energy efficiency, as well as aspects of the electricity bill itself.

One of the key findings in this respect so far, has been the tendency for information related to appliances and tips on energy efficiency to be shared and discussed socially with friends; whereas aggregate measurements of consumption such as bills are more private, commonly discussed only amongst close family.

Appliance purchase emerged as a social practice with many participants seeking information from friends or family regarding the purchases. Many of the interviewees also admitted to conversing about matters of energy efficiency with friends or neighbours, including the installation of their energy monitor. Conversations related to appliance usage and energy efficiency however tended to be in the context of everyday life rather than electricity consumption or operating cost.

"My toaster blew up the other week....so there were three of us lady's in the shop....stood there for about half an hour saying "ooh that'd be nice!" and it was mainly about colour and design and that" – (Interview 14).

However, aggregate measurements of electricity consumption such as electricity bills were much more private. Only two participants admitted to discussing the amounts of their electricity bills with friends or neighbours. In one instance, the bills were discussed in relation to generation from solar panels, while in the other, the participant openly discussed bills and other money matters socially with her group of friends. Aside from these two exceptions, electricity bills seem far more likely to be discussed within the immediate family or between family members in different dwellings.

Interestingly, suggestions of sharing electricity feedback information, both conversationally and online were also unpopular. Participants did not see value in comparing their own consumption to their friends' or immediate neighbours', nor were they willing to grant friends or neighbours access to their own consumption:

"...it's my business. I'll tell you if I want you to know but I won't put it out there for the whole world to see" – (Interview 6).

"I think that's a bit invasive, I mean I think I'm pretty good with my usage, but I don't want the lady across the road saying 'Hey turn off your air con!'" – (Interview 12).

Another tentative finding we make is the ability for sharing information to create frustration or foster misinformation. Four of our initial 14 interviews alluded to the fact that comparing bills with close friends or family had led them to become frustrated with their own bills, for instance:

"We've got a sister who's at home with two kids and they've got a pool, but their bill is less than ours and we're thinking 'Well how can that be?!'" - (Interview 14).

"They've got a similar bill to us, but she runs the air conditioning all the time... Something is very wrong with our power bill!" - (Interview 2).

The frustration in these cases manifested itself as a distrust of their electricity utility, with some participants expressing concern over being ripped off or being "at their mercy". In the absence of comprehensive electricity feedback or an energy audit of each dwelling in question, it is very difficult to prove or disprove these concerns. This highlights the potential for sharing information to in fact be counterproductive, potentially fostering unnecessary distrust or resentment.

5. CONCLUSIONS AND IMPLICATIONS FOR RESEARCH

This paper presents evidence suggesting that smart meters and interfaces for electricity feedback fall short of their potential to empower consumers due to a pre-occupation with demand management limiting the scope of design. We have approached this issue from a design thinking perspective (Schön 1990); where we first attempt to better define aspects of the problem, rather than create solutions to an assumed problem. We highlight the social sharing of electricity information as a potential means of expanding the scope for feedback and smart metering.

Preliminary findings from our qualitative interviews suggest much scope for technology better connecting households with their electricity consumption and better informing consumption decisions. Many interviewees so far have had trouble reconciling their electricity consumption with their household appliances or everyday practice, which is consistent with Strengers (2008). Similarly, participants with the digital energy monitors installed appear to draw relatively limited benefit from them. The wish of many participants to receive feedback better relating their electricity consumption to specific appliances and everyday practice is consistent with research into desirable attributes of feedback (Karjalainen 2011).

Sharing electricity information emerges as a compelling possibility for expanding the scope of design for electricity feedback and smart metering

systems. Many participants in our research gained enjoyment and benefit from sharing various information with friends and neighbours in relation to appliance purchase, use and energy efficiency. On the other hand, our interview responses suggest that sharing electricity information could potentially be counter-productive if households are not well informed about their consumption, or if erroneous information is shared, for instance suspicions of overcharging by utilities.

Recent literature accepts electricity consumption to be a social process within a home (Strengers 2008, Colley et al. 2010), but to what extent is it a private process outside the home? Our interview results suggest that aspects of electricity use are very private; that people may not feel comfortable sharing certain elements of their usage information such as instantaneous consumption data or dollar values. Current discussions of privacy in smart metering tend to focus on aspects of data access and security (Quinn 2009), whereas HCI argues for a more holistic understanding of privacy as embedded in social and cultural contexts (Dourish and Anderson 2006).

We consider a key contribution of design in this field will be to ensure that providing adequate privacy is not conceptualised as a "barrier" to sharing electricity information. Effort should instead be spent determining the types of information people are willing to share, benefit from sharing and thence designing feedback and smart metering systems that best facilitate these forms of sharing. Similarly pertinent here is the issue of trust: we consider the potential value of information sharing of this nature may be defined to some extent by perceptions of trust. Already during the interviews we have seen the emergence of a distrust (whether justified or not) of electricity utilities; an integral recipient of smart metered information. Further investigation is warranted into these social aspects of privacy and trust concerning electricity information and should form a focus for further HCI research on this subject.

5.1 What comes next? An outline of our future research "in the wild"

The aim of the next stage of our research is to further test the feasibility of socially sharing electricity information as a means of householder empowerment. This would precede an investigation of how feedback and smart metering systems can best be designed to facilitate this sharing. Our intervention is expected to take the form of an interactive sharing exercise between households; aiming to explore in practice what information people are willing to share and the contexts in which this sharing can occur. This next stage is envisaged to employ learnings from our workshop, interviews and from recent HCI work into

technology deployment in the home (Tolmie and Crabtree 2008, Petkov et al. 2011).

One idea is to measure the relative consumption of different appliances in participating households, with feedback being made available to all participants through an online web-interface, accessed through a laptop or tablet provided specifically for the study. This allows comparison with existing HCI literature on household experiences of electricity feedback (Riche et al. 2010, Strengers 2008) as well as contributing to work exploring how new technology is integrated into the home (Tolmie and Crabtree 2008). We would encourage households to share and discuss their appliance-usage information online with fellow participants and friends. Everyday practice emerges as a common link for this intervention: Participants thus far have desired feedback that relates their consumption to their everyday practices and appliances; they feel comfortable discussing appliance purchase in the context of everyday practice and most already communicate every day via social media.

Such an intervention would allow for observations into how people relate to different representations of their electricity consumption, the types of information they share, when they share it, and with whom. We consider this sharing of appliance-based data might provide a useful comparison to Colley et al (2011), where participants upload their aggregate daily consumption figures to a neighbourhood-accessible website. Following conversation threads allows us important insight into how social aspects of privacy and trust play out amongst participants in the intervention.

We hope that this small intervention may give us some understanding of the value of sharing electricity information and serve to inform subsequent work into how feedback and smart metering systems may be designed to better facilitate this sharing. However, being very much in the early stages of planning for this intervention at present, we warmly welcome all comments, suggestions and inspiration from the broader HCI community into our future research.

Acknowledgements

This research is supported by the Australian Research Council. We thank the organisers of the PINC 2012 conference and all workshop and interview participants. Special thanks also to Fiona Redhead for her comments and suggestions.

7. REFERENCES

Colley, J., Bedwell, B., Egglestone, S.R., Fischer, J., Pantidi, N. 2011. Exploring energy monitoring in the wild. In *Proc: Digital Engagement 2011*. Newcastle, UK.

Darby, S. 2010. Smart metering: what potential for householder engagement? *Building Research & Information* 38 (5):442-457.

Dourish, P., and K. Anderson. 2006. Collective information practice: Exploring privacy and security as social and cultural phenomena. *Human-Computer Interaction* 21 (3):319-342.

Faruqui, A., S. Sergici, and A. Sharif. 2010. The impact of informational feedback on energy consumption:-A survey of the experimental evidence. *Energy* 35 (4):1598-1608.

Fischer, C. 2008. Feedback on household electricity consumption: a tool for saving energy? *Energy Efficiency* 1 (1):79-104.

Garnaut, R. 2008. The Garnaut climate change review: Interim report to the Commonwealth, State and Territory governments of Australia. Vol. 1. Cambridge University Press.

Karjalainen, S. 2011. Consumer preferences for feedback on household electricity consumption. *Energy and Buildings* 43 (2-3):458-467.

Petkov, P, Köbler, F, Foth, M and Krcmar, H. 2011. Motivating domestic energy conservation through comparative, community based feedback in mobile and social media. In: *Proc: Communities & Technologies 2011*, Brisbane.

Pierce, J., Odom, W., and Blevis, E. 2008. Energy aware dwelling: A critical survey of interaction design for eco-visualizations. In *OzCHI 2008*. Cairns, Australia.

Quinn, E.L. 2009. Smart metering and privacy: Existing law and competing policies. A report for the Colorado Public Utilities Commission. Boulder, Colorado.

Riche, Y, Dodge, J., Metoyer, R, 2010. Studying always-on electricity feedback in the home. In *CHI 2010*, Atlanta, Georgia.

Red Jelly Consulting, 2008. Phase 2: Qualitative assessment of consumer responses to the National Electricity Smart Meter Rollout Program, Red Jelly, prepared for NERA Economic Consulting, Sydney, NSW.

Schön, D. 1990. The design process. In *Varieties of thinking: Essays from Harvard's Philosophy of Education Research Centre*, edited by V. A. Howard. New York: Routledge.

Strengers, Y. 2008. Smart metering demand management programs: Challenging the comfort and cleanliness habitus of households. In *OzCHI 2008*. Cairns, Australia.

Tolmie, P. and Crabtree, A. 2008. Deploying research technology in the home. In *Proc: 2008 CSCW*: ACM.