Design and diffusion of smart energy monitors for sustainable household consumption

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The synthesis report of the Secretary-General on the post-2015 sustainable development agenda acknowledges that "new technologies can open up more sustainable approaches and more efficient practices" (§ 31). Contemporary research and development efforts have led to the emergence of energy measurement technologies for residential use. However, the deployment of smart energy feedback systems has been limited thus far to just a handful of countries. The following summary of "lessons learned" from energy monitoring studies provides a basis for global expansion of smart energy feedback systems.

Introduction

The supply consequences of unbridled energy use on the environment[1] have long attracted the attention of planners and policymakers whose decisions ultimately thrust consumers into a central role through household-based sustainable energy consumption policies (OECD, 2008). These policy strategies may be said to have three parts: the design of user-centered energy monitoring tools to inform household decisions; attention to social and cultural factors that influence household energy practices even with the availability of smart energy monitors; and the expansion of household-level collection of energy use patterns within the system of national accounts to permit within-country and international comparisons for sustainable consumption.

Design elements

"Nobody wakes up in the morning and thinks, 'I want to use more energy than my neighbor today.' But inducing people to actually reduce their energy consumption still seems difficult" (Straub, 2011).

Research suggests that there are at least three elements in the successful design of smart energy monitoring systems: (1) making energy "visible" to consumers; (2) utilizing the full range of information delivery services available to consumers, such as point-of-consumption and mobile devices to monitor energy consumption; and (3) pushing the boundaries of technology design through participatory studies.

Energy demand is, of course, a derived demand embedded in the capital goods and services sought by consumers (Kristrom, 2008). As a result, designers work in close cooperation with human factors psychologists, software engineers and information managers to make energy use "visible" to consumers and to influence consumption decisions (idX, 2007; Hargreaves et al., 2010 and 2013).[2] Energy suppliers also see the availability of novel displays and design metaphors at the household level as an important way to prove energy savings to planners and policy makers (Goodwin et al., 2013).

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[1] "Some scientists estimate it would take five Earths to provide sufficient resources for everyone on the planet to indulge in our current rate of consumption." (Flattau, 2011, p. 63).

[2] Using theories and methods that govern the design and interpretation of information, the Information Design Exchange is just one example of a curriculum that combines practical, methodological and social competence for information designers (See: idX, 2007).

SOURCE: Power-Aware Cord, Interactive Institute, Sweden[3]

Advances in computational methods and commercial point-of-consumption devices (Rogers & Bartram, 2011) have made smart meter deployment possible in the United States, Europe, and parts of Asia (Armel, 2009).[4] Feedback systems are also available that integrate wireless hubs for use in mobile device applications (Petersen et al., 2009), wireless home area networks (HANs), and other micro-electromechanical systems (MEMS) for more energy efficient building systems (CBE, 2015).

Designers today are pushing the limits of information delivery for energy decisions. Introduction of even the most cutting-edge tools often begins with the measurement of the baseline understanding of energy by participants, followed by the presentation of innovative displays, and concluding with a carefully constructed analysis of users' likes and dislikes of the new technology (Rogers & Bartram, 2011).

It should be noted that few studies may be found in the literature specifically addressing the smart energy monitoring preferences of individuals with disabilities or the elderly (Massoud et al, 2014).

Qualitative research approaches

Since human behavior matters decisively for energy consumption (Kristrom, 2008), the literature on energy consumption includes a range of user-centered field studies (Hargreaves et al, 2010 and 2013), focus groups (Paetz et al., 2012), and panel data often combined with telephone interviews (Lutzenheiser et al., 2008).

These and other qualitative research studies point to a complex relationship between smart energy monitoring systems and household decisions regarding energy use. Some consumers were found to be willing to pay a premium for "greener products" or "greener energy sources" (Kristrom, 2008). Beyond economic decisions, however, households have been found to vary in their use of energy by ethnicity, age, household composition (including number of children), dwelling type, and square footage (Lutzenhiser et al., 2008).

Scientists are also paying attention to the role of social and cultural practices that confer different meanings to household energy decisions. Findings include such attitudes as the desire to create a "cozy home," as well as gendered differences in the way that men and women use in-home appliances.[5] Global expansion of smart energy monitors will underscore the need for continued attention to this aspect of household decision making.

The system of national accounts

As energy suppliers have worked with stakeholders at all levels to deploy smart energy technology, governments have begun to collect some information about patterns of energy consumption at the level of the household.[6] Statistical analyses emanating from these data have been used variously to understand discrepancies between modeled and actual energy use (Armel, 2009).

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[3] Time Magazine identified the Power-Aware Cord as one of the top 50 inventions in 2010. Deirdre Van Dyk Thursday, Nov. 11, 2010. http://content.time.com/time/specials/packages/article/0,28804,2029497_2030623_2029820,00.html

[4] Funded by the Advanced Research and Project Agency-Energy (ARPA-E), the Stanford University Sensors & Energy Behavior Initiative is building an application that integrates many of the effective projects to develop a program that will disseminate broadly and achieve significant energy savings.

[5] Hargreaves et al., 2010, summarize key studies in this area.

[6] It should be noted, however, that the US Department of Energy is collecting both quantitative and qualitative information as part of its smart.grid program to share "lessons learned" in areas of customer engagement, for example. https://www.smartgrid.gov/recovery_act/consumer_behavior_studiess/lessons_learned

It is important to note, however, that consumer concerns about data privacy often play a role in giving up flexibility and everyday routines to fit in with electricity tariffs (Paetz et al., 2012)

Policy considerations

- Given the state of the art, a global strategy is needed to bring smart energy monitoring systems to households throughout the world.
- Research into the social and cultural practices influencing household energy decisions must be a central component in the global deployment of smart energy monitors.
- A high-level political forum is needed to examine the benefits of introducing smart energy technologies globally, as well as privacy concerns associated with the anticipated data revolution.

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