C3 - Energy. Ideas. Change.

2.2.8 Visible Metering – A Literature Review

January 2014

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INTRODUCTION

When it comes to paying for the energy we use to operate our homes, we never know how much we've spent until a bill arrives in our mail or inbox. When forms of energy evolved from wood, kerosene and oil to electricity and natural gas, energy quickly became invisible. It's available at the flick of a switch and the amount that gets used is only revealed to us one month later.

Some authors liken this model to grocery stores not indicating prices for items on the shelves or a family filling up individual cars at a gas station and getting one combined bill a month later (Ehrhardt-Martinez 2011, Faruqui et al. 2009). Consumers would have no way of ensuring that they are spending their money wisely at the grocery store as well as no way of tracking mileage for individual cars.

When energy is invisible, it's out of our minds and so too is its efficient use. Currently the most common form of feedback in Canada is the monthly bill. On it, we are typically provided two pieces of information: how many kilowatt hours (kWh) were used in the home the previous month and how much it costs. It's not uncommon for homeowners to simply pay the bill and have no connection to the data presented. Froehlich et al (2011) cite multiple studies, spanning a total of 700 participants, which determined only one to two per cent knew how many kWh they used in a month. Most of the participants couldn't state where their electricity meter was located.

Households in Canada account for 45 per cent of national greenhouse gas emissions (Statistics Canada, 2013). Some authors suggest that more than half of carbon dioxide emissions of households are due to "background" appliances that consistently run a phantom load (van Dam et al. 2010). This data suggests that the convenience of invisible energy has become an incredible detriment to society and its sustainability.

Since the 1970s, research has been evolving into the efficacy of providing feedback to energy end users (Alahmad et al. 2012, Ehrhardt-Martinez 2011, Darby 2006). Initial studies indicated that feedback had merit and was worth pursuing. It was seen as a learning tool allowing users to teach themselves about their habits through experimentation. Research is rapidly concluding that the traditional bill is a "rudimentary form of feedback" (Ehrhardt-Martinez 2011). It doesn't tell us which end uses are using the most energy, how efficient our appliances are nor does it give any information about the changes in our choices and behaviour (Ehrhardt-Martinez 2011).

Typically most governments and utilities (mandated with conservation targets) attempt to encourage energy conservation in the home by providing generic information regarding energy-cutting measures. Information on its own typically does very little to motivate action (McKenzie-Mohr 2008, Darby 2006). One of the big challenges with information campaigns is that they are too generic and not relevant to people's individual circumstances. No one think the information applies to them and their particular situation (BEAMA 2012, Darby 2006).

To properly learn how to control energy use in the home, one alternative consistently proving itself in the literature is the demonstration of clear feedback over a long period of time. Specifically, instantaneous direct feedback in combination with accurate billing (indirect feedback) forms the basis of sustained demand reduction (Darby 2006).

This paper looks at visible metering literature specifically addressing a variety of topics: types of feedback, energy savings potential, persistence, monitor design considerations, monitors in combination with other tools, and smart meters. The literature reviewed in this paper was entirely focused on the residential application of energy monitors. Commercial applications do not appear to have made it into the research as of yet.

TYPES OF FEEDBACK

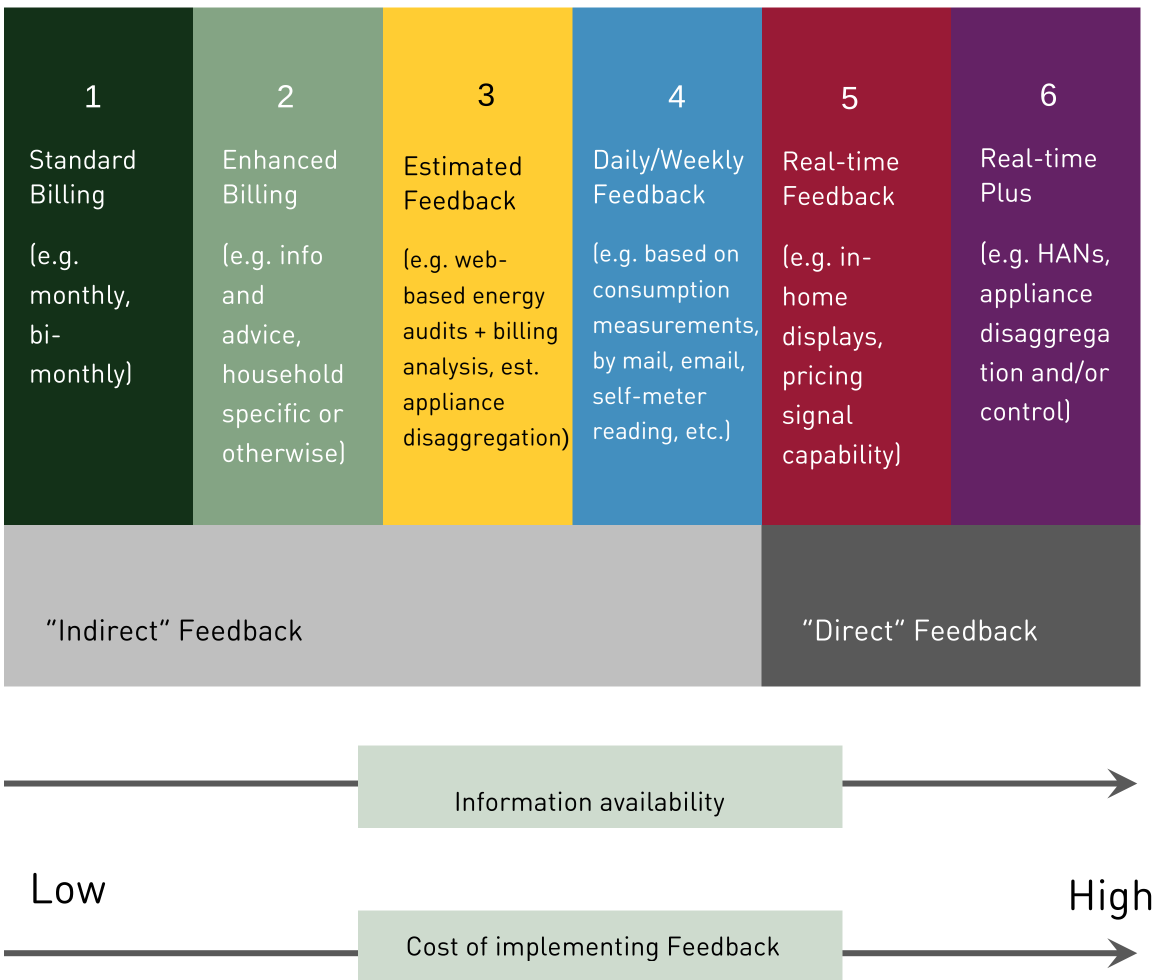
The literature on energy-related feedback typically distinguishes between two types of feedback: direct and indirect. Direct feedback is when energy consumption information is provided immediately to the consumer (in real time or near real time) while indirect feedback has been processed in some way before it gets to the energy user, normally in the form of a bill (Ehrhardt-Martinez 2011, Darby 2006).

Darby (2006) suggests that indirect feedback can be more effective than direct when it comes to indicating consumption changes in space heating, household composition and the impact of investments in efficiency measures or high-consuming appliances. Ehrhardt-Martinez (2011) indicates that programs aimed at energy conservation through indirect feedback have ranged from four to 8.5 per cent but this typically varies in association with the quality of information and the use of contextual measures. Bills that provide more information than basic kWh and costs are often referred to as "enhanced billing."

While indirect billing may be more suitable to large-scale, long-term changes in a household's operation, instantaneous feedback is more suitable to examining the impact of smaller end uses. "An instantaneous, easily accessible display may give the consumer adequate information on different end-uses, by showing the surge in consumption when the kettle is switched on, or the relative significance of a radio, vacuum-cleaner or toaster" (Darby 2006).

Ehrhardt-Martinez (2011) discusses a meta-analysis of 57 different feedback initiatives that her research team published in 2010. The research adopted a classification scheme developed by the Electric Power Research Institute in which indirect feedback is broken down into four distinct types and direct feedback into two (see Figure 1). The categories correspond with the amount of information provided to the end user and the costs associated with providing that information.

Figure 1: Types of Energy Use Feedback



Source: Ehrhardt-Martinez 2011.

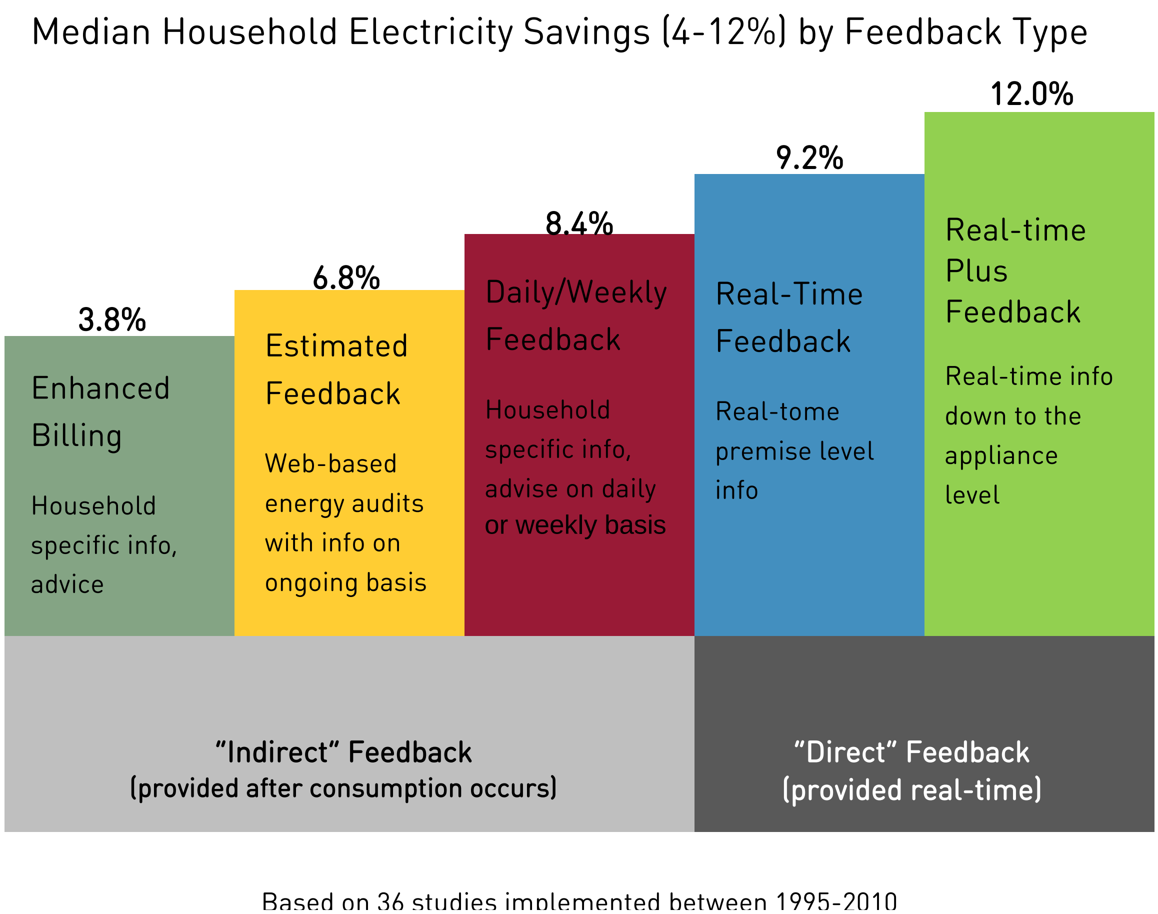
This literature review is primarily focused on direct feedback at the level of an in-home energy monitor. Energy monitors are distinguished from energy meters in that a meter measures the energy use of one appliance at a time. Energy monitors provide information about the home as a unit.

The energy monitors reviewed in the literature are typically only intended for read outs of electricity consumption. While monitors that measure both electricity and gas do exist, the focus here is on the more common variety that only measure electricity. Next, the majority of monitors discussed provide consumption data for the entire electrical load in the home. Some monitors are able to provide consumption data at the level of specific appliances (disaggregated) but they are infrequently mentioned in the literature. One possible reason is that this type of monitor might still be in the early stages of the innovation curve where cost is high.

ENERGY SAVINGS POTENTIAL

The meta-analysis of 57 feedback studies conducted by Ehrhardt-Martinez et al. (2010) supported work by Darby (2006) that suggests direct forms of feedback result in higher levels of energy savings (5-15%) as compared to indirect forms of feedback (0-10%). All studies took place between 1995 and 2010. Studies that only assessed enhanced billing were on the order of 3.8 per cent savings, estimated feedback and daily/weekly feedback were on the order of 6.8 and 8.4 per cent respectively. Within the direct feedback studies, savings from real-time feedback were 9.2 per cent and "real-time plus" feedback (disaggregated to the appliance level) was 12 per cent (see Figure 2) (Ehrhardt-Martinez 2011). Given this was a meta-review, it's difficult to compare the individual studies as they were each unique in sample size and duration.

Figure 2: Energy Savings by Type of Feedback



Source: Ehrhardt-Martinez 2011.

Froelich et al. (2010) cite similar results from an analysis of 20 studies. Only three of the studies involved computerized feedback (as compared to redesigned bills). Those three studies resulted in the greatest energy savings. Many authors (Allen & Janda, 2006, Abrahamse et al. 2005) also cite a study conducted in 1989 by Van Raaij & Van Houwelingen in which the average reduction in energy use for households with a monitor was twice as much as those houses given other types of feedback.

Foster and Mazur-Stommen (2012) attempted to verify the findings from the Ehrhardt-Martinez et al. (2010) analysis using recent, large-scale feedback pilots conducted in the U.S., U.K. and Ireland. Average savings across the pilots was 3.8 per cent. Two of the pilots had a design feature allowing participants to opt-out thus potentially resulting in the diluting of savings from true participants. The researchers did note that a small percentage of households in several of the pilots had exceptional savings of 25 per cent. These participants were referred to as “cybernetically sensitive” because they responded well to the new feedback.

One study often cited is a pilot that was conducted by Hydro One in Ontario (Faruqui et al. 2009, Alahmad et al. 2005). The study involved 400 participants over 2.5 years. In order to establish a baseline, participants’ energy use was monitored for 18 months prior to a real-time energy monitor being provided. In the summer of 2004, pilot participants began using a commercially-available monitor called the PowerCost Monitor (PCM) manufactured by Blue Line Innovations. The study area included homes that had both electric and non-electric space heating. For the households with non-electric space heating, the aggregate reduction in energy use was 8.2 per cent. For homes with electric space heating, the reduction was low, about 1.2 per cent. When the two sub-groups are combined, the aggregate savings for the entire pilot was 6.5 per cent. The researchers concluded that separating out the feedback from the electric heating load with the remainder of the electricity uses would be needed for homes in that situation. The authors point out that the behavioural response was sustained and did not decrease over the treatment period (approximately 12 months) (Mountain 2006).

In 2005, 200 customers of Newfoundland Power and BC Hydro were equipped with a PCM as part of an 18-month pilot study to determine the efficacy of real-time feedback in terms of reducing electricity consumption. Households in Newfoundland and Labrador were able to reduce their electricity consumption by 18 per cent on average. Participants in B.C. were able to reduce their consumption by 2.7 per cent rising to 9.3 per cent during the winter peak (Blue Line 2008).

Not all studies reveal such positive results however. One study out of Oberlin College investigated a potential relationship between home income levels and energy savings as a result of an energy monitor installation (Allen & Janda 2006). Ten households were randomly invited to receive a digital electricity monitor called The Energy Detective (TED). This study revealed no noticeable energy reduction between the participants and a control group, regardless of income level. It’s important to remark that this study was only three months in duration and involved a very small sample size (n=10). The authors also comment that participants reported usability programs with TED and that a more easily navigable device might have helped them better understand the information being displayed.

Many of the pilot studies include qualitative surveys of participants. Assessing quantitative results empirically reveals changes in behaviour; however, understanding human perceptions of their experiences can reveal additional information valuable to future research nuances. For example, in the Hydro One pilot, the majority of participants (60.5%) felt that having the monitor in their home made a difference to their electricity use. Most participants (65.1%) indicated they would go on using the meter after the pilot was over. In terms of their affinity for the PCM, the majority of respondents (63%) ranked it a three out of five.

With the Oberlin income study, although no significant change in energy use was observed, half of the participants asked to keep the monitor as they "did not want to lose the increased energy use awareness they gained from keeping the monitor in their homes" (Allen & Janda 2006). Other studies found that participants believed that the devices made them more conscious of their own energy use and hence modified their consumption patterns. This was despite no observed difference in power consumption (Alahmad et al. 2012). Perceived control is often believed to have a positive influence on users (van Dam et al. 2010, Abrahamse et al. 2005).

Some jurisdictions offer pre-payment options for electricity use. These programs typically began as a way to assist customers who had difficulties paying their bills. Faruqui et al. (2009) examined a variety of case studies in which only in-home displays were used as compared to case studies involving in-home displays in conjunction with a pre-pay energy program. The latter typically resulted in twice the energy savings.

The Salt River Project in Arizona began offering M-Power to 100 customers in 1993 and that number has grown to 50,000 today. This type of program requires that an in-home display be installed so that customers have feedback about consumption and to operationalize the prepayment system. Customers load a smart card at kiosks located around the city and then plug the card into an in-home display (custom designed for the utility). Compared to a control group, M-Power customers save on average 12.8 per cent annually. The same type of program exists in Woodstock, Ontario. Pay-As-You-Go customers there save on average about 15 per cent (Faruqui 2009).

In all, the vast majority of research indicates a correlation between energy savings and the presence of direct feedback. Darby (2006) concludes her review of various feedback studies by stating that they consistently show "the usefulness to households of having feedback information that is specific to them and allows them to control their energy use more effectively."

The next question to be asked is "for how long do the energy savings persist?"

PERSISTANCE

Ehrhardt-Martinez (2011) points out that as interest in the field of feedback-induced energy savings grows, the main question on the minds of policymakers, researchers and residents is the concern around the durability of the energy savings. The author acknowledges that when it comes to persistence, there are both skeptics and optimists. The main belief for the skeptics is that while research tends to indicate short-term energy savings, the novelty effect wears off over time and residents revert back to old behaviours. Optimists look to evidence that suggests:

- Feedback helps people learn about the consequences of new behaviours;
- Feedback helps people to establish new habits, routines and personal norms; and
- Feedback could increase people's belief that their actions matter (self-efficacy).

In Foster and Mazur-Stommen's (2012) review of various pilots in the U.S., U.K. and Ireland, not all tested for persistence, but of those that did, all but one showed savings to persist over the course of the pilot (up to 21 months). Other pilots showed that while savings did not completely drop, the high initial savings did fall over time.

A 15-month pilot study was conducted in the Netherlands between 2008 and 2009 to test specifically, the persistence of energy savings over the medium- to long-term (van Dam et al. 2010). The study involved 304 participants who were given the choice whether to keep their energy monitor after the initial four-month trial period was over. A follow-up study was conducted 11 months later. During the initial trial period, average energy savings were 7.8 per cent. At the conclusion of the trial period, approximately half chose to keep the monitor while the other half did not. Interestingly, neither group sustained their energy savings; and the rates at which the savings fell back were not different between the groups. Those who kept their monitors fared no better at maintaining their savings than those without the monitor. The authors conclude that an energy monitor is not effective over a longer period (van Dam et al. 2010).

As mentioned earlier, Allen and Janda (2006) cite the Van Raaij and Van Houwelingen study of 1989 in which the group with an energy monitor realized twice the energy saving as compared to other types of feedback. Allen & Janda further reveal that when the experiment was over, energy consumption within the monitor test group rose again to equal that of other feedback and control groups.

Some researchers are careful to distinguish between the categories of behaviour change when it comes to energy savings. Abrahamse et al. (2005) and Froehlich et al. (2010) refer to *efficiency behaviours* as one-time actions that provide lasting impact such as purchasing a more efficient appliance while *curtailment behaviours* involve forming new habits or routines to reduce environmental impact such as turning off the lights when exiting a room. Ehrhardt-Martinez (2011) makes the same distinction but refers to the categories as *technology choices* and *consumer behaviours* respectively. Within the category of infrequent technology choices, she further sub-divides activities into low-cost or higher-cost actions.

Ehrhardt-Martinez (2011) used her behaviour categorization to examine 13 primary research studies and assess the types of behavior that feedback typically elicits. She found that savings attributed to feedback are typically created through changes to everyday practices. Very little was attributable to investments in new, energy efficient technologies. This suggests that the persistence of feedback-induced savings is highly dependent on the continued actions of energy-conscious behaviour.

Next, Ehrhardt-Martinez (2011) went back to her team's meta-analysis of 57 feedback initiatives to review the relationship between study duration and energy savings. Average energy savings were in fact higher for shorter studies (10.1%) than for longer studies 7.7%. She then sought to determine whether this relationship remains regardless of study size (shorter studies often involved fewer participants). She determined that when the comparison is limited to studies of 100 people or more, the level of energy savings are roughly the same for both short- and long-term studies. As well, Ehrhardt-Martinez hypothesizes that some of the drop off in energy savings over the long term may be explained by the fact that the shorter-term, smaller studies are typically performed in the summer months when air conditioning demands skew energy use. The longer studies include the cooler months when the higher electrical demand is absent.

Ehrhardt-Martinez (2011) addresses the van Houwelingen et al. study of 1989 in which energy savings did not persist once the energy monitors were removed. This falls in line with Darby's (2006) belief that the persistence of energy savings may be dependent upon the continued provision of feedback. Ehrhardt-Martinez (2011) investigates 28 studies out of the 57 that specifically consider persistence and finds evidence that supports the expectations that feedback-induced energy savings are likely to persist over time. More importantly, six of the studies looked at discontinued feedback; five of those six studies observed either persistent or *increased* savings.

Qualitative surveys of research participants sometimes inquired as to whether participants wanted to keep their monitors and/or whether they used them as frequently in the latter stages of the trial as in the earlier (Alahmad et al. 2012, Mountain 2006). Although Ehrhardt-Martinez (2011) revealed that feedback-induced energy savings can persist over time, she recognizes that the research also suggests that use of the feedback displays tends to decline over time. She puts forth program-design implications these findings have. For example, in order to maximize the cost effectiveness of feedback initiatives, energy monitors could be installed in residences for a particular length of time and then moved to a new set of homes. However, as a caution, if feedback devices are used in tandem with other tools (discussed later), it may result in more persistent use of the devices.

DESIGN CONSIDERATIONS AND FUTURE EVOLUTION

Researchers make important decisions regarding the brand of energy monitor that is to be used by study participants. Unfortunately, the design of the monitor is something rarely discussed as a factor potentially resulting in enhanced use or even prohibited use. Indeed, Froehlich et al. (2010) provides a rare examination of the gaps between the disciplines of human-computer interface (HCI) and environmental psychology. While environmental psychology is focused on evidence of behaviour change, it places a lack of emphasis on the visual design of eco-feedback. On the other hand, HCI does the very opposite and instead evaluates design with no regard for actual behaviour change. Only half of the papers Froehlich et al. (2010) reviewed provide a graphic of the eco-feedback interface.

There are many considerations with regard to the characteristics of energy monitors that could trigger proper human-computer interaction. For example, in the study conducted by Alahmad et al. (2011), a portion of participants using one type of monitor as compared to another expressed frustration with the time delay in the monitor response when electric loads were switched on.

Installation requirements of energy monitors can be an issue as well. Some monitors require that a main unit be connected to the home's power box which typically requires professional installation. Others, such as the PCM requires that a transmitter be attached to the utility meter with a ring clamp suggesting that it can be self-installed by a homeowner (Mountain 2006). In reviewing the survey results of the Hydro One pilot, Faruqui et al. (2009) reveals that 45 per cent of participants found installation difficult, both in fitting the transmitter around the conventional meter and also in programming the electricity rates into the in-home monitor.

In 2006, Darby suggested that user-friendly displays are needed as part of any new meter design specification and that at a minimum monitors should show instantaneous electricity usage, expenditure and historic feedback. She also raised the future need of displaying microgeneration data including tariffs and carbon emissions.

Allen and Janda (2006) suggest that research to date was not conclusive as to whether sophisticated real-time monitors are more effective than simpler versions. Contrasting this finding is Froehlich et al (2010) who cite studies that suggest the most effective feedback interfaces contained multiple feedback options (e.g. consumption over multiple time periods, comparisons, energy saving tips); were updated often, were interactive (e.g. offering ability to "drill-down" into data); and/or were able to provide disaggregated, appliance-specific data.

"Push versus pull" data is beginning to be talked about in the literature (BEAMA 2012, Foster & Mazur-Stommen 2012, Froehlich et al. 2010). Currently, energy monitors require a user to interact with the device to gather its information. In some cases, the more robust historical data associated with a home's energy use is only available through an online portal, providing a second layer of user-required action to access such valuable information. The future of real-time feedback displays will likely include "push" style applications on smartphones.

Ideally, energy monitors will have the ability to detect energy use of specific appliances. Froehlich et al. (2011) envisions energy monitors providing such tailored energy tips as the following, "Based on your energy consumption patterns, you could save US$360 per year by upgrading to a more efficient refrigerator, which would pay for itself after 21 months." Further, disaggregated data could be used to inform homeowners of malfunctioning equipment or appliances on inefficient settings, "The water circulation pump appears to be operating continuously rather than being triggered by a thermostat" (Froehlich et al. 2011). Ideally, the culmination will be when these kinds of tailored notifications are pushed to the user via mobile devices.

In the U.K., the Consumer Energy Display Industry Group has learned from its members' customers that they desire energy information online through a smart phone or the web; when provided with in-home energy monitors, they choose to upload this data online to benefit from online services; and that owning an in-home display increases the desire for online services suggesting that having an in-home display is really just the first step in customer engagement and not the final one (BEAMA 2012).

This is encouraging in that depending upon the quality of online services, requiring the user to access the internet may not be as much of a barrier as initially posited.

In this literature review, we discovered one study investigating usability of a variety of monitors. However, this study was performed specifically for people with some kind of impairment (e.g. sight loss, arthritis, hearing loss). Non-disabled and tech savvy individuals were included as study participants and were able to complete all of the scenarios requested of the researchers; however, they still had to overcome challenges of poor usability (Consumer Focus 2012).

We can hypothesize that participants in a research study might take extra time to familiarize themselves with the functionality of an energy monitor given that their behaviours are being evaluated. However, when energy monitors are implemented at the program level, there's much less guarantee that homeowners will take the time to overcome usability barriers. The U.K. focus group revealed that some people were not interested in taking the time to learn a new piece of technology (Consumer Focus 2012). Therefore it's extremely important that a monitor selected for widespread roll-out be given adequate user testing to ensure its functionality is intuitive and that the supporting information demonstrates simple ease of use.

MONITORS IN COMBINATION WITH OTHER TOOLS

The reality is that energy is very abstract and even when our consumption is visible in our homes through the use of monitors; it's still just a number. Even when a kWh value is translated into dollars and cents it remains just a number. A homeowner is left wondering "is that good or bad?"

The research is beginning to investigate the efficacy of utilizing feedback in conjunction with other forms of interventions. Literature reviews suggest that feedback tends to be more effective when combined with other strategies (van Dam et al. 2010, Abrahamse 2005).

Past research suggests that feedback initiatives integrating motivational components, empowerment measures, and support structures (such as goal setting, social norms, prompts, competition and group-based programs) are likely to achieve greater energy savings than programs that do not include these components. Not only do these tools help to increase overall savings, they are shown to increase persistence of the savings (Ehrhardt-Martinez 2011).

In 2007, San Diego Gas & Electric initiated an energy monitor pilot with 300 voluntary participants, targetting high electricity consumers. In addition to the energy monitors, conservation phone calls and emails on consumption patterns were also incorporated. The combined effect of feedback and support resulted in an average conservation effect of 13 per cent as compared to the previous year.

Ehrhardt-Martinez (2011) found that goal setting can be effective at enhancing energy savings from feedback. An interesting study was conducted in 1978 in which households were given either a relatively difficult goal to achieve in reductions (20%) while others were given an easy goal (2%). The houses with the difficult goal were split into two groups, one receiving feedback three times a week and the other receiving no feedback. The group with the difficult goal and receiving the feedback conserved the most (15.1%) and was the only group to significantly differ from the control. The easy goal appeared to not have been worth the effort (Abrahamse et al. 2005).

Social norms have been investigated in the behavioural literature for some time. One well-known study by Schultz et al. (2007) involved feedback (via door hangers) about household energy use in 290 California households. The homes were divided into two groups. The first group received information about their home's energy use along with a descriptive norm indicating average energy use in the neighbourhood, along with energy saving tips. The second group received the same information but the door hanger also included a smiley face if the home performed better than the average and a sad face if it performed worse. Homes that were performing worse than the average in the first treatment group experienced overall savings of 5.7 per cent. However, the homes that were performing below the neighbourhood average experienced a 7.9 per cent increase in consumption. This holds true to normative theory in that people's personal tendencies are to follow how the group behaves. This can result in the boomerang effect counter-acting good energy-use behaviour. The boomerang effect was negated when a happy face was provided to similar homes in the second group. The average energy savings in the second group was higher. The smiley and sad faces act as an injunctive norm providing approval for constructive behaviour or disapproval for non-constructive behaviour.

This theory is behind OPower's enhanced billing service. Two studies investigated how effective this type of billing is in encouraging energy saving behaviour. 35,000 customers in the Sacramento Municipality Utility District and a similar number in the Puget Sound Energy Program were mailed OPower's energy reports. Modest savings emerged: 1.1 per cent in Puget Sound and 2.35 in Sacramento (Ehrhardt-Martinez 2011). Normative thinking is now being applied to some energy monitor read outs where energy use is compared to a neighbourhood average. Some read outs even provide the happy/sad face (van Dam et al. 2010).

Contrary to the above results however, in the meta-analysis provided by Abrahamse et al. (2005), comparative feedback did not prove to be more effective than individual feedback. However, when comparative feedback was structured in a socially-based approach, savings became significant. Researchers in the Netherlands designed an approach specifically to address the lack of persistent energy savings in earlier Dutch studies (Ehrhardt-Martinez 2011). EcoTeams were used in which small groups (e.g. neighbours, friends and family) came together once every month to exchange information about energy saving options. At the meeting, homeowners received information about their own energy savings and that of other EcoTeams. Energy was not the only focus at the meetings; in all, six sustainability-related themes were addressed over eight months. Progress over the 150 participants was monitored over three years. At the conclusion of the first year, electricity savings resulted in a 4.8 per cent reduction. By the end of the third year, well after the program had ended, savings had even *increased* to 7.6 per cent as compared to the general population. The researchers concluded that a supportive social environment can play a significant role in determining the persistence of energy savings (Ehrhardt-Martinez 2011).

SMART METERS

A discussion of energy monitors wouldn't be complete without recognizing the move some jurisdictions and utilities are making toward smart meters. The U.K. Government is requiring that energy companies install smart meters for their customers so that they become standard across the country by 2020 (with no legal obligation for homeowners to have one).

In Canada, there is a varying rate at which utilities are implementing a switch to smart meters. BC Hydro has already installed over 1.8 million meters across the province (Globe and Mail 2013). SaskPower is in the process of installing 500,000 smart meters over the next few years (SaskPower 2014).

Every home and small business in Ontario will have a smart meter installed through Hydro One. According to its website, 1.3 million have already been installed (Hydro One 2014). Unlike BC Hydro and SaskPower, Hydro One is introducing time-of-use pricing as a means of smoothing out peak demand. Ehrhardt-Martinez (2011) indicates that research focused on reducing peak-demand was largely successful but not effective at reducing overall energy consumption. Therefore, she states that when utilities move to smart meters to reduce peak loads, the message to consumers is effectively that they don't need to be concerned with how much electricity they use, but rather only on *when* they use it.

Manitoba Hydro conducted a smart meter pilot project from 2006 to 2009. Approximately 4,500 smart meters are currently in place in Winnipeg and will remain there even though the pilot is over. According to its website, the utility is still compiling data from the pilot to determine the business case for broader implementation (Manitoba Hydro 2014).

At this point, we should clearly define what a smart meter is. A smart meter essentially is a digital version of the analogue meter we are all currently familiar with. The older meters require manual readings while the smart meter provides high-resolution, accurate, real-time data sent wirelessly to the utility through the Advanced Metering Infrastructure (BEAMA 2012).

This literature review has been focused on in-home energy monitors which are meant to give users direct insight into their energy consumption. Smart meters on the other hand are predominantly intended to benefit the utility (van Dam et al. 2010).

The UK's Consumer Energy Display Industry Group goes so far as to suggest that many of the smart meters in the world "are really not that smart." The meters merely communicate readings back to the utility. The type that are to be deployed in the UK are, in the authors' opinion, considerably smarter because they exist on a local Smart Meter Home Area Network allowing other devices to be connected including in-home energy monitors along with a Consumer Access Device (CAD). The UK has mandated that in-home energy displays be rolled out in conjunction with the installation of smart meters.

The CAD is the interesting piece of the system that can address many of the barriers to increased and persistent energy savings in the home. While the in-home energy monitor provides information about energy use, it can't tell a homeowner what to do to reduce their bill. The CAD is used, in conjunction with the in-home display, to connect from the smart meter to the rest of the consumer's world. It takes the energy use information and connects to the Cloud where multiple online services turn it into useful information to the consumer wherever he or she wants it (e.g. smart phone app, web portal, text message etc.). The CAD can help manage appliances in the home through such prompts as:

- “Your dishwasher is costing you $XX/year to run.”
- “Your fridge is behaving as if it has an E-class rating – or perhaps the seals have failed. Click here for tips or coupons toward a new A++ fridge.”
- “Your fridge is running continuously – have you left the door open?”

This is not a future vision, these Cloud services are already bringing new energy management options to consumers. This industry group points out that 25 per cent of meters in UK homes were installed prior to the internet existing. Energy services innovation should evolve at the pace of consumer technology and the CAD is the key piece of technology that allows that (BEAMA 2012).

This is mentioned as a comparison to the jurisdictions in Canada that are not providing in-home displays as part of the smart meter installation. Instead, customers have access to a web portal where they can receive enhanced information about their energy use. It is interesting to note that two of the jurisdictions moving forward with smart meters had noticeable success in causing energy savings through the use of energy monitors in test pilots.

CONCLUSION

The vast majority of research studies indicate that energy monitors are a viable means of reducing overall electricity use. While some skeptics suggest that these results are only proven for the long-term, when removing studies with small sample sizes, energy savings hold over the medium and long terms. The more progressive research is beginning to combine energy monitors with the use of other motivational tools such as goal setting, social norms and supportive community networks. The combination effect often results in greater savings and higher persistence.

While some jurisdictions in Canada are beginning to roll out smart meters, whether they will utilize some of the proven research to encourage energy savings remains to be seen. Hopefully installation of the new meters is simply about updating energy infrastructure and represents the first step in making energy visible.

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