Understanding and Supporting Emerging Domestic Energy Practices

Conference or Workshop Item

Understanding and Supporting Emerging Domestic Energy Practices

Jacky Bourgeois
The Open University
Walton Hall
Milton Keynes, MK67AA UK
jacky.bourgeois@open.ac.uk

Janet van der Linden
The Open University
Walton Hall
Milton Keynes, MK67AA UK
Janet.vanderlinden@open.ac.uk

Gerd Kortuem
The Open University
Walton Hall
Milton Keynes, MK67AA UK
g.kortuem@open.ac.uk

Johann Bourcier
INRIA
Campus de Beaulieu
35700 Rennes FRANCE
johann.bourcier@inria.fr

Benoit Baudry
INRIA
Campus de Beaulieu
35700 Rennes FRANCE
benoit.baudry@inria.fr

Blaine A. Price
The Open University
Walton Hall
Milton Keynes, MK67AA UK
b.a.price@open.ac.uk

Abstract
The current transformation of the domestic energy landscape, including local generation, new consumption and storage, requires rethinking our research approach. This paper reports experiences from two case studies with their implications for future HCI research in the home.

Introduction
The home energy environment, as part of the smart grid implementation, is starting a deep mutation: (i) householders have started generating their own electricity, (ii) new high electrical demand appliances have appeared such as heat pumps and electric vehicles, significantly increasing consumption, and (iii) domestic electricity storage is now commercially available. These transformations will result in both the challenge of increasing the complexity and the opportunity of closing the gap between producer and consumer – thus making energy more tangible for householders.

The increasing evidence of emerging energy behaviors in a domestic context requires us to rethink both how we investigate energy in the home and our approach to contributions to address climate change.

In this paper we report on our experience in studying emerging domestic energy practices. We briefly review existing HCI research in home relating to energy. Then, we present two case studies – that of doing laundry and driving an electric vehicle – in the context of domestic solar electricity generation. Finally, we discuss the implications for the domestic energy and HCI research.

Background

Eco-feedback

Computer displays are widespread in everyday life and the home is no exception, with In-Home Displays (IHD) showing graphs and diverse values of energy use among other things. Despite these devices being designed for domestic use, Strengers mentions that householders express difficulty understanding data provided through their IHD [1], and sometime they misunderstand these data resulting in behavior that adversely impacts energy consumption. In spite of these negative points, studies have shown that energy feedback savings range from 5% to 15% of energy [2]. However, it is not clear whether these savings are sustainable or not. To find out what energy feedback is effective, Fischer conducted a review [3] to determine which type of feedback is the most successful. She extracted key points including appliance-specific breakdown, computed and *customized*, *interactive* and *engaging*, often, and over a long period.

Emerging Energy Practices

Until now, electricity feedback focused mainly on electricity consumption rather than the electricity generation. A review of 50 recent HCI publications details opportunities in domestic energy design based on emerging energy systems such as smart grid, smart meters, Demand Response and Distributed Generation [4]. The authors highlight opportunities to support behavior change by increasing awareness of these emerging energy technologies. They suggest (i) to promote visualization of energy sources, (ii) to privilege the use of energy differently rather than promoting conservation behavior through energy shifting and sharing, and (iii) to redesign appliances, making them generator of awareness. For example, washing machines could be designed in order to promote sustainable behavior by selecting low energy program by default.

Evidence is beginning to emerge that households with solar photovoltaic (PV) generation exhibit saving behaviors intended to maximize the use of local energy and to minimize the use of imported grid energy [5, 6]. Keirstead [6] describes microgeneration as delivering a 'double dividend' – that is, not only does microgeneration produce renewable energy but also changes resident's behavior, giving rise to reduced electricity consumption. It encourages households to reduce their overall electricity consumption by approximately 6% beyond the solar savings and shift demand to times of peak generation.

Studying Technologies in the Home

Over the few last years, methodologies to study technologies in the home have evolved. Most of them make use of a mixed methods approach and in-the-wild studies. Those focusing on energy aim to explore and validate new designs to raise awareness, aiming for energy consumption reduction. Emerging energy technologies require a deeper understanding of new practices, thus highly contextual information. This implies an adaptation in the way we investigate this environment.

Energy Demand-Shifting

In the UK, each kilowatt-hour of electricity produced by domestic solar PV provide subsidies, whether it is consumed locally or exported to the grid. Although there is payment for exporting to the grid, this benefit is smaller than buying electricity from the grid. It is financially more interesting for householders to

maximize *self-consumption* – the use of their own electricity. From an environmental point of view, self-consumption reduces energy losses and improves grid stability.

We used a mixed method approach to explore and understand emerging energy practices in households with solar photovoltaic (PV) generation on the roof. We combined exploratory interviews, participatory data analysis [7] and in-home interventions to get a deep understanding of this context. We investigated two case studies focusing on Energy Demand-Shifting in the context of domestic solar electricity generation. Energy Demand-Shifting is a particular form of behavior change where energy consumption is shifted towards times of the day when local production is at its highest, thus using 'green energy'. Our objective was to understand the connection between consumption and local generation and design support for emerging energy practices.

Washing machine and Laundry Routines

Laundry routines have a central place in most households. We conducted our study across 19 participants [7]. First, we used Technology Probes and thematic analysis [5]. In parallel, we collected and analyzed energy data such as overall consumption, solar generation and export, and individual appliance consumption. We observed contrasting results: while most householders tended to shift their consumption, the collected data did not reflect such a behavior. Second, we designed per-household visualizations of actual running time, ideal shift and potential savings over a month. We highlighted that most participants were naturally engaged in demand-shifting however, it was a time consuming task. Finally, we sent reactive and proactive information via text messages and we controlled the washing machine based on local maximum generation predictions. In contrast to reactive feedback, we found that proactive suggestions and contextual control were more engaging and supported by participants.

Through this study we highlighted that technology support for demand-shifting is viable and effective, taking a supportive approach of emerging practices instead of behavior change. Engagement and utility increased from decontextualized information to embedded contextual control. The demand-shifting 'negotiation' increased interactions with the user and widened the energy audience. This contrasted with eco-feedback which was more passive and mostly designed for the householder who already '*managed*' energy in the house.

Electric Vehicle and Mobility

The Electric Vehicle (EV) appears much less flexible in time than the washing machine, though, its consumption is much higher. We conducted 16 interviews with EV drivers across England to get a sense of this complex environment at the intersection of home, mobility and energy. Then we focused on 7 households with EV, with and without PV. We collected energy data and ran a diary study to capture mobility activities. Combining this information into a visualization, we were able to analyze this data with the householders. We are now in the process of designing and conducting an intervention in the home.

In contrast with laundry routines, the connection between EV and local generation is less obvious. However, we observed a desire for self-sufficiency for

householders with solar PV and found it to be the motivation to invest in solar PV for others. We identified another need for proactive information and suggestion, connected to the planning of mobility (EV driving).

Implication for domestic and HCI research

The previous sections presented the methodology we implemented to investigate the emerging home energy context. Beyond this user-centric procedure, it is important to highlight the radical change of approach. In contrast with previous research targeting energy consumption reduction, we aim to support new practices that naturally emerge with new energy technology including generation, local storage and high demand appliances.

First, consumption reduction is no longer always the best behavior. We may want to increase the consumption when green energy is being wasted or cheap. Second, we tend to promote engagement and interaction, highlighted by Fischer as requirements [3], by enhancing what householders are already trying to implement. In this context, customized experience are needed as each setting (generation, tariffs, etc…) and householder's objectives (financial cost, environmental impact, disruption, etc…) are different and may change over time. Finally, energy consumption feedback is not enough to make decisions on what to do. More investigations are required on how to proactively inform and suggest options for the householder.

Conclusion

This paper highlighted the radical transformation taking place in domestic energy through emerging energy technologies from local generation to electric vehicles. Two case studies on laundry and mobility routines are presented helping to understand this new context and its implications.

References

[1] Y. A. Strengers, "Designing eco-feedback systems for everyday life," 2011.

[2] S. Darby, "The Effectiveness of Feedback on Energy Consumption," 2006.

[3] C. Fischer, "Feedback on household electricity consumption: a tool for saving energy?," *Energy Efficiency,* vol. 1, pp. 79--104, may 2008.

[4] J. Pierce and E. Paulos, "The local energy indicator: designing for wind and solar energy systems in the home," 2012.

[5] B. A. Price, J. v. d. Linden, J. Bourgeois and G. Kortuem, "When Looking out of the Window is not Enough: Informing The Design of In-Home Technologies for Domestic Energy Microgeneration," in *ICT4S*, 2013.

[6] J. Keirstead, "Behavioural responses to photovoltaic systems in the UK domestic sector," *Energy Policy,* vol. 35, pp. 4128--4141, aug 2007.

[7] J. Bourgeois, J. van der Linden, G. Kortuem, B. A. Price and C. Rimmer, "Using Participatory Data Analysis to Understand Social Constraints and Opportunities of Electricity Demand-Shifting," in *ICT4S*, Stockholm, 2014.

[8] J. Bourgeois, J. van der Linden, G. Kortuem, B. A. Price and C. Rimmer, "Conversations with my Washing Machine: An in-the-wild Study of Demand Shifting with Self-generated Energy," in *UbiComp*, Seattle, 2014.