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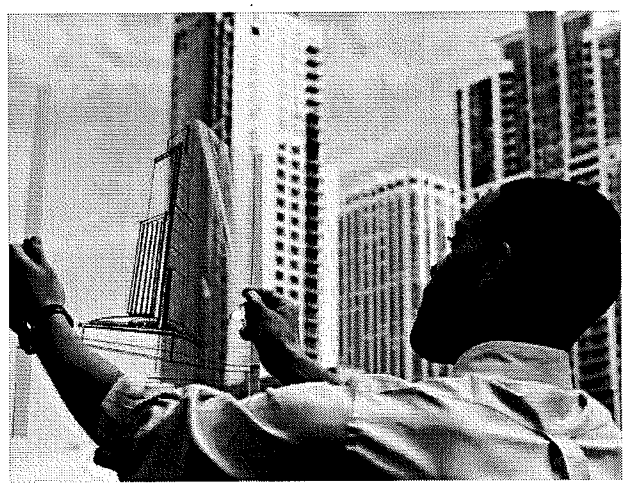
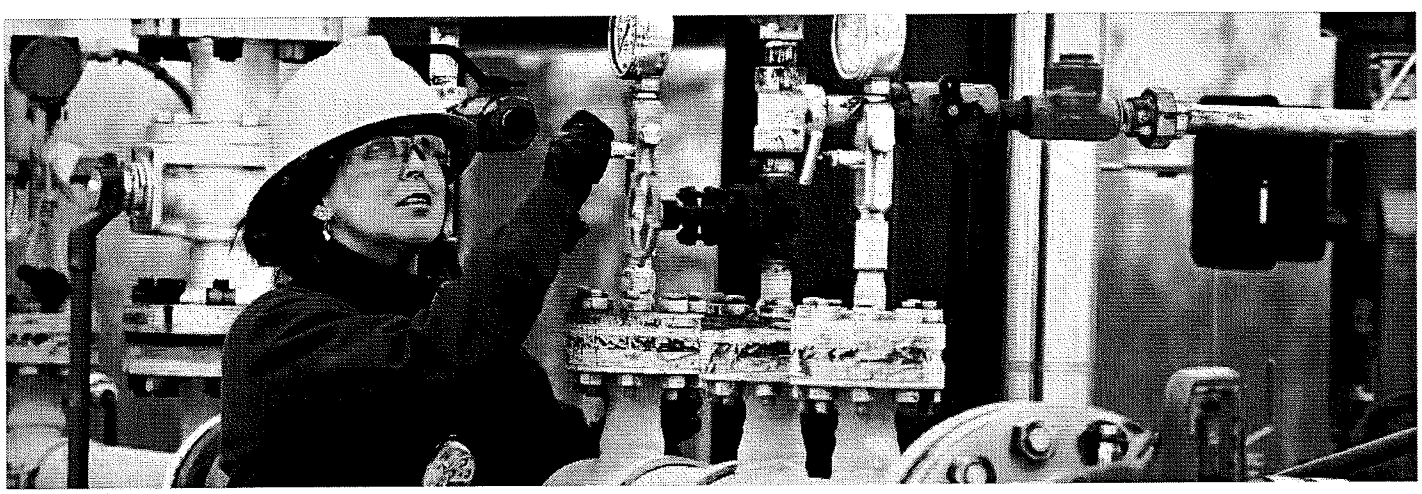
Unlocking Energy Efficiency in the U.S. Economy





EXCERPT

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Sidebars

DEMAND-SIDE MANAGEMENT

Opportunities in demand-side management (DSM) are prompting utilities to invest in smart grid and advanced metering infrastructure. DSM's main goal is to reduce peak loads, which allows utilities to flatten their power demand curves, shifting load from expensive peaking units to lower-cost base-load plants. Reducing peak consumption increases reliability of the electric grid, reducing outages for customers and operations and maintenance costs for utilities. Furthermore, some DSM measures can decrease total energy consumption while delivering the same value to customers.

Since the 1980s, DSM has focused primarily on commercial and industrial (C&I) customers, with more than 165 utilities in North America having programs for these customers, including direct load control (DLC) and tiered-pricing programs. However, emerging smart grid technology is shifting the focus in DSM from direct load control to dynamic pricing and making programs possible for residential and small-to-medium business segments. Residential DSM programs have so far achieved mixed results: pilots in California and Nevada have demonstrated strong potential, though other high-profile pilots, such as Puget Sound Energy in 2001, reported high implementation costs and insufficient peak reduction. Larger residential DSM deployments will be needed to better understand its actual savings potential.

Four types of DSM programs warrant discussion:

- **Direct load control and incentive-based programs.** DLC programs are one of a range of incentive-based DSM approaches that include interruptible/curtailment rates, demand bidding/buyback programs, emergency demand response programs, and capacity market programs.[1] DLC programs allow utilities to control specific energy-intensive loads, such as air conditioners, in exchange for a billing discount to the customer. DLC programs are wide-spread; about one-third of utilities cycle residential air conditioners, with average participation rates of 15 percent, and roughly 60 percent of utilities offer load-management programs for C&I customers.[2]

  DLC programs have proven cost effective and have yielded substantial savings: A survey of 24 programs showed average peak load savings of 29 percent for participating customers with minimal reduction in total energy consumed.[3] Con Edison, for example, offers its residential and small commercial customers a free programmable thermostat in exchange for the ability to cycle their air conditioning load, although the customer can override the decision if it occurs at an inconvenient time. Con Edison has installed more than 24,000 thermostats with a peak load reduction of 29 MW.[4] Furthermore, Con Ed's DLC program appears to be cost effective, with costs estimated at $455 to 626 per KW saved,[5] compared to $500 to $1,400 per KW for additional peak generation capacity.[6]

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1 "Assessment of Demand Response and Advanced Metering," Federal Energy Regulatory Commission, Staff Report, August 2006.

2 "Utility Load Control Programs," Chartwell, March 2006.

3 "Residential Electricity Pricing Pilots," eMeter Strategic Consulting, July 2007.

4 New York State Public Service Commission, "Energy Efficiency Portfolio Standard Working Group 2 – Program Summaries: Direct Load Control," September 2005.

5 New York State Public Service Commission, "Consolidated Edison Company of New York, Inc's Direct Load Control Program," September 2005.

6 According to World Bank report on equipment prices in the power sector, a gas turbine simple cycle plant costs $530/KW for a 5 MW plant, $970/KW for a 25MW plant and $1380 for a 5 MW plant. "Study of Equipment Prices in the Power Sector." The International Bank for Reconstruction and Development, The World Bank Group. 2008.

Because DLC programs are used primarily for air conditioning loads in the residential sector and inductive loads in C&I, its potential is limited; other programs will be needed to reduce peak loads further. In addition, DLC programs are perceived to be heavy-handed, because they give control of devices inside homes and businesses to utilities.

- Dynamic pricing. Dynamic pricing programs create energy prices that more closely reflect the utility's actual cost of power at the time of consumption. Use of these programs has been limited mostly to large C&I customers; however, residential pilots have emerged recently in many states. Almost one-third of utilities offer dynamic rates,[7] including Time of Use, Critical Peak Pricing (CPP) and Real Time Pricing.[8] Pilots show an average residential reduction in peak consumption due to price signals of approximately 22 percent, although results vary significantly by pilot, with overall consumption dropping by around 4 percent.[9] California's 2,500-participant Statewide Pricing Pilot suggests CPP can reduce California's peak load by 1,500 MW to more than 3,000 MW.[10] Because results have varied significantly by pilot, more large-scale pilots and roll-outs will be necessary to better understand the energy savings potential.
- Consumption information and transparency. Other DSM programs provide customers with greater transparency into their consumption, thereby encouraging them to reduce demand. Methods include bill-related signals, in-home displays, and home automation. Bill-related signals provide more frequent and easier-to-understand billing with clear indications of relative consumption levels. When done monthly, these programs can reduce consumption by up to 6 percent, while weekly or daily billing offers savings of 10 to 13 percent.[11] Early pilots suggest that in-home displays, devices that provide real-time information on home energy consumption, could provide savings of 4 to 15 percent.[12] Home automation, including programmable thermostats and smart appliances, are in the earliest development phase of all DSM programs; however, early results indicate peak reduction of up to 46 percent, with reductions in total consumption of 11 percent.[13]

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7 "Utility Load Control Programs," Chartwell, March 2006.

8 Time of Use (TOU) rates: electricity rates are set in tiers for different times of the day and typically do not change more than twice per year. Many large commercial and industrial customers already have TOU pricing. Critical Peak Pricing (CPP): during times of extreme peak, prices will increase dramatically. Real-Time Pricing (RTP): prices change on an ongoing basis to reflect closely the utility's cost of generating or purchasing electricity.

9 "Residential Electricity Pricing Pilots," eMeter Strategic Consulting, July 2007.

10 Roger Levy, "California Statewide Pricing Pilot (SPP) Overview and Results 2003-2004," 2005.

11 Sarah Darby, "The Effectiveness Of Feedback On Energy Consumption," Environmental Change Institute, Oxford University, April 2006.

12 Sarah Darby, "The Effectiveness of Feedback on Energy Consumption, "Environmental Change Institute, University of Oxford, April 2006.

13 "Residential Electricity Pricing Pilots," eMeter Strategic Consulting, July 2007.

THE EFFECTIVENESS OF FEEDBACK ON ENERGY CONSUMPTION

A REVIEW FOR DEFRA OF THE LITERATURE ON METERING, BILLING AND DIRECT DISPLAYS

Sarah Darby
April 2006

Environmental Change Institute
UNIVERSITY OF OXFORD

CONTENTS

EXECUTIVE SUMMARY

Most domestic energy use, most of the time, is invisible to the user. Most people have only a vague idea of how much energy they are using for different purposes and what sort of difference they could make by changing day-to-day behaviour or investing in efficiency measures. Hence the importance of feedback in making energy more visible and more amenable to understanding and control. This review considers what is known about the effectiveness of feedback to householders. The focus is on how people change their behaviour, not on the detail of the technology used.

There is considerable variety in the feedback literature, but common themes emerge. The first studies, in the 1970s, established that feedback (mostly via display monitors) has measurable effects and was worth pursuing, on its own or in combination with other processes. Feedback came to be seen in terms of a learning tool, allowing energy users to teach themselves through experimentation. Overall, the literature demonstrates that clear feedback is a necessary element in learning how to control fuel use more effectively over a long period of time and that instantaneous direct feedback in combination with frequent, accurate billing (a form of indirect feedback) is needed as a basis for sustained demand reduction. Thus feedback is useful on its own, as a self-teaching tool. It is also clear that it improves the effectiveness of other information and advice in achieving better understanding and control of energy use.

Scope of the review

The literature reviewed here mostly consists of primary sources, with a few review papers. Most of it comes from the USA, Canada, Scandinavia, the Netherlands and the UK. The focus is on feedback on gas and electricity consumption, with some reference to the literature on advice and information. There are not many studies of the use of feedback in the UK, or on feedback for low-income households, but these have been sought out where possible.

Savings from feedback

The norm is for savings from *direct feedback* (immediate, from the meter or an associated display monitor) to range from 5-15%. The role of the meter is to provide a clearly-understood point of reference for improved billing and for display. If there is no separate, free-standing display then the meter must also be clearly visible, within the building. There is some indication that high energy users may respond more than low users to direct feedback.

Indirect feedback (feedback that has been processed in some way before reaching the energy user, normally via billing) is usually more suitable than direct feedback for demonstrating any effect on consumption of changes in space heating, household composition and the impact of investments in efficiency measures or high-consuming appliances. Savings have ranged from 0-10%, but they vary according to context and the quality of information given (see below). Historic feedback (comparing with previous recorded periods of consumption) appears to be more effective than comparative or normative (comparing with other households, or with a target figure).

Feedback that is *disaggregated by end-use* at the electricity meter is relatively expensive and complicated to supply. 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. Information on how energy use is disaggregated among end-uses in an average home can also be given on the bill, as a general guide. Accurate, frequent billing will give the householder a much better sense of the heating load at different times of year than can be gained from a direct debit statement.

Pay-as-you-go systems with some form of display allow customers to be more in charge of their electricity use. Savings of 10-20% are quoted for North American systems. A full evaluation of the keypad pay-as-you-go meter in Northern Ireland is under way; figures from small-scale earlier studies show savings of around 3% compared with previous usage.

While online billing can provide a useful interactive feedback service and can incorporate analysis and advice, it is unlikely to be an adequate substitute for a direct display. Ideally, every household needs to be able to see what is happening to consumption without having to switch on an optional feedback service.

Time-of-day pricing
The case for time-of-use electricity pricing or real-time pricing for the residential sector is not yet made for the UK. Opportunities for reducing peak usage are limited and there are equity concerns. But time-of-use or real-time pricing may become important as part of more sophisticated load management and as more distributed generation comes on stream.

Persistence of effect

Persistence of savings will happen when feedback has supported 'intrinsic' behaviour controls – that is, when individuals develop new habits – and when it has acted as a spur to investment in efficiency measures. People may need additional help in changing their habits – this is where well-thought-out energy advice can be of use. Where feedback is used in conjunction with incentives to save energy, behaviour may change but the changes are likely to fade away when the incentive is taken away. As a rule of thumb, a new type of behaviour formed over a three-month period or longer seems likely to persist - but continued feedback is needed to help maintain the change and, in time, encourage other changes.

The future of feedback
Important factors influencing the effectiveness of feedback are

- General context, eg social, educational and historical factors, energy infrastructure
- Scale and timing of usage. Indirect feedback is most likely to give a compelling picture of what is happening to the heating load, while instantaneous direct feedback illustrates the impact of smaller end-uses.
- Synergies between feedback and other forms of information. It is not always easy to separate out these effects, even in relatively small-scale and intensive studies.
- Timing. Billing or other periodic feedback (eg via a PC) will show up longer-term effects best, eg investment in insulation, use of new appliances, replacement of heating systems and appliances, home extensions, new members of the household. Direct displays will show up the significance of moment-to-moment behaviour best.

Any development of 'smart metering' needs to be guided by considerations of the quality and quantity of feedback that can be supplied to customers. Direct displays in combination with improved billing show promise for early energy and carbon savings, at relatively low cost. They also lay the foundations for further savings through improved energy literacy.

CONTEXT

The scale of the challenge facing the UK in reducing carbon emissions and maintaining adequate, reliable energy for the future is set out in the recent energy review paper (DTI 2006). There is clearly an enormous task ahead in terms of developing more sustainable ways of living and there is a growing recognition that energy efficiency alone is inadequate to achieve the aims of a major reduction in carbon emissions (see Boardman et al. 2005 for a discussion of issues for the residential sector). Many Energy Conservation Authorities are behind schedule on progress towards their targets under the Home Energy Conservation Act and the indications are that their reporting arrangements are unreliable, overestimating levels of improvement in the energy efficiency of the housing stock (New Perspectives 2004). In spite of professed public concern about climate change, improved appliance efficiency and information campaigns, domestic electricity consumption rose by 6% in the third quarter of 2005 (DTI press release, 5.1.06).

Energy supply and consumption are sociotechnical in nature: technology and behaviour interact and co-evolve with each other over time. It is well established that technical and physical improvements in housing are not enough to guarantee reduced energy consumption. Consumption in identical homes, even those designed to be low-energy dwellings, can easily differ by a factor of two or more depending on the behaviour of the inhabitants (Sonderegger 1978; Curtis 1992-93; Keesee 2005). Any attempts to change the patterns of supply and consumption therefore have to take into account the interfaces between supplier, technology and consumer and the ways in which these can be improved. This is where feedback issues enter the debate.

> *Energy and power are not terms within the natural language of mainstream householders. Gas and electricity operate at the level of the subconscious within the home... Whilst there does seem to be some latent cultural guilt about the notion of waste... there appeared to be virtually no sense of being able to actively and significantly reduce energy consumption in the household.*
>
> \- Dobbyn and Thomas 2005, p6

'Smart metering' or 'advanced metering' is proposed as a promising way of developing the UK energy market and contributing to social, environmental and security-of-supply objectives. Five years ago, the Smart Metering Working Group estimated that meters offering more information to consumers could help reduce household consumption of gas and electricity in addition to other potential benefits (SMWG 2001). A new European Directive requires a substantial improvement in the information given to energy consumers (see box) and there has been a considerable debate on the future of metering in the UK, with Ofgem carrying out consultation on domestic metering innovation at the time of writing. The Ofgem consultation in 2005 on the regulatory implications of domestic-scale microgeneration is also relevant: increasingly, householders are becoming generators as well as consumers of energy.

EU Energy end-use efficiency and energy services directive (2005)

Preamble

- In defining energy efficiency improvement measures, account should be taken of efficiency gains obtained through the widespread use of cost-effective ... innovations, eg electronic metering...
- to enable final consumers to make better-informed decisions ... they should be provided with a reasonable amount of information ... consumers should be actively encouraged to check their own meter readings regularly.

Article 11
... Member States may establish a fund... to subsidise the delivery of energy efficiency improvement programmes and ... measures... These shall include the promotion of energy auditing ... and, where appropriate, improved metering and informative billing.

Article 13
Member States shall ensure that, in so far as it is technically possible, financially reasonable and proportionate in relation to the potential energy savings, final customers ... are provided with competitively priced individual meters that accurately reflect actual energy consumption and that provide information on actual time of use.

- ... Billing on the basis of actual consumption shall be performed frequently enough to enable customers to regulate their own energy consumption.
- MS shall ensure that, where appropriate, the following information is made available to final customers in clear and understandable terms ... in or with their bills...:

Current actual prices and actual consumption of energy;

Comparisons of the final customer's current energy consumption with consumption for the same period in the previous year, preferably in graphical form;

Wherever possible and useful, comparisons with an average normalised or benchmarked user of energy of the same user category ...

This paper sets out general issues that are relevant to the debate on the future of energy in the residential sector and how it is understood and controlled. It revisits a review of feedback carried out six years ago (Darby 2001), updating it with some more recent findings from the literature and supplementing it with what has been learned since then about the nature and possibilities of different types of feedback. The review does not look at the detail of technology, but concentrates on principles of feedback, basic types of feedback and responses to it. The focus is on the energy user rather than the supplier.

THE LITERATURE ON ENERGY FEEDBACK

The early studies on energy feedback, carried out in the 1970s and 1980s, were carried out mostly by psychologists. Feedback was mostly seen as an 'intervention', an interruption in the normal order of things. For example, a typical early feedback experiment would involve a note posted on the consumer's kitchen window each morning, telling him or her how the previous day's consumption compared with some reference level. It was also often interpreted in terms of behaviour reinforcement, motivating individuals who were seen as relatively passive and motivated by reward and punishment. These studies established that feedback can have measurable effects on behaviour, at least in the short term.

> Feedback: *Information about the result of a process or action that can be used in modification or control of a process or system ... especially by noting the difference between a desired and an actual result.*
>
> \- Oxford English Dictionary

Some researchers began to emphasise that feedback is part of a learning process, in which people are information processors who actively make sense of the world around them (Ellis and Gaskell 1978). Another early review pointed out that interventions tended to focus too narrowly on the control of 'target behaviours' at the expense of viewing them within a systems context (Winkler and Winett 1982). The wide-ranging study by Hutton et al (1986), carried out in three North American cities, 'cautions against saying that any type of feedback, under any conditions, directed at any population, will produce positive results' – context is important. It was not always easy to set boundaries to the scope of a study of feedback or to establish a theoretical basis for studying it. For example, a review of the effectiveness of feedback as demonstrated in experimental conditions concludes that 'Feedback research is...marked by a simultaneous lack of concern with theory and overemphasis on application. As a result our understanding of *how* feedback does or does not work remains unexplored or untested' (Katzev and Johnson 1987). One answer to this rests with learning theory (Ellis and Gaskell 1978; Darby in press).

More recently, the focus has shifted to more 'ecological' studies, carried out on a longer timescale and with larger samples. These are typically funded by energy suppliers, regulators or government. There is less danger of a 'Hawthorne effect' in these conditions (that is, of participants behaving differently because they know they are being observed).

Qualitative work has also become more significant in feedback studies. For example, van Houwelingen and van Raaij included interviews in their work on the effect of goal-setting and daily electronic feedback on gas use (1989). These give some additional insight into how the householders actually used their feedback, 'mainly as a permanent check on the effects of energy conservation efforts'.

The consumer's 'energy analysis environment' under traditional billing was shown to be inadequate for decision making, lacking the detail which would make sense of the bill and allow for effective experiments in reducing it:

> *...consider groceries in a hypothetical store totally without price markings, billed via a monthly statement... How could grocery shoppers economise under such a billing regime?*
>
> \- Kempton and Layne 1994

Informative billing initiatives in Norway showed how customers appreciated improved accuracy and extra information (historic and comparative feedback, a guide to which end-uses were the highest consuming), began to read their bills more frequently and with more understanding, and began to alter their behaviour (Wilhite 1997; Wilhite et al, 1999). Various qualitative studies (eg Egan 1999, Roberts et al 2004) give more detail on how customers respond to different billing designs. The latter deals with UK billing and shows some distrust of comparative feedback: customers were suspicious about the validity of their comparison group but appreciated feedback that compared their recent consumption with that in previous billing periods.

As the literature on feedback expanded, so did that on energy use and on measures to reduce consumption and promote efficiency. In my earlier review, I described five main categories of feedback with various degrees of immediacy and control by the energy user, ranging from the home energy audit (carried out very infrequently, often by a professional) to the glance at a display panel (carried out at any time by the householder). Those that are relevant to this review are shown in the box below.

Direct feedback: available on demand. Learning by looking or paying

- *Self-meter-reading*
- *Direct displays*
- *Interactive feedback via a PC*
- *Pay-as-you-go/keypad meters*
- *'Ambient' devices*
- *Meter reading with an adviser, as part of energy advice*
- *Cost plugs or similar devices on appliances*

Indirect feedback – raw data processed by the utility and sent out to customers. Learning by reading and reflecting

- *More frequent bills*
- *Frequent bills based on readings plus historical feedback*
- *Frequent bills based on readings plus comparative/normative feedback*
- *Frequent bills plus disaggregated feedback.*
- *Frequent bills plus detailed annual or quarterly energy reports.*

Inadvertent feedback – learning by association

- *With the advent of microgeneration, the home becomes a site for generation as well as consumption of power.*
- *Community energy conservation projects such as the Dutch 'Eco-teams'.*

Utility-controlled feedback – learning about the customer

- *Utility-controlled feedback via smart meters, with a view to better load management.*

Energy audits – learning about the 'energy capital' of a building

Audits may be

- *undertaken by a surveyor on the client's initiative*
- *undertaken as part of a survey for the Home Information Pack*
- *carried out on an informal basis by the consumer using freely available software, eg carbon calculators.*

Feedback covers a wide range of practices and these are best analysed and understood in context. The overall idea here is to look at feedback in terms of its contribution to the building up of a body of 'tacit knowledge' or know-how about the supply and use of energy. In this, people take in information concerning their energy use, they act (change their behaviour in some way) and they gain understanding of what has happened by interpreting any feedback that is available. These three elements do not always happen in a neat sequence but all are involved when a person learns about energy use (Figure 1).

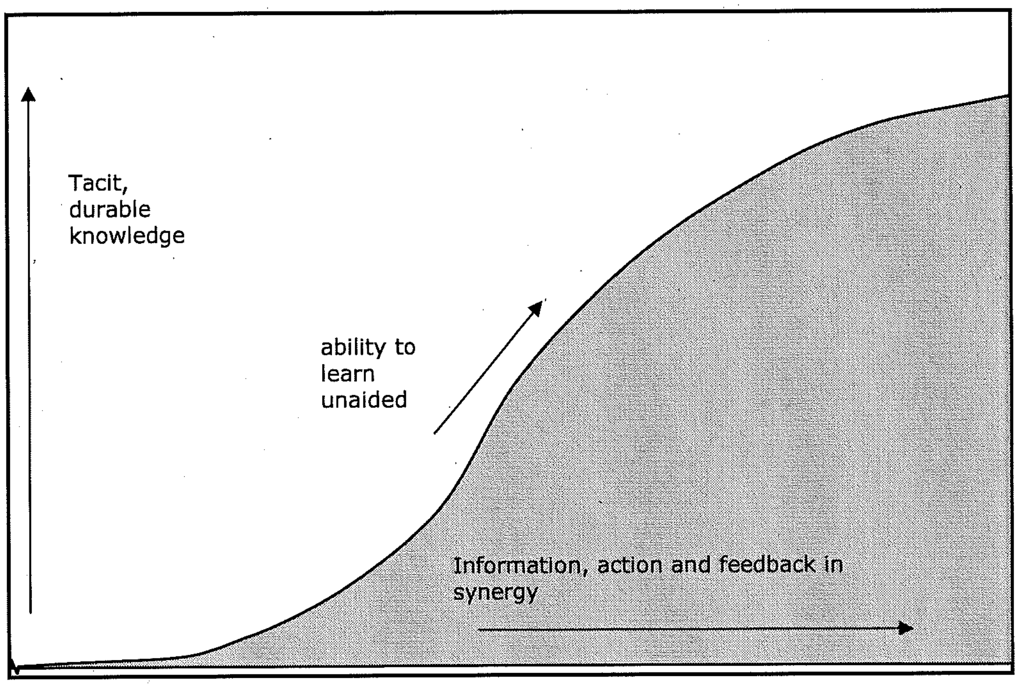

Figure 1: A model for the development of tacit, durable knowledge

EFFECTIVENESS OF DIFFERENT TYPES OF FEEDBACK

This section of the report refers frequently to studies which are summarised in the attached Tables 1 (direct feedback), 2 (indirect) and 3 (time of use).

It is worth saying at the outset that savings from feedback will always vary according to the technology under consideration, whether the main heating fuel is under consideration or a subsidiary fuel, and the institutional and cultural background against which the study takes place. In addition, the quality of feedback information and the way in which the study was conducted will affect the recorded outcomes. However, the studies reviewed below do show, consistently, the usefulness to households of having feedback information that is specific to them and allows them to control their energy use more effectively.

The savings presented here challenge the estimated 1% savings from 'more accurate billing and more sophisticated pricing' and 0.5% from 'the simple meter which provides more accurate billing information' in the recent Ofgem consultation document (Ofgem 2006, p18). The consultation document appears to confuse potential savings from indirect feedback (when the customer does not have easy, direct access to the meter and consumption data and relies mainly on bills or statements) with the higher potential savings from direct feedback, where customers have easily-accessible displays.

Basic metering without separate direct display monitors

The standard gas or electricity meter can be used to give a very basic form of energy consumption feedback. A painstaking householder can chart consumption from one meter reading to the next and use the meter to check the accuracy of bills or statements, but there is no obligation to do either and the meter is normally hidden out of sight. Nonetheless, over a quarter of householders appear to check their meters fairly regularly (Attan 1985; Darby in press). There is an association between the level of energy awareness of householders, the likelihood that they have installed efficiency measures, and whether they check their meters (Darby, ibid.).

Using feedback in this way requires a level of commitment to reading the meter regularly, but it has been effective as a tool in advice programmes, in conjunction with information on how to save energy, and in 'eco-team' conservation programmes (eg Sluce and Tong 1987; Gaskell et al. 1982; Nielsen 1993; Staats and Harland 1995). The potential savings, with motivated participants, can be in the region of 10-20% (see Table 1). The advice programme run by West Lothian District Council has asked clients to phone in their meter readings over a number of weeks in order to check that they are making progress, with encouraging results. Savings have been in the region of 10% after three months from behavioural change alone and mostly from fuel-poor clients. There may be further savings after efficiency measures have been installed (WLEAP), and the advisers estimate that habits formed over three months or more are likely to stick. A US energy advice evaluation showed savings in the third year after weatherisation and advice visits that were 85% of the 26% saved in the first year. This was comparable with the persistence of savings from weatherisation alone (Harrigan and Gregory 1994).

The standard meter cannot however establish *when* energy was used and cannot be activated remotely.

Key meters and keypad meters

Approximately 85% of electricity consumers and 90% of gas consumers in Great Britain pay for their energy in arrears (NEA 2004). This is not conducive to conservation, or to control of costs. A study of British householders on prepayment tariffs (mostly low-income households) showed that over 80% of electricity customers and 70% of gas users wished to continue with this method of payment although most of them knew that it was more expensive than payment in arrears (Waddams Price 2001).

Key meters are 'semi-smart' in that they allow transfer of information such as tariff-changes and meter reading data to and from the keycode at the payment point/shop. When keypad meters were introduced as an option to low-income customers in Northern Ireland they proved extremely popular and have now been made available to all customers. There is a 2% discount for electricity bought in this way – a regulatory decision. Around 25% of NI households now use keypad meters, buying credit from a nearby outlet and keying a 20-digit code into their meter, which looks something like a telephone and is situated in a room of their choosing. Savings to date for all keypad customers are estimated at 3% (reported in Owen and Ward 2006). A fuller evaluation is due in 2006.

Utilities in towns in Ontario have experimented with 'pay as you go' systems successfully (these are similar to the keypad meters in operation). The local utility Woodstock Hydro claims that the 25% of their customers who use the system are using between 15 and 20% less energy than they were doing under the traditional system of payment, because the display unit makes them aware of what they are consuming. (http://www.ec.gc.ca/pp/en/storyoutput.cfm?storyid=109; http://www.energyprobe.org/energyprobe/index.cfm?DSP=content&ContentID=9838) The disparity between North American and Northern Ireland figures may be partly due to differences in what is displayed to customers.

> You need three pieces of equipment to use the pay-as-you-go system. First, there is an electronic meter. Then, there's an in-home display unit, which resembles a thermostat and plugs into any electrical outlet.
>
> The in-home display unit communicates constantly with the ... meter, relaying how much energy you're using at the moment. For example, if you have the washing machine, dishwasher and dryer running at the same time, the meter might read 25 cents an hour, as opposed to late at night, when nothing is running, when the meter shows lower rate of eight cents an hour.
>
> Lastly, there is the smart card. Like a prepaid phone card, users go to select stores and purchase electricity on their card. At home, you swipe the card through the in-house meter to keep the electricity flowing.
>
> -description of pay-as-you-go system in Ontario
> http://www.melaniechambers.ca/pay-as-you-go.html

Direct displays on monitors separate from the meter

Direct displays are a supplement to the meter. Almost all show electricity consumption, though there is one recorded trial of a display that showed the previous day's gas consumption in relation to a weather-adjusted target, producing savings of 10% against controls (van Houwelingen and van Raaij 1989). Over half of those interviewed during the trial said that they would like to have such a display permanently.

With a free-standing display, the meter can be left alone once a transponder is attached. Householders can look at the displays for instantaneous information and/or information on previous consumption. On some displays, they can also set an alarm to go off when the load rises above a level chosen by them.

Savings are typically of the order of 10% for relatively simple displays (McLelland and Cook 1979; Dobson and Griffin 1982; Mountain 2006). These are small panels that can be carried around the home, typically showing instantaneous electricity consumption along with cost per hour at the current rate. The most recent displays also show carbon dioxide emissions for a given rate of consumption. They cost £15-£80. Trials are under way in the UK at the time of writing.

Use of TVs and PCs for display

More complex displays are also being developed, such as a complex interactive online display tested in Japan that cost around $5000, showing historic consumption, daily and 10-daily costs, living room temperatures and comparisons with other homes. Over a nine-month trial, this gave electricity savings of 18% and gas savings of 9% compared with controls, for the 10 householders who took part in the trial (Ueno et al. 2005). Benders et al. (2005) report 8.5% savings from the use of an interactive web page by 137 Dutch households. This helps analyse consumption and establish relevant conservation measures. Money saved by using less energy was invested in efficiency measures, contributing to the persistence of the savings. Brandon and Lewis, in one of the few British feedback trials, found interactive display via a PC the most promising method (1999). A major trial of feedback on gas, electricity and water via digital TV is scheduled to begin in the autumn of 2006, carried out for the Market Transformation Programme.

Disaggregated feedback

Information on which end-uses consume most energy is seen as useful by customers (Harrigan et al. 1995). When 1000 Norwegian households were given a pie-chart on their bill showing a typical breakdown of six main domestic end-uses, 81% of respondents thought it useful and 38% appeared to have learned something new from it. A direct display can convey the same information provided the response to the signal from the meter shows up instantaneously. Customers can then see immediately what happens when they switch on the kettle or vacuum cleaner, or when the central heating pump goes on. Portable end-use monitor plugs are on sale in the UK for £25 and serve the same function, one appliance at a time.

End-use disaggregation can be carried out by identifying appliance 'signatures' (Sidler and Waide 1999), but this is likely to be unfeasibly expensive for everyday use by householders in the foreseeable future (IEA-DSM 2005, subtask 2).

There are no data on persistence of effect for this type of feedback. The argument for it rests on the educational effect in raising awareness of the relative demand from different appliances.

Ambient displays

Ambient displays rely on 'pre-attentive' processing of information. They do not show text or numbers, but simply alert the householder to the fact that something relevant to their electricity supply has changed or is about to do so. Some direct displays can be programmed to sound an alarm when load has exceeded a given level (a more user-friendly version of the load-limiting trip switch). A flashing light was used to alert a sample of American householders that the outdoor temperature had dropped below 68°F and it was time to turn off the air-conditioning and open windows for cooling instead. This gave savings of 16% over a three-week period (Seligman et al. 1979).

Martinez and Geltz (2005) describe the testing of an 'energy orb' which changes colour according to the time-of-use tariff in operation. The orb flashes during the two hours before a 'critical peak' with high unit costs, and users who tried it out tended to reduce consumption well in advance of the peak and to continue with the reduction for some time afterwards. As a consequence, there was some overall saving as well as load-shifting.

The Design Council's recent 'Future Currents' project has come up with some innovative and attractive designs for displays that do not necessarily show numbers but give a clear impression of electricity demand in the home (http://www.designcouncil.org.uk/futurecurrents/).

INFORMATIVE BILLING

A [standard] *utility bill is a form of feedback in which the feedback loop is too far removed from the use of inputs to have any information value'* (Gaskell et al, 1982). But bills can be adapted to show broad trends in consumption over time. First, they can demonstrate how the heating load is spread over the year – something that direct debit payers may be completely unaware of. They can also show how consumption has changed relative to the same period of the previous year, giving the energy user the chance to work out what might have caused the change: a new person in the household, a new boiler or appliance, insulation or the addition of an extension to the house. Bills can also include an annual 'energy report', compare the household's consumption with that of a comparable household (though this is not straightforward), or give a breakdown of how consumption is distributed between end-uses in an average home (Wilhite et al. 1999; Kempton 1995).

The minimum requirement at present in the UK is for a meter reading every two years, so that most bills and statements are based on estimated consumption – the source of endless queries and complaints to the suppliers. With some suppliers, customers can phone or email their meter readings as an alternative, but this is not a guarantee of regular, accurate billing. Since October 2005, UK suppliers have begun to disclose the generation fuel mix of electricity supplied to the customer.

> *We can't be using that much...It's just the two of us in this two-bed flat. I am out all day ...and we are on income support. I just don't know how the bills are so high... I think there is something wrong with them.* - Londoner in her 30s, whilst in broad daylight lights were on in most rooms, a TV and radio were playing in an unoccupied bedroom, and all appliances in the sitting room were on standby.
>
> - Dobbyn and Thomas 2005, p26

Table 2 (see Appendix) indicates the range of savings that have been achieved through informative billing – from 0-12% - with comments on characteristics of each study.

The Norwegian informative billing studies show persistence of savings over several years. Wilhite and Ling (1995) reported savings averaging 10% for customers of Oslo Energi who received bills based on electricity meter readings at 60-day intervals (as opposed to the usual single meter reading a year and four bills, three of which were estimates). The figure rose to 12% when the frequent bills were supplemented by feedback comparing the consumption with the same period of the previous year and all periods in between. Interestingly, advice tips did not appear to add to the impact of the frequent bills and feedback. 79% of customers showed an interest in continuing with the new billing system at the end of the project. Eventually, the government made quarterly informative billing mandatory.

A further Norwegian study (Wilhite, 1997) involved customers in Stavanger reading their own electricity meters and sending the readings to the utility. They were helped to understand their new informative energy bills by a well-designed brochure in simple language. Increases of 15-20% in claimed awareness and understanding of billing information resulted over a period of just over a year. Consumer reaction to this project was also very positive. Both studies involved a representative cross-section of households, with roughly 25% using all-electric space heating and 50% some electric space heating.

Three years after the start of the Stavanger trial, the customers who read their meters and received informative bills were consuming 8% less electricity than the general population in the area who were receiving quarterly bills that were mostly based on estimates (Wilhite, pers comm). Their consumption had fallen by 4% compared with that before the new bills were introduced, while that of the control population had risen by 4%. These Norwegian findings are highly relevant to a discussion of Automated Meter Reading.

A review of billing in the Nordic countries found that the longer the duration of a trial and the more information available to the customer, the more persistent the effects were likely to be (Henryson et al, 2000). It seems that the regular reminders of consumption can be a continuing influence, as well as reducing consumption in the first instance. These findings support those of van

Houwelingen and van Raaij (above), that savings fell off when the gas consumption display monitor was removed from homes. Persistent feedback promotes persistent conservation behaviour and also has implications for the development of technology. The regulatory requirement for monthly, accurate bills in Sweden drove the move to smarter (and remote) metering.

Wilhite and Ling found that the single most effective change was from quarterly estimated bills (only one meter reading per year) to bimonthly, accurate bills. They set out what they saw as the chain of causation from bimonthly, accurate bills with historic feedback to savings:

Increased feedback – increase in awareness or knowledge – changes in energy-use behaviour – decrease in consumption

On the basis of qualitative work carried out by the Bristol Centre for Sustainable Energy, historic feedback is likely to be more popular than comparative feedback in the UK (Roberts et al. 2004). Studies using comparative feedback by Haakana et al. (1998) and Egan (1999) show that, while householders are interested in comparisons, they do not necessarily make savings when shown them. The choice of comparison groups is problematic (people may be unhappy with the validity of the group they are assigned to) and the response to comparisons may not be positive. In one study, over 70% of respondents said that they would take conservation action if they were shown to be over the 80th percentile of their comparison group (Iyer et al. 1998). But what if they found themselves at the frugal end of a high-consuming comparison group? It is questionable whether that would provide much motivation to reduce consumption further.

TIME-OF-USE PRICING

Time of use pricing, critical peak pricing and real-time pricing have been major concerns mostly in those parts of the world with summer and winter peaks in demand allied with supply constraints: California, Ontario, the northeastern states of the USA and parts of Australia.

There is evidence of reductions of up to 30% of peak demand through a variety of reduction programmes involving some sort of time-sensitive pricing, with or without direct load control by the supplier. Automatic Meter Management, a likely next step in UK metering, allows for time-sensitive tariffs to be used and communicated remotely to the consumer. But the business case is not yet made for time of use pricing in the UK (Owen and Ward 2006). Moreover, domestic customers are not usually enthusiastic about real time pricing, in which prices are based on utilities' short-term marginal costs and risk is transferred to the customer (IEA-DSM 2005, subtask 2; Barbose et al 2005). There is little scope for load-shifting among domestic consumers. 80% have gas heating, while almost all the rest use off-peak electricity, oil or solid fuel for their heating. There is also a danger that it would penalise some low-income householders with lifestyles that make it very difficult to alter their consumption patterns. This picture could change as the proportion of demand that is met by building-integrated renewables and distributed generation increases, but that is a subject for further research.

Electricity tariff structures do not have to be based on time of use in order to have an impact on load: for example, progressive block pricing offers an incentive to conserve and could be combined with informative billing and displays of how close the customer is to reaching a threshold above which the unit cost will be higher.

COMPARISON WITH OTHER 'SOFT' DEMAND REDUCTION MEASURES

Information on its own has a poor track record in achieving energy conservation. While people may appreciate the message, few are likely to be spurred into action (Heberlein 1975; Condelli et al. 1984; COI 2000; Valente and Schuster 2002). The problems with large-scale information campaigns are those of giving information relevant to people's circumstances at the same time as convincing them that they can achieve change and that it is worthwhile. Learning to use energy more effectively is not possible unless the consumer experiments with the system.

Evaluations of energy advice supplied by the EEAC network show estimated savings of around 5% of annual energy bills following the installation of efficiency measures – that is, capital investment (New Perspectives and NFO BJM). New Perspectives/Energy Inform (2004) give estimated cost savings of around 9% for advice on day-to-day behaviour via the EEAC network. Those on lower incomes are estimated to save more than those on higher, while client-led and 'opportunistic' advice programmes, with personal interaction with an adviser, are able to achieve higher levels of savings than paper-based advice programmes. There are examples of advice programmes that incorporate feedback from meter readings into their procedure achieving measured savings of around 10% in gas and/or electricity (Darby 1999).

Energy education in schools can be a powerful resource (eg, the NP/NFO Utilities evaluation of the 'Energy Matters' course in schools, 2003). Home audits are a part of the course, 76% of pupils' families took some action and the level of behavioural change appeared to be higher than that achieved by advice services such as the EEACs. However, we do not have figures for savings arising from education programmes and they would be difficult to isolate.

PERSISTENCE OF SAVINGS

The main general points to make are the importance of internal motivation as opposed to external incentives and controls (de Young 1993; Dwyer et al 1993) and the need for feedback to be maintained over time in order to allow householders to monitor the impact of any changes in their lifestyles, housing and appliances.

The 3-year trial of informative billing in Oslo found that the effect lasted throughout the trial. Post-experiment interview of the householders showed up no uniform pattern of behavioural changes or purchase/investment decisions to account for the savings. The interviewees rarely remembered any specific changes unless prompted, and the authors of the study state that '*Our impression from the interviews is that after three years the changes people made had become so routine that they had trouble identifying them*' (Wilhite and Ling 1995 p151).

In the West Lothian energy advice programme, the measured savings were made solely from behavioural change. An adviser commented that '*If someone was going to return to their old inefficient habitual ways they would do so within three months. In our experience, if they have adopted a change in behaviour for over three months they have changed for at least a year.*' This does not contradict the need for continuing feedback to keep the householder informed as his or her circumstances change, and as a constant teaching aid for all members of the household.

MICROGENERATION

With energy production as with consumption, it is important to make the whole process as visible as possible. Microgeneration will need to become widespread if the government's renewables and carbon dioxide emission targets are to be met. ECI research shows that most households with solar PV expect a fair payment for their own-generated electricity and would like to be able to see, separately, the amounts of electricity that they are importing and exporting. In spite of the cost of installation of solar PV, displays of this sort are optional and not part of any standard package. In households where this information is visibly displayed, increased awareness has led to a conserving behavioural effect, reducing total electricity consumption by as much as 20% from pre-microgeneration levels (Keirstead and Boardman, 2005).

Some solar water heating installations have associated display units showing water temperature and/or the amount of energy absorbed from the sun in a given period. Again, there are no norms as yet, but such displays do have a powerful effect in raising awareness of the potential for cutting carbon emissions and saving gas or electricity.

> *Beyond the sheer excitement and pleasure of DIY energy generation, the impact is seen in householders' shifting attitudes to energy conservation and consumption ... there starts to develop a strong sense of which behaviours are free and self-provided, versus ones that cost money and are supplier-dependent.*
>
> - Dobbyn and Thomas 2005 p6

SYNERGIES

The literature shows clear evidence of synergies between different types of feedback and between feedback and other types of information. The value of different types of information will obviously vary between individuals and social groups. For some, feedback may jolt them into considering energy for the first time. For others, it complements what they have learned from other sources. The study by Gaskell et al (1982) illustrates both these points. It showed that the most effective means of achieving savings came from supplying groups of householders with information on energy use and at the same time asking them to read their meters daily. Daily monitoring without information, though, led to *increased* consumption (5% gas and 11% electricity), possibly because of an overzealous approach: daily meter readings, temperature readings and keeping an energy diary would be tiresome for most of us unless we could see a clear point to the exercise. The highest savings came from relatively young high consumers.

> The clearest indication of the positive role of feedback in energy advice ... comes from the West Lothian programme [where clients are encouraged to phone in meter readings to their adviser until they are reaching their target consumption]. WLEAP believe that the method *'gives the customer ownership of the problem. They can see right away the positive effects of the energy advice - they can see an immediate drop in consumption without having to wait for a bill to come in and compare it with a bill from the previous year'*. The majority of the fuel savings recorded come from behaviour changes, before any energy efficiency measures have been installed. Of 999 enquiries in 1996/97, 421 clients are recorded as having made savings: these ranged up to €1500 per year, although the bulk (279) fell between €75 and €450 (WLEAP 1997).
>
> The West Lothian approach is supported by other projects studied. A component of two advice projects was the encouragement of tenants to read their own meters and to keep a record of their consumption, while a third project involved monthly meter readings by a project worker (EEO 1988; Sluce and Tong 1987; Hill 1991).
>
> \- Darby 1999

There is also the potential to link feedback at various levels, from the household upwards. Learning about energy from daily usage in homes can connect with learning in the community, or with learning by utilities and government.

There needs to be a common language in which the information is expressed. For example, a web page with a graph of current load and available capacity plus forecasts for the Californian electricity system received more than 2m hits each day during the 2000/01 electricity crisis (LBNL 2001). The page was a simplified version of data that had previously only been available to the state's energy policy makers and utilities. The authors stated that their impression from limited interactions with visitors to the site was that many people were modifying their actions as a result of observing what was happening on the grid.

SUMMARY AND CONCLUSIONS

Domestic energy consumption is still largely invisible to millions of users and this is a prime cause of much wastage. Feedback on consumption is necessary for energy savings. It is not always sufficient – sometimes people need help in interpreting their feedback and in deciding what courses of action to take – but without feedback it is impossible to learn effectively.

Immediate direct feedback could be extremely valuable, especially for savings from daily behaviour in non-heating end-uses. In the longer term and on a larger scale, informative billing and annual energy reports can promote investment as well as influencing behaviour. Savings have been shown in the region of 5-15% and 0-10% for direct and indirect feedback respectively.

User-friendly display is needed as part of any new meter specification. Monitors would be most useful if they showed instantaneous usage, expenditure and historic feedback as a minimum, with the potential for displaying information on microgeneration, tariffs and carbon emissions (linked to disclosure in the bill of the emissions factor of their supply).

Feedback is of value in itself as a learning tool and must be seen in context. The outcomes from feedback will vary according to circumstances, but they can also sometimes be improved by using feedback in conjunction with advice and information.

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APPENDIX: SUMMARY OF QUANTITATIVE FINDINGS

1: Direct feedback studies

Study	Date	Savings	Persistence	Sample size	Control	Location	Energy source	feedback type	Other change	Comments by authors [and by SD]
Seligman, Darley and Becker	1979	16% against controls for feedback+light or light alone	4-week study, summer	10 with blue light and feedback, 10 blue light, 10 feedback	10	USA	electricity	Flashing light went on as outdoor temperature cooled beyond 68F; feedback 3 times/ week, giving ratio of actual:predicted consumption		The feedback was ignored because it jumped around and did not seem credible.
McClelland and Cook	1979	12%	11 month study, Sep-Jul	25	75	USA	electric, in new, insulated, all-electric homes	Fitch energy monitors with display of cents/hr.	none	Displays 'may have served more to teach residents what activities consume the most energy than simply to draw attention to the cost of energy.' Homes with monitors had lower consumption than controls in all 11 months (Sept -July) with greatest differences in months with moderate weather. Suggests that conservation actions taken by households with monitors primarily affected energy uses other than heating and cooling.
Gaskell, Ellis and Pike	1982	9% from feedback, 11% from fb + info	4 weeks	80 had fb/fb + info	80 had info alone/nothing	UK	electricity	Meter readings	weekly visits, daily diaries	Information alone gave 8% saving
Gaskell, Ellis and Pike	1982	5% and 22%	4 weeks	80 had fb/fb + info	80 had info alone/nothing	UK	gas	Meter readings	weekly visits, daily diaries	Information alone gave 9% saving
Winett et al	1982	15% against controls for feedback and/or video	3-week baseline + 5-week intervention, winter and summer	85 winter, 53 summer	yes	USA	electricity	Daily, plus weekly visits from experimenters	Videos demonstrating alternatives for comfort	Feedback alone and feedback+video were more effective than video alone. The video showed ways of being comfortable without recourse to overheating or air-conditioning, using positive language.
Hutton, Mauser, Fillatrault and Ahtola	1986	up to 7% over controls, depending on context	unclear	3x25 (I city in US and 2 cities in Canada): ECI + education	3x75: education only, experimental control, blind control	USA + Canada	gas + electricity	Energy Cost Indicator (ECI)	Education materials for 2 groups	Consumer response influenced by situation, eg all-electric homes, extreme weather=high motivation, Quebec, the coldest area, gave strongest behavioural effect and had highest levels of knowledge about usage and savings. 'It does appear that the ECI enhances learning in low-knowledge situations' - California. No evidence from Quebec and BC that the ECI made a significant difference to knowledge about energy-saving actions. For Quebec, ECI+info gave 4.1% savings over exptal control; BC, 5% less increase in consumption than control. In California, only middle-class, educated consumers made savings, 7% over control.
Sluce and Tong	1987	13%	5-month study	31	25	UK	gas + electricity	Fortnightly advice visits including meter readings by adviser	Energy diaries	Low-income households in town houses. All received draughtproofing in the course of the study
van Houwelingen and van Raaij	1989	12% compared with previous; 10% with control; 7% with self-monitoring; 4% with external feedback	1 year experiment. 1 year later, differences between groups ceased to be significant	50	5x 55	Netherlands	gas	Indicator showing daily gas use along with reference figure (agreed norm), adjusted for weather. Signal light to show when heating was on.	None	Supports view that commitment in combination with feedback leads to greater savings than external feedback or self-monitoring alone. Cumulative daily feedback via a display/indicator better than monthly external feedback or self-monitoring. 'People seem to need a permanent reminder and a regular check in their home in order to save energy' [savings lessened when the indicator was taken away]. Interviews with participants showed growing awareness of energy use. Self-monitoring did not work, perhaps because people could not distinguish between weather-related change and other change.
Dobson and Griffin	1992	13% compared with controls and compared with weather-adjusted baseline	a persistence of conservation behaviour,.. with electrical consumption declining by approx 5% over the 60 days' [for the households with displays]	25, random sample	75, randomly selected	Canada	electricity in all-electric homes	Residential Electricity Cost Speedometer, showing cost on hourly, daily, monthly and annual basis; also breaks down by end-use	No change	A post-test interview indicates that households with the RECS 'began thinking about their electricity usage in ways not possible without specific feedback. Two contacted the supplier for information on heat pumps. The group reported increasing their use of the RECS over the period of the test.
Harrigan and Gregory	1994	26% over controls for feedback+education+ weatherisation. 28% for education+ weatherisation. 14%, weatherisation only	14-month study, then reevaluation in 3rd year. Persistence of 84% of 1st-year savings for the education+feedback+ weatherisation group in year 3, comparable with weatherisation-only group (90%).	47 x 3	39 in yr 1; 13 in yr 3	USA	gas	Energy Log display	Weatherisation+education sessions+ electric DSM measures+ payment plan	No significant difference between education and education+feedback: the difference was between the groups that did or did not have three intensive in-home sessions on energy and money management. The educational focus had been on space and water heating (both gas);
Nielsen	1993	1% (flats), 10% (houses)	3-year study	approx 1500		Denmark	electricity in non-electrically heated homes	meter reading	written information	Savings were low in the flats - relatively low-income householders.
Staats and Harland	1995	27%	savings were measured 6-9 months after the 6-month project was over.	93		Netherlands	electricity	Householders read their meters and compared readings with the others in their 'Eco-team'		Social factors and commitment a key element. Savings persisted/ increased 6-9 months after programme ended. Participants installed more low-energy lights and low-flow showers than Dutch population
Staats and Harland	1995	23%	savings were assessed bewtween Jan-Feb and Oct)	144		Netherlands	gas	Householders read their meters and compared readings with the others in their 'Eco-team'		Social factors and commitment a key element in the Eco-teams
Brandon and Lewis	1999	12% for PC feedback over baseline for those who saved; 3% increase for those who did not.	9 months	120 in 7 groups, including control group	yes	UK	gas and electricity	Written or via the PC	various information materials for some groups	Income and demographics predicted historic consumption but not changes during the study, where environmental attitudes and feedback were influential. The only feedback form the authors are confident about is interactive via the computer (smart metering and household-specific systems may do away with need for a PC).'Visibility may be the key to change.'
McCalley 2000	2000	Up to 21% over baseline, according to experimental conditions.		1	25	Netherlands	washing machines	Simulation using a copy of washing machine control panel	various items of information	Emphasises the importance of goals and social or self-orientation as determinants of effectiveness of feedback.
Wood and Newborough	2003	14% over baseline for ECI only; 12% for ECI+information; 3% for information only	12-month baseline, then 2-months+ for trial of display. No data on persistence after experiment	10 with Energy Consumption Indicator; 10 with ECI+ information pack	12 with information pack only, 9 in no-action control	UK	electric cookers	Direct, through ECI attached to cooker		The use of electronic feedback indicators deserves further attention and optimisation. The units that the ECI displayed were cenbtral to the user being able to understand the display.
NIE	2002?	11% compared with previous usage		former prepayment customers		UK	electricity	Keypad display, pay-as-you-go	no bills; induction/advice	Keypad fitted in room of customer's choice.
NIE	2003?	4% compared with controls	12 months	26 former credit customers	national consumption	UK	electricity	Keypad display, pay-as-you-go	no bills; induction/advice	Keypad fitted in room of customer's choice.
Mountain	2006	6.5% against baseline (adjusted for weather, appliances, demographics)	2.5-year study. Response was persistent across the study period.	505	52	Canada	electricity	Portable monitor with instantaneous feedback, consumption in kWh, $ and CO2, per hour, in total and predicted		Only 2% of the selected customers refused to have one in their house for the study. Highest savings (16.7%) came from homes with electric WH but not SH (air-conditioning made no difference to this figure) . Separating feedback from the heating load and the rest of the load would be needed to encourage conservation in this sector.'
Benders et al	in press	8.5% over control	5months	137 households, Groningen	53	Netherlands	gas and electricity	Web-based tool, using billing data	information as well as feedback	Quite a high drop-out due to lack of time, computer difficulties, lack of Internet connection. Those who persevered were +ve about the website.

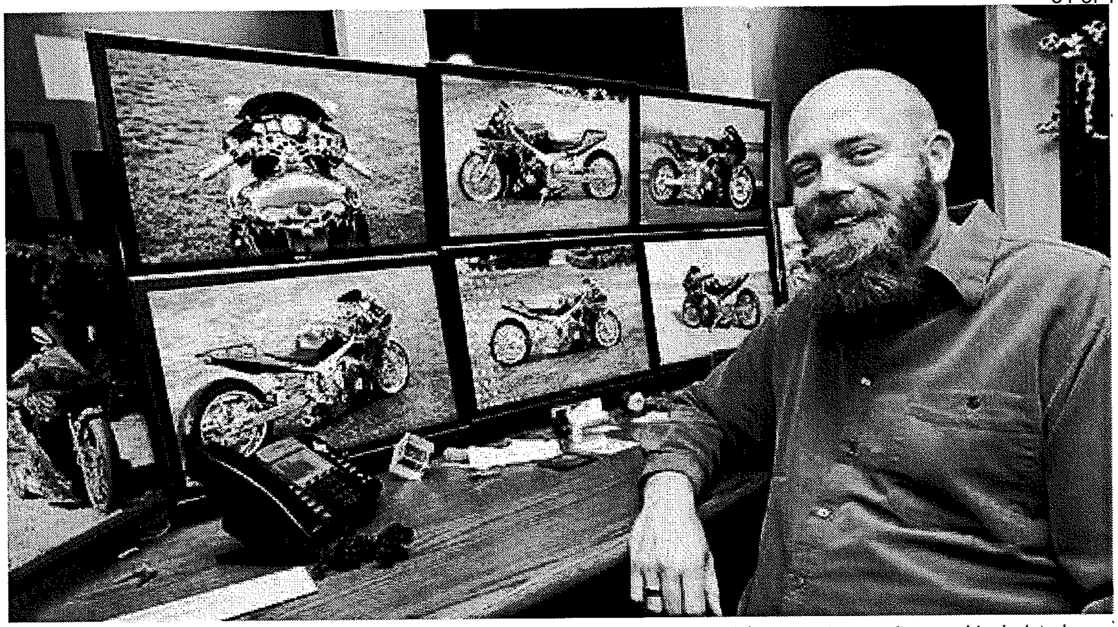
2: Indirect feedback studies (billing)

Study	Date	Savings	Persistence	Sample size	Control?	Location	Energy source	feedback type	Other change	Comments
Bittle, Valesano and Thaler	1979	Mixed effect	2-month study, summer	353	delay group' with no feedback from days 18-28. 16-day baseline study	USA	electricity	6 days/week, historic feedback, 4 types, from the experimenters. kWh/day, cumulative kWh since start of month, cost/day and cumulative cost..		Feedback led to 18% reductions by high consumers but had opposite effect for some med and low consumers. Baseline study was not a true baseline - it involved experimenters coming to the house to read the meter.
Seligman, Darley and Becker	1979	10%	3-week study, summer	15	14	USA	electricity	Almost daily from the experimenters, giving ratio of actual:predicted consumption		Providing homeowners with feedback about their rate of consumption can be an effective strategy for conservation.
Seligman, Darley and Becker	1979	13%	4-week study, summer	80 in 4 groups	20	USA	electricity	3 times/week from the experimenters	householders asked to set a difficult or easy conservation goal	Feedback especially effective if the homeowners are motivated to save a considerable amount of energy. Controls also had a notice ir their kitchen window that was ticked each time the meter was read - ie, likely Hawthorne effect.
Arvola et al	1994	3% against controls for feedback; 5% for feedback+ advice tips	2 year study	525	175	Finland	all-electric	Bills every 36 days; in the 2nd year, historic feedback was added to the bills.		Frequent billing seemed to have the largest single effect. The experiment had most influence on families with lower incomes and those with high baseline consumption.
Garay and Lindholm	1995	A 'tendency of red. consumption in electrically heated homes', but an inc in district heating. .	15 month project	600	600	Sweden	electricity+ district heating	Monthly bill with measured energy use + historic and comparative feedback		Through interviews, discovered that the new bill improved householders' control over their energy costs. 96% satisfaction. Treatment and control groups were not similar enough to give good comparisons.
Haakana et al	1998	7% over internal controls	2.5yrs after end of study, almost 1/2 h/holds still making savings. Monitoring still frequent; most freq in h/holds which had made savings.in electricity and water.	105		Finland	electricity, no electric heating	H/holds sent monthly form with meter readings. Utility sent monthly comparative+ weather-adjusted historic feedback .		Advice after feedback had no further effect. The 7% may be an underestimate - it comes from comparing monthly consumption from Dec-March with monthly consumption April-November.
Haakana et al	1998	4-5% over blind control	2.5yrs after end of study, almost 1/2 h/holds still making savings. Monitoring still frequent; most frequent in h/holds which had made savings.in electricity and water.	79 with fb	26 w no fb or info; 650 blind controls	Finland	gas	H/holds sent in mnthly form from meter readings. Utility sent monthly comparative+ weather-adjusted historic feedback.	advisory material as requested - video or written - for 2 exptal gps.	Savings were not necessarily according to the written advice recd.Internal controls made almost as many beh changes as exptal gps. Type of (video, written. Meter) made no diff.
Wilhite and Ling	1995	10% over controls	3 years. 'our impression from interviews is that after 3 years the changes people made had become so routine that they had trouble identifying them.'	191 with frequent bill;209 with feedback; 211 with feedback+tips	675, matched for ownership status, size of home and stage in family cycle	Norway	electricity	6 bills/year based on meter readings, with simplified text and a graphic showing each period compared with the previous year, temperature-corrected.		Wasteful habits linked to misunderstandings about where energy is used in the home. Recipients of the new bills paid more attention to them, were more likely to discuss them and wanted to continue with the new system. Costs minimal in relation to savings - about $0.01/kWh saved. A small amount of saving may have been achieved by fuel-switching. Younger customers more likely to reduce consumption than older.
Wilhite	1997	8% (see next column)	The project ran from March 1995-Dec 1996. In April 1998, consumption of the participants had fallen by 4% compared with baseline, while that of customers in surrounding areas had risen by 4% (Wilhite, pers. comm).	2000	comparison made after the study was over	Norway	electricity	Customers read their meters and sent in the figure to the utility, every 60 days. After a year, they were sent historic feedback.	transfer of meter-reading from utility employee to customer	Good results in terms of customer satisfaction and loyalty. 18% more customers read their bills often or always; 19% more were satisfied with the information; 20% fewer of the younger customers said they did not know whether their consumptioh had changed over the past 2 years; 8% more customers reduced temperatures at night. The costs of billing doubled but the supplier expanded the recipient group from 2000 to 25,000 households in 1997.
Henryson et al	2000	0, 2, 2, 3, 2-4, 10 and 12%		7 studies, samples of 600-1500 inc. Wilhite&Ling		Scandinavia	electricity	Increased energy awareness and customer satisfaction in 6 of the 7 studies. One reports that increased information did not change attitudes.	With and without additional information	The longer the duration of a trial or the larger the quantity of information, the more prolonged the effects.

3: Electricity feedback with time of use pricing

Study	Date	Savings	Sample size	Control?	P:OP ratio	Location	feedback type	Comments
Kasulis et al	1981	some rescheduling of consumption	30			USA	written, with bill: use + cost, peak and offpeak	Participation was mandatory
Sexton et al	1987	26% savings at peak when p:op at 9:1	480	120	various	USA	monitor showing peak, offpeak and total consumption	Customers were informed that the exercise was to do with load-shifting, not conservation
CPUC pilot of DR to CPP with sms cited in Owen and Ward	2003-4	27% peak reductions with automated response at highest CPPs to 5-10% without automated response				USA		Information about peak periods without a price signal gave no savings. No impact on overall demand - just shifting. Though an IEA study cited, which showed 4% average conservation effect
Crossley for IEA, cited in Owen and Ward	2005	12-14% peak reductions	1200					
NIE	2005	11% reduction in evening peak when price signal is applied	100 price message gp - 4 keypad ToD bands+ 3 tariffs	100 - 4 keypad ToD bands + flat tariff	5.8p:8.6p: 15.4p	UK	keypad display	93 in each group finished the trial. Best prospects for load management = wet appliances (12%). Also lighting at 24%. Functionality of meter has changed little - just added display giving real time cost data.
Puget Sound Energy (from IEA DSM subtask 2)	2005	5% peak reduction	300,000		14 Euro-cents, reduced to 12 after a year	USA		Customers left the programme when the P:OP ratio was reduced and they realised they were paying slightly more by participating than they would by not participating.
Gulf Power Company (from IEA DSM subtask 2)	2005	22% reduction against controls at peak periods; 37% in critical peak periods	3000		8:5, with CPP = 3x peak price	USA		Customers were given a thermostat that could be programmed to control their major end-uses when prices exceeded a preset level
SWALEC (in IEA DSM subtask 2)	2005	25% reduction in peak - enough to avoid reinforcing a rural distribution network	100+			UK		Demand control algorithm scheduled charge and release of energy from storage heating based on half-hourly price message 24 hours ahead. No customer override - but acceptable to customers. Could not be used with profile settlements and was not rolled out because of additional cost needed for TOU metering and processing of the data.
Martinez and Geltz	2005	some overall reduction	32 residential, 29 commercial		up to 4:1	USA	ambient - the Energy Orb. Notification the day before a Critical Peak Pricing event	4-month trial. Many reduced consumption well in advance of peak pricing time. Resdential customers more interested in real-time information than commercial

FINANCE & COMMERCE



Josh Headlee, CEO and co-founder of St. Paul-based Accelerated Innovations, has eight computer monitors on his desk to keep track of business. But his screensaver features the custom motorcycle he owns. (Staff photo: Bill Klotz)

Sustainable: Reducing energy use through behavioral science

By: Frank Jossi September 1, 2014 10:00 am 0

Accelerated Innovations LLC

Ownership: Private

Location: Brooks Building, 366 Jackson St., St. Paul

Product: MyMeter, engagement tool used by customers of utilities to reduce energy

Website: mymeter.co

CEO and co-founder: Josh Headlee

Latest annual revenue: N/A

Employees: 15

Projected hiring: Anticipates openings for IT professionals

What's next: Working on new products focused on commercial building owners

The St. Paul-based company behind a Web portal that lets residential customers of utilities view their energy use recently achieved an important milestone. A third-party report released in July validated that the product, called "MyMeter," leads customers to make changes that reduce their utility bills.

Accelerated Innovations LLC, the developer of MyMeter, now plans to aggressively court business customers, said CEO Josh Headlee.

"We're rolling out the large office product soon," he said. "We think there's a great market for it with commercial building owners."

MyMeter, offered by 30 utilities in 15 states and two countries, has attracted 264,000 users since opening in 2008. The company's "engagement technology" platform initially focused on supporting fan-based sports sites before finding a niche with MyMeter.

Verona, Wisconsin-based Illume Advising LLC conducted the study that proved the behavioral energy efficiency approach worked and that MyMeter reduced annual energy use by 1.8 percent to 2.8 percent among the utilities' residential customers.

"I was a little nervous about the study," Headlee said. "But I had a gut feeling there was something there."

Minneapolis-based Xcel Energy Inc., the region's major utility, has similar residential and business programs. On the residential side, Xcel uses reports created by Arlington, Virginia-based Opower, available at its website.

On the business side a new pilot program called "Energy Feedback" has about 20,000 small and mid-size businesses in Minnesota, Xcel spokeswoman Mary Sandok said. Businesses can also use "My Account's My Energy" services at the company's website, but the data are not available in real time, she said in an email.

Similar studies of the business community's reaction to behavioral energy efficiency programs show an even larger savings, usually from 3 percent to 5 percent annually, Headlee noted. The difference is building owners have much larger structures to manage, and some simple changes — LED and sensor lighting, new equipment — can often have a significant impact on energy use, he said.

For now, MyMeter allows residential customers to log in to a Web portal and study energy use on a daily basis. They can establish an energy-saving goal and track progress, sign up for text or email alerts to warn them of peak demand periods, and compare their energy usage to their neighbors.

Customers who actively use MyMeter reduced energy use by turning off lights, changing to energy efficient bulbs, air-drying laundry, using power strips to turn off multiple devices and changing thermostats to temperatures that are a little cooler in winter and a bit warmer in summer, Headlee said.

Changing behavior

From FitBit exercise tracking devices to water usage monitors, the idea that access to data prompts behavioral change is gaining ground. People who see data will often take action and change their behavior, said Headlee.

The more customers look at the Web portal describing their energy use, the more likely they are to start saving energy, he said. Utilities offer the service free to commercial and residential customers.

Anne Dougherty, co-owner of Illume Advising, conducted the MyMeter study. The results fell in line with other behavioral studies that generally show utilities seeing a 1 percent to 4 percent energy decrease. MyMeter, though, had data going back several years, much longer than others offering a similiar service, shesaid.

Favorable data on smart meters have changed the way utilities invest in energy savings programs, Dougherty said, because behavioral energy efficiency is so cost- effective.

Web-based monitoring programs "are now making their mark very quickly," she said. "These programs offer an opportunity to save energy that wasn't there six or seven years ago."

The study's verification of energy reduction through MyMeter has other ramifications. The Minnesota Department of Commerce has accepted the findings and allows state utilities using MyMeter to count the kilowatts saved toward a state mandate that requires power producers to reduce electric energy use 1.5 percent annually.

Just two other companies in the nation have had their energy reduction programs validated, according to Jan Cook, MyMeter's vice president of customer engagement. They are Opower and Redwood City, California-based C3 Energy, the brainchild of Siebel Systems' founder Tom Siebel.

Going after business customers

The next move for the company is selling services to businesses, said Cook, who once worked for Opower. MyMeter's customer base is 90 percent residential and 10 percent commercial, but the potential is clearly there to support more business involvement, said Cook.

A deeper dive into the company's data from the Illume study indicates that businesses using MyMeter could see a 5 percent to 6 percent annual savings, she said. Those figures come mainly from Bemidji-based Beltrami Electric Cooperative, which offered MyMeter to business customers.

Recent clients include Duluth-based Minnesota Power, which will apply the data management feature to track solar production and other issues. In Tennessee, the Nashville Electric Service deployed the technology to study the impact of load control devices on commercial building rooftops, Cook said.

One large utility outside the Midwest recently awarded a contract to MyMeter to build a program to encourage energy reduction in buildings of more than 100,000 square feet. Although MyMeter isn't ready to reveal the name, Cook said, the idea behind the program is to reduce energy in more than 60 office buildings by devising friendly competition among them — and within them by pitting floors against one another.

The project will require an upgrade of the MyMeter software to allow for even more detailed data, such as energy use by floor, she said.

A new MyMeter project for a convenience store chain involves creating a program to educate managers on energy use and recognize those who succeed in reducing it, Cook said. It's all part of a growing campaign by MyMeter to develop products to achieve a greater foothold in the commercial real estate and business world, she added.

Perhaps those efforts will be as successful and fun as the programs that utilities involved in the study used in promoting MyMeter. The Rockford-based Wright-Hennepin Cooperative Electric Association sponsored contests such as "The Biggest Loser" and the "The Littlest User" over the past few years.

Customers who won those contests decreased their energy consumption as much as 60 percent by drying clothes without using dryers, charging cell phones at work or at friends' homes, sleeping in tents and turning down the heat and air conditioning, said Sonja Bogart, the co-op's vice president of sales and marketing.

She was not surprised by how MyMeter data influenced customers' behavior. "It's a nice tool that helps make customers aware of their energy use and encourages them to make it better," she said.

Tagged with: ACCELERATED INNOVATIONS LLC | C3 ENERGY | ILLUME ADVISING LLC | MINNESOTA DEPARTMENT OF COMMERCE | MYMETER | OPOWER | SIEBEL SYSTEMS | UTILITIES | XCEL ENERGY INC.

OPOWER

WHITE PAPER

The Value of Utility Customer Engagement

Engaged customers deliver cost savings across the utility business

Abstract

Utilities around the world are planning or deploying massive customer engagement initiatives, and for good reason. Customers in the U.S. currently spend less than seven minutes each year interacting with their utilities,[1] and persistent deficits in customer engagement can become a major liability. According to J.D. Power, disengaged customers are less satisfied with their utility service[2], and low satisfaction correlates with reduced operating margins[3]. In addition, disengaged customers are most likely to resist new utility initiatives, ranging from smart grid infrastructure updates to rate increases to a variety of other projects. Lastly, as energy delivery models change, with mass-market distributed generation on the horizon and energy storage technology steadily progressing, utilities have to create a sticky relationship with their customers today to stay relevant tomorrow.

Successful customer engagement creates significant value for utility shareholders. Opower has developed a business case framework to quantify potential benefits of customer engagement through cost savings across various areas of utility operations. According to this model, each engaged household can add an incremental $40-$90 annually to a regulated utility's bottom line. This white paper identifies the sources of this incremental value across several utility domains: program marketing, customer care, energy efficiency, and demand response.

1. Accenture, Actionable Insights for the New Energy Consumer, 2012
2. J.D. Power, 2013 Consumer Engagement Study, 2013
3. J.D. Power, How Customer Satisfaction Drives Return On Equity for Regulated Electric Utilities, 2012

Figure 1 provides a summary of the estimated annual savings potential:

Value source	Annual savings per regulated household
Effective marketing of new offerings	**$4-5**
Reduced cost-to-serve	
Reduced call volume, decreased escalations, etc	**$3-16**
Increased adoption of e-Billing	**$3-5**
Improved payment discipline	**$1-4**
Improved cost-effectiveness of EE Program portfolio	
EE program cost savings via Behavioral EE	**$2-5**
EE program cost savings via Thermostat EE	**$20-35**
Behavioral Demand Response (DR) capacity and energy cost savings	
Behavioral DR capacity savings	**$7-20**
Potential Aggregate Value, $/Household, per year	**$40-90**

FIGURE 1: POTENTIAL ANNUAL COST SAVINGS FROM INTEGRATED CUSTOMER ENGAGEMENT SOLUTIONS

Customer engagement enables utilities to expand the value of each household

Happier Customers are an Asset

The traditional utility business model is changing rapidly. Major drivers include the transition to Smart Grid, market restructuring, increased adoption of distributed energy resources, and decelerating sales growth. During this period of change, engaged customers can be a significant asset.

Most typical customers today interact at moments when they feel discontent, like during an outage or upon receiving an unexpectedly high bill. Engaged customers, on the other hand, actively participate in utility innovations. They hear what utilities have to say and act accordingly.

Utilities around the world are activating customers by investing in Customer Engagement platforms that allow them to deliver the right message to the right customer, through the right channel, and at the right time. This approach — which borrows from the success seen in other industries that have employed similar techniques, such as retail, personal banking and even social media — creates a personalized and highly tailored engagement approach for each customer and has also been proven to increase customer sentiment.

SUCCESS STORY: LARGE IOU

Opower finds that recipients of personalized insights have a better perception of their utility provider. The difference in customer sentiment can be as much as 5-9%.

I agree that my utility wants to...

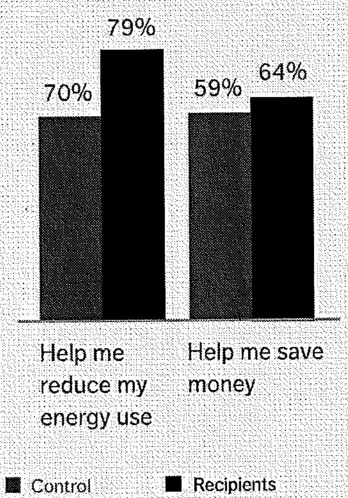


FIGURE 2. CUSTOMER SENTIMENT IMPROVEMENT WITH ENGAGEMENT

Through customer engagement initiatives, utilities can develop better relationships with their customers.

Importantly, engaged customers are more satisfied with their utility service. That increased customer satisfaction translates into a positive regulatory environment, which can lead to higher returns and support for new utility investments.

Based on dozens of surveys conducted globally with utilities, Opower's customer research team has confirmed that engagement indeed leads to higher customer benevolence metrics. Empowered with personalized insights and consistent feedback, engaged customers perceive their utilities as providers of trustworthy information interested in helping customers save money (Figure 2).

Proactive customer engagement also affects how customers perceive Smart Meters. Opower has found that AMI customers, provided with integrated communication solutions, express 15% higher satisfaction with Smart Meters.

Sentiment improvements are significant, but more meaningful are measurable impacts to the utility bottom line. In the next four sections we show how more engaged and more satisfied customers deliver incremental value to the utility business.

VALUE SOURCE #1: LOWER CUSTOMER ACQUISITION COST WITH EFFECTIVE MARKETING

As utilities continue to expand their program offerings, they need to educate customers on a wide variety of efforts, including new self-service options, online energy insights, demand response programs and other services such as appliance rebates. Traditionally, utilities have used standardized, one-size-fits-all mass mailing to drive education, and have struggled with low open and recall rates. With modern technology, utilities can now offer highly personalized outreach through both mail and digital channels. Utilities can also boost their marketing effectiveness by segmenting customers based on a variety of customer information (demographic, psychographic, behavioral) and tailoring messaging and channel choice to meet the needs of each individual customer.

Home Energy Reports that many utilities send to their customers are one example of an outreach strategy that leverages modern technology. Thanks to the personalized insights they provide, this product has been proven to yield very high open and recall rates (>80%). Taking advantage of increased customer receptivity, utilities have successfully used contextual promotions within the Home Energy Report to increase participation in key programs such as home audits, appliance rebates or weatherization. This participation lift translates into reduced outreach cost.

By saving on per-customer fixed costs, regulated utilities can either increase participation using the same marketing budget or reduce the budget while still realizing the same participation levels. Either approach translates into $4-$5 cost savings per household[4].

4. Assumes participation lift of 20% - 60% and benchmarks against sample utility marketing budgets.

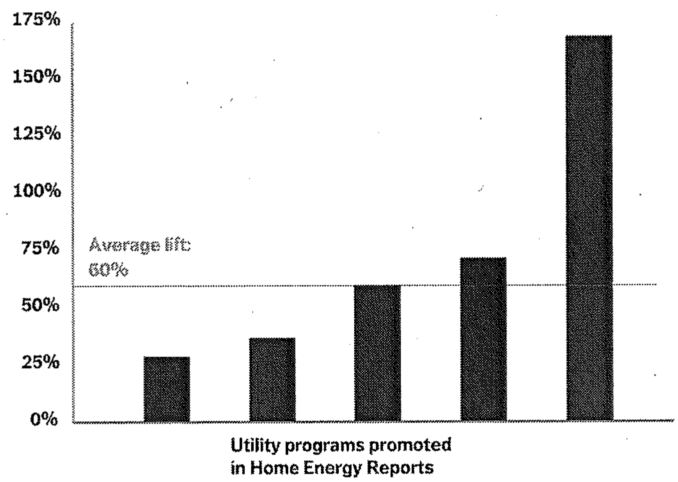


FIGURE 3. PARTICIPATION LIFT FROM HOME ENERGY REPORT MARKETING

When Home Energy Reports and other personalized outreach mechanisms are used to actively promote programs, participation increases are significant.

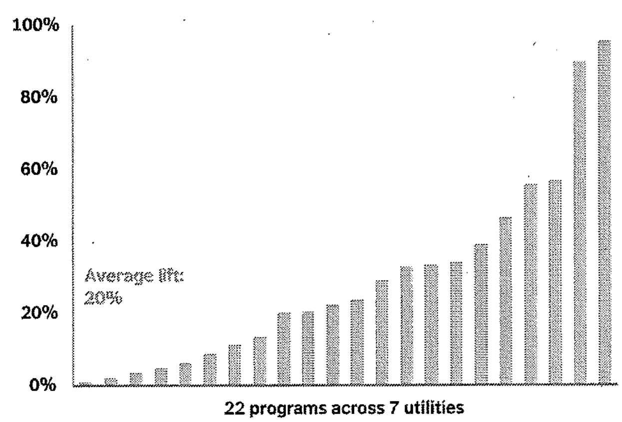


FIGURE 4 .CUSTOMER PARTICIPATION LIFT FROM HALO EFFECT

Even when Home Energy Reports do not actively promote programs, increased awareness leads to higher participation.

SSE SUCCESS STORY: PAY FASTER? NOT A PROBLEM!

Scottish and Southern Energy (SSE), a leading UK energy retailer, drastically improved payment discipline by introducing a mobile payment technology. In fact, consumers liked the app so much that, for 74% of the customers who used it, the average bill payment time decreased from 14-21 days to 48 hours.

Furthermore, it was discovered that 25% of users actually pay the bill within 15 minutes of bill notification!

VALUE SOURCE #2: REDUCED COST-TO-SERVE VIA PROACTIVE ENGAGEMENT

Utility cost structures are under growing pressure. As a result, utilities are always looking for opportunities to reduce cost to serve. And increased customer engagement can be a key tool to reducing cost to serve because engaged customers are more likely to use self-service tools and be more reliable ratepayers.

Specifically, proactive customer engagement leads customers to shift to lower-cost interaction channels (like digital channels), increases the adoption of paperless billing, and increases on-time payments. As a result, from a utility's perspective, an engaged utility customer costs anywhere between $7-$25 less to serve per year.

» **Increased call center efficiencies** - Customers call their utility providers, on average, between three and five times a year[5]. Most of these calls relate to account details, billing, and moving service (50% of all calls, on average). Some of these calls (high bill calls in particular) result in expensive call escalations and truck rolls to investigate potentially faulty meters. But when customers receive personalized energy insights, they are more likely to take advantage of self-service tools and call less frequently. This is because they can find the information they need either online or via their smartphones. This analysis estimates that customers with access to online self-service information, outbound opt-out usage alerting and informed contact center representatives will call approximately 20% less, and will have reduced rates of repeat calls, call escalations and truck rolls. Assuming an average cost-to-serve of $6[6], this improvement translates into approximately $3-$16 of cost savings per engaged household per year. The large range in value is due to geographic and utility-specific variation in the cost of many inputs, such as labor, frequency of call escalation, and truck-roll requirements (among many others).

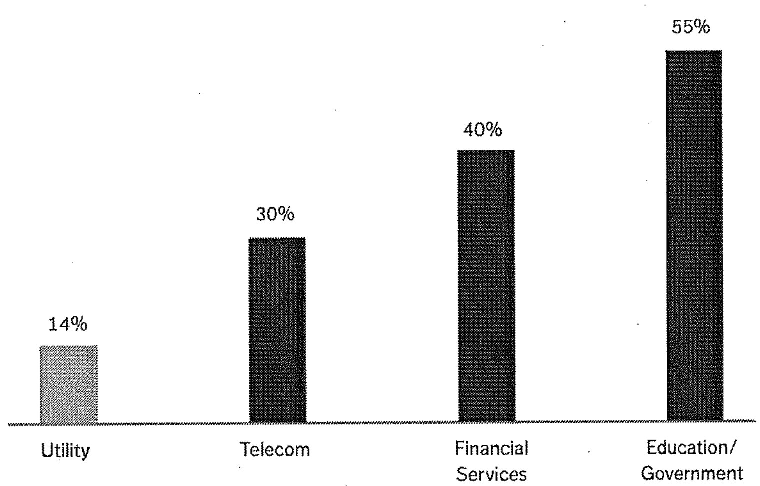


FIGURE 6. E-BILL ADOPTION RATE BY SECTOR, 2011

Utilities lag other industries in e-Billing penetration

5. Gartner; Opower
6. Opower call centers benchmarking

STATEWIDE BEHAVIORAL EE: NATIONAL GRID

In 2013, National Grid Rhode Island expanded their Behavioral Energy Efficiency program to all 425,000 residential customers. Utility President Timothy F. Horan remarked, "The Home Energy Report program is a great way for Rhode Islanders to save on their energy bills. Not only does the program provide simple energy efficiency measures, it also gives customers a chance to see how their efforts are paying off." The customer engagement strategy includes mailed reports, a web-based application, a rewards program, and community initiatives.

» **Increased adoption of e-Billing** - The utility industry significantly lags other major industries in its ability to get people to pay their bills electronically (FIGURE 6). By transitioning to e-Billing, utilities eliminate the costly need to print and send paper bills. While the exact value and duration of value from switching customers to electronic payments varies widely across the utility industry, we estimate that, on average, these savings equate to $3-$5 per average household, per year, or $0.25-$0.45 per household on a monthly basis[7].

» **Improved payment discipline through mobile and reminders** - The Scottish and Southern Energy success story[8] (see sidebar) shows how an engaging mobile app can transform how customers pay. Mobile technology[9] helps customers pay on time and helps utilities avoid 30- to 90-day payment delays from some of their customers. By improving accounts receivable turnover, utility providers can save on the cost of working capital. Given an average monthly bill of $100 and an average annual utility cost of capital of 10%, on-time bill payments translate into annual savings of $1.20-$4.00 per household.

Overall, the potential cost-to-serve benefits driven by increased customer engagement adds approximately $7-$25 per household per year to a utility's bottom line.

VALUE SOURCE #3: MORE COST-EFFECTIVE, SCALABLE ENERGY EFFICIENCY

Over the past decade, Energy Efficiency programs have experienced significant growth driven in large part by state regulation, mandates, and self-imposed targets. However, the rate of participation in non-CFL residential EE programs is just 1-3%[10]. Customers are either not aware of utility offerings (in fact, even the most promoted efficiency programs have awareness rate of only 28%[11]) or they do not see any value in participating.

As a result, many utilities are trying a new approach – delivering highly engaging, personalized insights to a broader set of customers to drive behavioral change and energy savings. These programs can work using information alone or can work in conjunction with installed devices such as thermostats. In either case, they create value for utilities by providing a highly scalable source of energy savings that can maintain cost effectiveness even as efficiency goals increase.

» **Behavioral EE** - Behavioral programs are some of the most cost-effective efficiency programs at scale, rivaling lighting programs. We estimate that Behavioral Energy Efficiency, if implemented across the United States, has the potential to save residential consumers alone more than 18,000 GWh and $2 billion each year[12]. These programs implement advanced customer targeting and segmentation to effectively engage a broad set of customer groups. In some states, the difference between the costs of more expensive programs (e.g. water heating programs, cooling, refrigerator recycling, and low-income solutions) and behavioral EE is as large as $0.06/kWh[13]. With the average cost-effectiveness of behavioral energy efficiency programs being $0.03 per kWh

7. Opower client study
8. Telrock press release, 2011
9. See Opower White Paper: *Is Mobile Turning into a missing Opportunity?*
10. Industry benchmarks
11. J.D. Power, 2013 Consumer Engagement Study, 2013
12. For more information on the potential of Behavioral Energy Efficiency, reference www.beepotential.com
13. ACEEE, Achieving 20% Energy Savings by 2020, 2012

saved[14], behavioral EE can replace less cost-effective programs and save $2-$5 per each household per year, assuming conservative average household electricity and gas savings rates of 1-2% (across an annual average usage of 80 million Btu[15]).

» **Thermostat-derived EE** - Customers are beginning to embrace WiFi thermostats to enhance comfort and convenience, motivated by increasing device choices and personalization of the supporting platforms. When paired with behavioral engagement software, these thermostats can create new opportunities for cost-effective energy savings for consumers and utilities alike. Behavioral software nudges customers to save by encouraging more efficient setpoints regardless of whether cycling is engaged remotely through a push signal. As a result, utilities can reach energy efficiency and demand response goals more effectively. Studies have shown that customers who respond to personalized recommendations achieve consistent, year-round savings on their air conditioning and heating costs[16].

Also like traditional A/C switches, WiFi thermostats, when connected to utility systems, can enable cost-effective direct load control. By coaching customers on how to best save energy during peak times, utilities can realize a significant improvement in load drop during DR events[17]. This equates to an incremental $5-$9[18] in avoided capacity costs per household annually and evens out the incremental cost of the thermostat itself.

Two-way WiFI thermostats are less expensive to market to customers when integrated with efficiency audits and other personalized recommendations. And unlike load control switches, utilities do not need to maintain cash incentives to keep the program running and the customer participating. As a result, two-way WiFi thermostats enable savings of a scale that would require an additional $20-$35 per household per year to achieve via conventional, less cost-effective efficiency programs[19].

VALUE SOURCE #4: INCREASED ADOPTION OF DEMAND RESPONSE

As with efficiency programs, demand response (DR) initiatives are constrained by very low customer engagement. In fact, it is estimated that only 5%[20] of retail customers participated in DR programs in 2012. As a result, there is currently a huge (70%[21]) gap between actual peak reduction achieved and potential peak reduction.

The gap persists largely because existing options for demand response programs have been limited and, customers are largely unaware of program benefits. The vast majority of residential demand response is accomplished through Direct-Load Switch devices that utilities use to cycle air conditioning conditions during periods of peak demand. While these programs have been effective in certain regions, they are expensive for utilities to deploy and provide customers limited benefit.

To reach deeper into their service territories and involve customers with varying needs, utilities must provide customers additional alternatives. While some customers are interested in automation, other customers prefer to maintain more control. Progressive

14. Hunt, Allcott. "Social norms and energy conservation," *Journal of Public Economics* 95:9-10 (2011): 1082-1095.
15. Annual electricity and natural gas consumption per household, EIA; 89% of total fuel site consumption of 89.6 million Btu
16. LBNL, Home Energy Saver predicts 5%-30%; 7-10% is assumed in this analysis
17. Median per-customer load drop is typically 1kW/household: 10 largest Residential DLC Programs, FERC Assessment of Demand Response & Advanced Metering, 2010
18. Assuming avoided capacity costs of $46/kW-year
19. Assuming average levelized energy efficiency program cost of 3 cents/kWh
20. 2012 Assessment of Demand Response and Advanced Metering, Federal Energy Regulatory Commission; based on reported number of customers enrolled in direct load control and TOU DR programs
21. Ibid; Calculated difference between reported potential and actual savings across eight U.S. regions (Figure 3-7)

NEXT GENERATION OF DR: BGE SUCCESS STORY

A recent deployment of a Peak Time Rebate (PTR) program at BGE emphasized the role of customer engagement in DR. BGE utilizes Opower BDR to reach all 1.1M residential customers by 2015, achieving a significant uplift in participation compared to average rates. Customers receive alerts through their preferred communication channels and, at the end of each event, the MDM system calculated how much each customer saved. Savings and rebates were then communicated back to the participants by Opower.

utilities have begun to offer customers an array of options, which puts customers in control of their reductions.

Behavioral Demand Response (BDR) is a new type of a two-way communication platform that provides an opportunity to bridge this gap. BDR is designed to drive customer awareness and peak energy savings at scale without devices. Through personalized communication and feedback delivered across email, text, and voice channels, BDR can drive behavioral change at peak times. These programs can drive between 5-15% decreases in usage during peak times can save utilities $7-$20 in avoided capacity costs per household over the course of a year[22].

Next Steps

With a better understanding of the value of each engaged customer, utilities must answer three key questions in order to efficiently capture this value.

1. **How many customers within a utility's base can be successfully engaged?** In financial terms, if engagement can drive anywhere from $40-$90 in incremental value for those customers that are engaged, what is the overall potential impact on net income?

2. **How should engagement approaches vary based on customer type?** Innovations in the domains of segmentation and personalization have opened the door for utilities to consider engagement approaches that are customized to a customer's unique demographic, psychographic or behavioral characteristics. What impact does this have on the ability of a utility to capture value?

3. **How should a utility coordinate its customer engagement investment to minimize cost and maximize impact?** Increasing customer engagement requires significant coordination and personalization across every touch point that a utility has with its customers. This will likely require significant new technology and process investment, but what exactly is required and who will fund it? Can a single technology platform meet the needs of diverse stakeholders within a utility such as Customer Care, EE, DR and Marketing? Should utilities build a platform themselves or buy an existing one?

Leading utilities have been able to successfully address these questions head-on, taking a systematic approach that dramatically expands the number of engaged customers over time, while avoiding conflicting or redundant investments that lead to higher cost-to-serve and reduced satisfaction.

For additional guidance on how to design an effective customer engagement program and deploy the right technology platform to support it, contact Opower or refer to Opower's related whitepaper: *Defining Customer Engagement Platforms*[23].

22. Assuming 10 peak events, excluding program cost.
23. For more information, visit opower.com/platform.

Study: Utility customer engagement programs are worth it

07/23/2013By Editors of Electric Light & Power/ POWERGRID International

While many electric utility companies provide programs to help their customers manage their energy costs, a large percentage of theircustomers are not aware of the programs available to them, according to the J.D. Power 2013 Consumer Engagement Study.

Data from the J.D. Power 2013 Electric Utility Residential Customer Satisfaction Study shows that overall satisfaction is highest among customers who participate in one or more of their electric utility's offerings at 679 on a 1,000-point scale. Satisfaction declines to 642 among those who are aware of the offerings, but have chosen to not participate in them, and declines even further to 582 among those who are unaware of any offerings from their utility.

Customers were asked about their awareness of 29 various programs, products and services commonly offered by utilities. Study findings show that 19 percent of customers are not aware of any of the programs being offered by their utility provider. Electric utility company programs with the highest awareness rates are e-bill or electronic bill statements and payments (53 percent); in-home energy audit (28 percent); and awareness of rebates on Energy Star appliances (28 percent).

Among customers who are familiar with their utility's programs and services, the highest usage levels are for e-bill (43 percent); high-efficiency light bulb rebates/discounts (27 percent); and household electricity usage comparison tools (26 percent).

- Based on customer awareness, familiarity, and the impact of programs, the following are the most engaging programs offered by electric utilities:
- E-bills
- Level or equal pay plan
- In-home energy audit
- Rebates on Energy Star appliances
- High-efficiency light bulb rebates/discounts

The following brands perform particularly well in overall customer engagement: APS; Clark Public Utilities; Salt River Project; Seattle City Light and SMUD.

"Only about a dozen utilities excel at offering a wide variety of options for their customers," said Conklin. "While many other utilities do a good job, far too many utilities lag behind in engaging with their customers."

According to the study, 21 percent of customers indicate that their home is equipped with a smart meter, most frequently citing avoiding on-site meter readings; more accurate bills; the ability to track energy use online; and more control of home energy usage as benefits of the device.

Campaigns and incentive programs that incorporate ENERGY STAR

Whether it's delivering technical assistance or hosting a competition, organizations nationwide are incorporating ENERGY STAR in their incentive programs and voluntary campaigns.

Use the list below to find and take advantage of incentives available to you or look for campaigns in your area to join. If you're considering developing an incentive program or launching your own competition to save energy, check out the initiatives below for ideas and inspiration.

You can also download the full list of federal, state, and local governments leveraging ENERGY STAR.

Jurisdiction	Program	Summary
		NATIONAL PROGRAMS
	ASHE Energy to Care Launched 2006	Energy to Care (EtC) is a healthcare energy benchmarking program allowing users to access detailed energy data at no cost, compare and challenge similar or nearby facilities using a data visualization tool, and apply for recognition. EtC uses the ENERGY STAR **Portfolio Manager** tool to benchmark hospital energy performance.

Associations	Building Owners and Managers Association (BOMA) 7 Point Challenge Launched 2007	BOMA's 7-Point Challenge is a five-year program that incentivizes voluntary market-driven efforts among commercial real estate companies to reduce their use of natural resources, energy, and waste. Participating companies are challenged to: decrease portfolio energy consumption by 30 percent; benchmark energy performance and water usage through ENERGY STAR metrics; provide sustainability education to building staff members; perform energy audits to implement low-cost strategies; and improve operations and building maintenance systems.
	Architecture 2030 Districts Launched 2011	Architecture 2030 Districts Network encourages participating building and business owners to improve their energy performance to meet Architecture 2030 Challenge goals on carbon emission reductions. Participants are encouraged to use the ENERGY STAR **Target Finder** and **Portfolio Manager** tools to track their energy consumption and share results.
	International Facility Management Association (IFMA) ENERGY STAR Challenge Launched 2012	IFMA ENERGY STAR Challenge participants use the ENERGY STAR **Portfolio Manager** tool to benchmark their building's energy performance against similar facilities, compete against other chapters, and make efficiency improvements.
	Chief's Energy Challenge Launched 2013	The Chief's Energy Challenge invites fire departments to achieve a 10 percent reduction by year one and a 20 percent reduction by year three. The challenge uses the ENERGY STAR **Portfolio Manager** tool to easily track buildings' progress and help fire departments work towards their energy reduction goals. All Challengers are recognized for their participation as well as for their accomplishments.
	U.S. Department of Energy's Better Buildings Challenge Launched 2010	Participants in DOE's Better Buildings Challenge commit to improve the energy efficiency of their portfolios by 20 percent over a ten-year period using the ENERGY STAR **Portfolio Manager** tool as the preferred tool for tracking, verifying, and

		reporting their energy performance over time.
Federal Agencies	U.S. EPA's ENERGY STAR National Building Competition Launched 2010	Each year since 2010, EPA has hosted a national competition to see which building can cut energy waste the most. Competitors track their energy performance over time using the ENERGY STAR **Portfolio Manager** tool, and the competitor with the greatest percent reduction in energy use at the end of the competition period is declared the Biggest Loser.
	STATE PROGRAMS	
New Jersey	NJ Pay for Performance Program Launched 2009	Under the Pay for Performance program, commercial building owners are given technical assistance with developing and implementing an Energy Reduction Plan to reduce energy use by 15 percent or more. Participants track their energy performance using the ENERGY STAR **Portfolio Manager** tool.
	NJ Local Government Energy Audit Program Launched 2009	The Local Government Energy Audit Program provides local governments with cost-subsidized energy audits for publicly owned facilities to identify cost-justified energy efficiency measures. Both programs use the ENERGY STAR **Portfolio Manager** tool to measure progress.
New Mexico	HB 534: Sustainable Building Tax Credits Launched 2007	To qualify for income tax credits, applicants must demonstrate that the commercial building is 60 percent more efficient than an average building of the same type using the ENERGY STAR **Target Finder** tool.
Pennsylvania	Department of Education Planning and Construction Workbook	PlanCon is a set of forms and procedures used to apply for Commonwealth reimbursement for school districts that undertake a major renovation or construction project. Beginning July 1, 2011, all projects initiating the PlanCon process are subject to the following: 1. New District-Wide Facility Study requirements: a. Facility benchmarking for each existing building, using the ENERGY STAR

	(PlanCon) Launched 2010	**Portfolio Manager** tool. b. For each construction option, a predictive utility budget must be completed using the ENERGY STAR **Target Finder** tool. 2. Comprehensive Energy Modeling requirements using Target Finder.
	LOCAL PROGRAMS	
Albuquerque, NM	Green Path Program Launched 2008	This program encourages and facilitates voluntary design and construction of energy-efficient buildings that meet measurable criteria, which includes earning **Designed to Earn the ENERGY STAR** through the ENERGY STAR **Target Finder** tool.
Arlington County, VA	Arlington Green Games Launched 2011	The Arlington Green Games is a competition for commercial property owners/managers and office tenants to realize the benefits of going green. The year-long competition compares participating buildings across a variety of sustainability categories. Each participating building is required to assess their energy and water use performance using the ENERGY STAR **Portfolio Manager** tool to benchmark and track improvements throughout the year.
	Green Building Density Incentive Program Launched June 2012	Through the Green Building Density Incentive Program, new development project teams may request additional bonus density and/or height in exchange for a minimum level of energy savings, ENERGY STAR certification, and LEED green building certification. All project owners will also be asked to provide ENERGY STAR **Portfolio Manager** utility reporting data after occupancy each year for 10 years.
Atlanta, GA	Atlanta Regional Council Green Communities Program Launched 2012	The Green Communities Program encourages local governments to demonstrate leadership and set an example for environmental sustainability. Applicant communities can earn points toward certification by implementing a local policy requiring new construction owned by the jurisdiction to be **ENERGY STAR** certified.

Boise, ID	The Building Performance Partnership Boise Kilowatt Crackdown Launched 2012	Participants in the Building Performance Partnership Kilowatt Crackdown track and work to improve their buildings' energy use in the ENERGY STAR **Portfolio Manager** tool. The competition is open to owners and managers of commercial offices.
Boston, MA	A Better City Challenge for Sustainability Launched 2009	Participating building and business owners compete to improve their energy efficiency and reduce their energy costs. Competitors are encouraged to use the ENERGY STAR **Portfolio Manager** tool to track their energy consumption and reductions over time, and all participants receive free energy audits, technical support, energy efficiency rebates and incentives, and complementary training in energy management.
Chicago, IL	Chicago Green Office Challenge Launched 2009	Participants in the Chicago Green Office Challenge use the ENERGY STAR **Portfolio Manager** tool to track energy and water use and compile results at the end of the contest period.
Chicago, IL	Chicago Green Office Challenge Launched 2009	Participants in the Chicago Green Office Challenge will use the ENERGY STAR **Portfolio Manager** tool to track energy and water use and compile results at the end of the contest period.
Cincinnati, OH	Green Cincinnati Plan 2013	The Green Cincinnati Plan challenges the city's businesses to reduce greenhouse gas emissions 2 percent each year and reduce the total energy consumption of the city's built environment 15 percent by 2020. The plan specifies the ENERGY STAR **Portfolio Manager** tool as the tool that businesses will use to benchmark their energy consumption, make energy efficiency improvements, and demonstrate achievement of their energy use reduction goals.
Columbus, OH	Columbus Energy Challenge Launched 2014	The Columbus Energy Challenge aims to reach over 70 percent of commercial and industrial buildings in Columbus over 50,000 square feet in order to achieve a 20 percent reduction in building energy use by 2020. Building energy performance will be measured using the ENERGY STAR **Portfolio**

		Manager tool.
Denver, CO	Watts to Water Launched 2008	Participants in the Watts to Water program benchmarked energy and water consumption in the ENERGY STAR **Portfolio Manager** tool to measure reductions against the calendar year 2010 baseline. The competition will reward buildings with the greatest reductions in energy- and water-use intensity at the end of the contest period.
	Denver City Energy Project October 2014	The Denver City Energy project encourages participants to enroll by benchmarking building energy use in the ENERGY STAR **Portfolio Manager** tool and sharing their buildings' ENERGY STAR scores with the city. The goal is to encourage improved energy management, cut the city's energy costs by $1.3 billion, and reduce greenhouse gas emissions by 800,000 metric tons.
Fort Worth, TX	City of Fort Worth Business Smart Program Launched 2011	To participate, a prerequisite of the Fort Worth Energy Conservation program is to track and report energy usage in the ENERGY STAR **Portfolio Manager** tool. More points are awarded for energy reduction off the baseline.
Knoxville, TN	City of Knoxville Energy & Sustainability Initiative 2014	As part of the 2014 Work Plan & Emissions Inventory Update, under Energy Management, the City of Knoxville tasked its sustainability personnel with actively tracking energy usage at city facilities using the ENERGY STAR **Portfolio Manager** tool and Utility Trac Plus.
Louisville, KY	Louisville Kilowatt Crackdown Launched 2009	Participants in the Louisville Kilowatt Crackdown track and work to improve their building's energy use in the ENERGY STAR **Portfolio Manager** tool. The competition is open to owners and managers of all commercial buildings in the city.
Minneapolis, MN - Greater Minneapolis	BOMA Greater	The Greater Minneapolis Kilowatt Crackdown aims to challenge the real estate community to improve energy efficiency and reduce greenhouse gas emissions. All participants receive free assistance from Xcel Energy and BOMA to benchmark building

Building Owners & Managers Association (BOMA)	Minneapolis Kilowatt Crackdown Launched 2010	energy use and water consumption using the ENERGY STAR **Portfolio Manager** tool and develop action plans to improve performance through 2012. Top performers will be awarded in the spring of 2013 based on three categories: highest performing buildings, most-improved performance, and most valuable tenant.
Philadelphia, PA	EnergyWorks Loan Fund Launched 2010	Philadelphia's EnergyWorks Loan Fund (previously the Greenworks Loan Fund) issues low-interest financing to small businesses to help them fund energy efficiency improvements. The city requires each participating business to use the ENERGY STAR **Portfolio Manager** tool to report its pre-retrofit ENERGY STAR score on a 1–100 scale, as well as energy performance data for the first 12 months following implementation of the financed energy efficiency project.
Phoenix, AZ - Building Owners & Managers Association (BOMA) of Phoenix	BOMA Phoenix Kilowatt Krackdown Launched 2009	As part of its 7-point Challenge to reduce building energy consumption by 30 percent by 2012, BOMA Phoenix launched the Kilowatt Krackdown to encourage members to benchmark their energy and water consumption using the ENERGY STAR **Portfolio Manager** tool. BOMA Phoenix hosted a series of workshops on benchmarking building data and identifying trends in energy and water consumption for property managers, facility managers, maintenance staff, and building engineers.
Pittsburgh, PA	Pittsburgh Green Workplace Challenge Launched 2011	Participants in the Pittsburgh Green Workplace Challenge will use the ENERGY STAR **Portfolio Manager** tool to track energy and water use to establish baselines and compile results at the end of the contest period.
	Pittsburgh 2030 Challenge Launched 2013	The Pittsburgh 2030 District is a collaborative, nationally recognized yet local community of high performance buildings in Downtown Pittsburgh that aims to dramatically reduce energy and water consumption, using ENERGY STAR **Portfolio Manager** to measure performance over time.

Portland, OR	Portland Carbon4Square Initiative Launched 2011	Participants in the Carbon4Square Initiative compete to improve their sustainability practices in multiple areas, including energy. Competitors use the ENERGY STAR **Portfolio Manager** tool to track their energy performance, and technical support is provided for applying to earn the ENERGY STAR.
Rockville, MD	High Performance Buildings Tax Credit for Existing Commercial Buildings April 2012	The Tax Credit for Existing Commercial Buildings establishes a high performance building tax credit that provides an incentive to existing commercial buildings that invest in energy efficiency and green improvements. For the first year of the tax credit, the building must achieve LEED certification and **ENERGY STAR** certification (if applicable). For years 2 through 5, building owners or managers must either submit the Statement of Energy Performance to the City demonstrating achievement of ENERGY STAR certification or submit the ASHRAE Building Energy Certificate demonstrating that the building has maintained or improved energy performance compared to the first year.
Salt Lake City, UT	Salt Lake City Skyline Challenge May 2014	The Mayor's Skyline Challenge encourages building owners to exceed the city's target of achieving a 10 percent improvement in energy efficiency by 2015 and will continue annually past 2015. Participants will use the ENERGY STAR **Portfolio Manager** tool to benchmark and report annual building energy use in comparison with a baseline period of calendar year 2013.
St. Louis, MO	St. Louis High Performance Building Initiative Launched 2012	A regional project initiated to accelerate the increase in square footage of third-party verified space in the St. Louis region. The initiative focuses on promoting the use of energy management tools, including the ENERGY STAR **Portfolio Manager** tool.
Westchester,	Westchester Green Business Challenge	The Westchester Green Business Challenge is a friendly competition for all businesses. Buildings are evaluated using an innovative Green Business Scorecard. Using the ENERGY STAR **Portfolio**

NY	Launched 2010	**Manager** tool, buildings establish energy and water usage baselines and develop reduction goals for the building's overall energy and water consumption.
Winneshiek, IA	Winneshiek Energy District Green Business Challenge Launched 2011	Participants in the Winneshiek Energy District Green Business Challenge use the ENERGY STAR **Portfolio Manager** tool to track energy and water use to establish baselines and compile results at the end of the contest period.
Wisconsin	WI Lt. Governor ENERGY STAR School Challenge Launched 2010	This program challenges 100 new WI school districts to join as ENERGY STAR partners and reduce energy use by 10 percent or more across their building portfolios. Participating school districts agree to measure and track energy performance using the ENERGY STAR **Portfolio Manager** tool and set goals and plan improvements based on the **ENERGY STAR Guidelines for Energy Management**.

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DOE Home

Home Energy Report Helps Customers Track Energy Use, Save Money, Protect the Environment

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Approximately 150,000 NIPSCO customers will take part in an innovative energy-efficiency program – the NIPSCO Home Energy Report – that provides gas and electric customers essential information about their energy usage, ultimately helping to save energy, money and protect the environment.

The report – being mailed this month – anonymously compares customers' energy use with that of similarly sized homes and demographics, employing the peer-proof theory that people take action when they have comparative information about what others are doing. Customers can view the past 12 months of their energy usage, and compare and contrast their energy consumption and costs with others in the same region.

The Home Energy Report is the latest step in NIPSCO's ongoing focus to help customers save energy and money, and it falls directly in-line with Indiana's long-term efforts to achieve measurable reductions in energy consumption across the state.

"We've found that our customers are eager to make their homes more efficient and save money, but they're not always sure how to do it," said Debora Owen, executive director of customer service for NIPSCO. "These reports not only show customers exactly how to achieve savings, but they have a proven track record when it comes to motivating customers to become more energy efficient."

According to Owen, the company believes an individual electric customer could save approximately 275 kilowatt-hours annually simply through behavioral changes and by taking advantage of the energy-efficiency tips offered in the quarterly report. Collectively, customers who receive the report could save approximately 41,000 megawatt-hours of electricity annually – enough to power more than 3,500 homes or remove more than 2,000 cars from the road.

By comparison, an individual natural gas customer could save approximately nine therms per year. If every customer who receives the report used the suggested tips, the total savings could result in a reduction of 1,350,000 therms – equivalent to the amount of natural gas needed to provide heat and hot water for approximately 1,500 homes for one year.

Customers are expected to save more than $7 million on their utility bills, cumulatively, in the first year of the Home Energy Report program.

NIPSCO has partnered with OPOWER – an energy-efficiency software company that works with utilities to meet their efficiency goals through effective customer engagement –

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to design, prepare and deliver the Home Energy Reports. Using behavioral science and cutting-edge data analytics, the OPOWER platform enables utilities to connect with their customers in a highly targeted fashion, motivating reductions in energy use and increased program participation.

As a proven energy efficiency resource with verified savings, OPOWER's program will help NIPSCO reach statewide energy efficiency goals of 2% by 2019.

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Behavioral approaches to energy conservation pay off

Cost-effective, quantifiable results with residential customers

Jamie Wimberly | Feb 26, 2012

The utility sector is being required to meet mandated targets for energy efficiency and demand response, while these targets often double over time. Traditionally, utilities have used various engineering-driven measures to meet these targets; e.g., offering customers compact fluorescent light bulbs or pricing programs with incentives. These measures are straightforward to deploy and measure.

Today it is widely recognized that the traditional approach will not be enough to meet escalating targets, creating a need for a more diversified resource portfolio. New approaches are required.

Utilities have begun to experiment with pilot programs that embody a behavioral approach. These programs are designed to change consumer behavior towards energy consumption, resulting in load reduction. Such behavioral approaches include any program that initiates a change in behavior that doesn't require a widget or a rebate on a "widget-based" program. A behavioral approach is not technology based.

New behavioral approaches to energy conservation represent an opportunity and a challenge to traditional management of the demand side management (DSM) portfolio. These behavioral approaches should be considered in a strategic context, tying together pieces of the DSM portfolio, leveraging real-time information from smart grid systems and then further tying into customer service and marketing/communications efforts.

Opportunities

To date, utilities have largely focused on providing a consumer's energy use information through reports or other means and linking that information to comparative statistics from the consumer's community, creating a competitive lever to change behavior. This is one approach—a marker, if you will, on a behavioral landscape that would leverage motivations such as fear, persuasion, commitment, etc.

Overall, the utility sector's use of behavioral approaches has been largely limited to pilots, but the savings so far are real and significant—2 percent, on average. The new behavioral approaches have quickly become one of the more important initiatives to drive savings in the residential sector, especially for utilities serving urban service territories where the savings potential is limited by the number of apartment dwellers or addressable loads (namely, air conditioning).

Our interviews with utility managers also point to specific benefits to behavioral approaches. They are:

- Cost effective in the first year
- Easy to quantify
- Able to scale quickly
- Useful in meeting regulatory requirements
- Conducive to customer satisfaction

The experience of utility portfolio managers implementing behavior-based pilots have largely been positive.

Challenges

The way that utilities think about energy consumers is often dramatically different than the way energy consumers think about themselves. This thinking gap makes it difficult for utilities to fully understand their customers and to create strategies that will effectively motivate behavior change. To drive the future consumer behavior change that leads to demand reduction will require a more "customer-centric" perspective from utility providers across all programs and for all customer types (residential/business, rural/urban, etc.).

From a utility manager's perspective, the biggest challenge is that the sector's experience with behavioral approaches has been limited to a year or two (i.e., their initial pilot programs), yet their planning horizons are three to five years. There are many open questions: Will the savings impact persist or degrade over time? Will cost effectiveness be maintained over time? How will behavioral approaches integrate with back office systems and other parts of the enterprise? When these questions are addressed at scale, they become challenges to overcome.

If behavioral programs are going to be effective tools for demand reduction, they need to be big, sustainable, relatively cheap and well-received by customers.

+ Strategy

Looking beyond a stand-alone approach to behavioral program design, we suggest consideration of what I call a "+" strategy. In other words, use a behavioral approach connected to another part of the energy efficiency (EE) portfolio or utility offering to either optimize the underlying program or to serve as a glue to hold pieces of the offering together in new, stronger ways.

A "+" strategy would encompass:

- Optimization: Combine a behavioral approach with a device or offering to optimize the potential for demand side impacts. For example, residential lighting + behavioral approach = broader, faster adoption, optimization of program objectives and persistent behavior.
- Glue: Employ a behavioral approach to connect pieces or programs of the proposal into a comprehensive approach, with the whole producing more impacts and savings than the individual parts combined. The glue can also be thought of as "stickiness" (persistence) over a sustained period of time. For example, audits/retro commissioning + behavioral approach = continuous/ monitoring-based commissioning to optimize original controls and measures, along with operational guidance and incentives focused on behavior for greater savings.

Behavioral approaches represent a significant opportunity for both energy savings and re-examining the utility's customer strategy. Taking a strategic view, many utilities now aspire to become the "trusted energy advisor" to their customers, with trust becoming the currency of a more engaged customer relationship that creates value for both the utility and the customer. Trust is difficult to gain, yet behavioral approaches tied to the DSM offering and to customer service represent a good base to start.

Jamie Wimberly is CEO of DEFG EcoAlign, a management consulting firm focused on the energy sector.

Related Topics

- Demand Response & HAN

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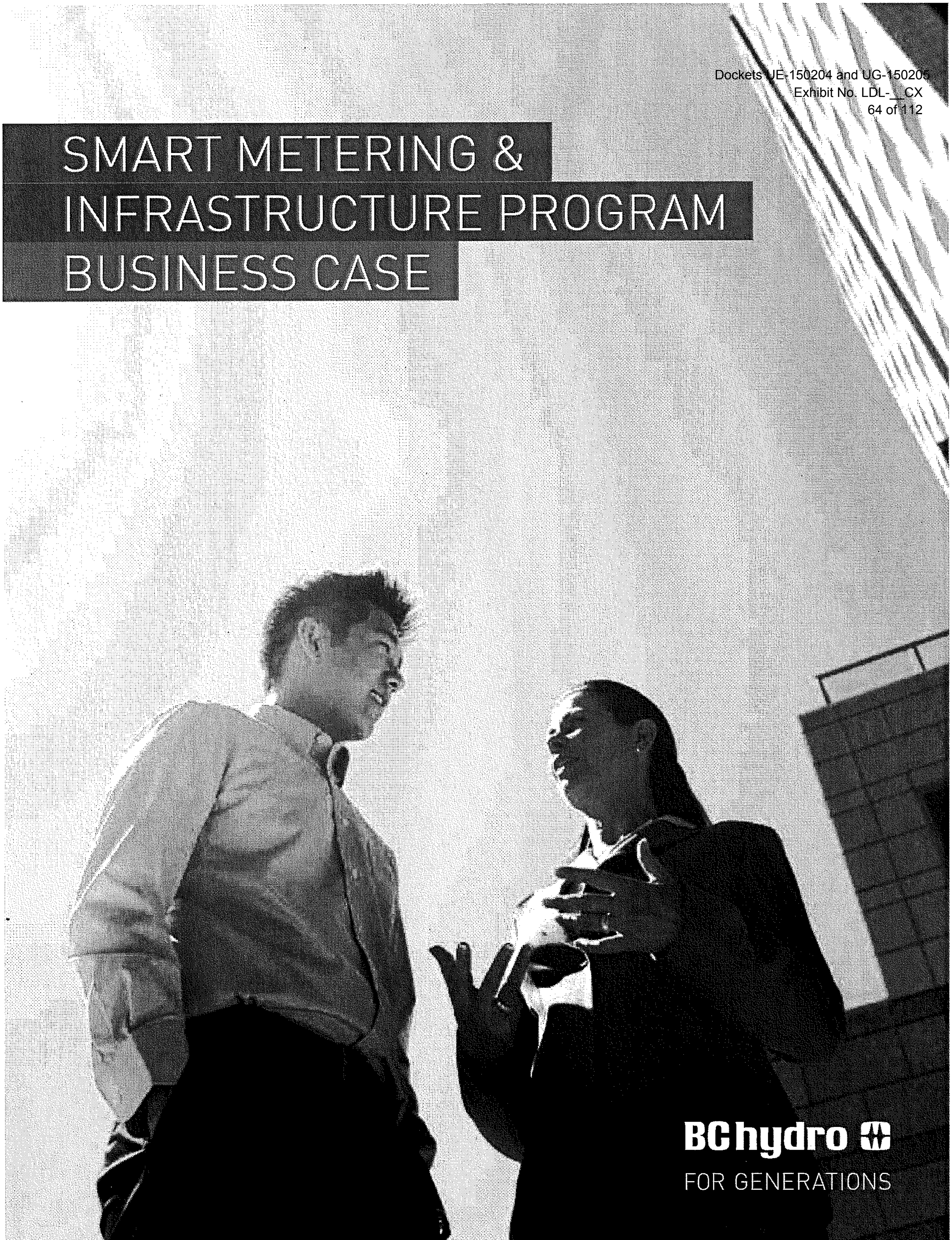
SMART METERING & INFRASTRUCTURE PROGRAM BUSINESS CASE



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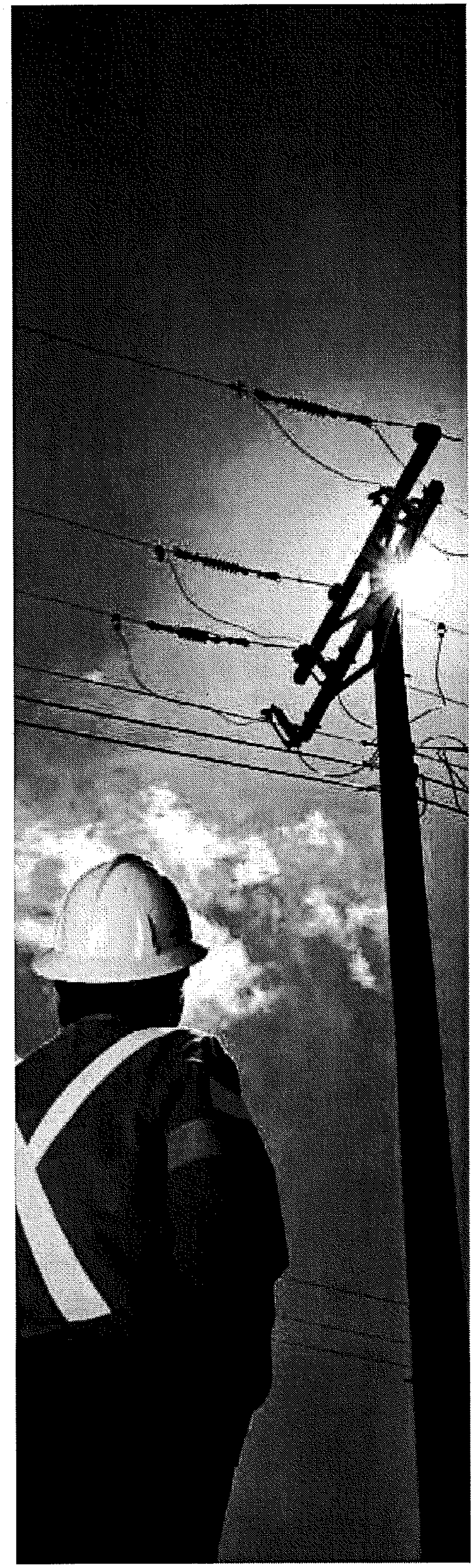


EXECUTIVE SUMMARY

In 2011, BC Hydro will begin implementation of the Smart Metering Program. The Smart Metering Program will pay for itself through reduced theft of electricity, energy savings, and operating efficiencies.

BC Hydro's Smart Metering Program is an important foundational step in the modernization of BC Hydro's electricity system. The program involves replacing existing customer meters, now becoming obsolete, with a comprehensive smart metering system. This system includes the technology and telecommunications infrastructure needed for BC Hydro to continue to manage the electricity system in a reliable, safe and cost-effective manner.

Substantial Benefits to Customers

The Smart Metering Program will:

- **Improve safety and reliability** through faster and precise outage notification and a reduction in the damage caused by illegal electricity diversions.
- **Enhance customer service** by reporting electricity use more accurately, eliminating estimated bills, simplifying the process of opening and closing an account when moving, and reducing the need for onsite visits by field crews.
- **Reduce electricity theft** that currently amounts to approximately $100 million a year in lost revenue—costs that are borne by all legitimate BC Hydro customers.
- **Improve operational efficiency and reduce wasted electricity** through voltage optimization. Lower operating costs are passed on to all customers in rates.
- **Support greater customer choice and control** by offering optional in-home feedback tools that provide direct and timely information to customers about their electricity consumption.
- **Help modernize British Columbia's electricity system** by replacing nearly obsolete meters, and creating the foundation for supporting new uses of electricity such as electric vehicles, customer generation and microgrids.

Implementation to be Prudent and On Budget

Smart meter installation will be on time and on budget. Installation of smart meters will begin in 2011 and **will be complete by the end of 2012** with other elements of the program implemented through 2014.

Security, privacy and safety features in smart metering infrastructure will include encryption of data similar to that used by online banking systems, and mandatory criteria was included in all procurement processes to ensure only proven technologies were considered.

BC Hydro will **maintain existing rate structures** throughout the meter installation process. Any new rate structures will be subject to public consultation and review by the independent British Columbia Utilities Commission.

The BC Utilities Commission will review the prudency of BC Hydro's decisions and actions in relation to the implementation of the program.

Benefits for BC Hydro Customers Exceed Costs

The Smart Metering Program business case shows that the benefits exceed the cost by $520 million in today's dollars. These benefits are attributed to four primary areas including:

- **Operating Efficiencies**—More efficient use of distribution assets and streamlining of business processes, reducing operating and future capital expenses;
- **Energy Savings**—Lower electricity use through improved system control, operational efficiencies and providing customers with new options to better manage their electricity consumption;

- **Revenue Protection—**Includes both recovery of revenue (e.g. back-billing) and prevention of future potential revenue loss (e.g. reduced theft); and
- **Capacity Savings—**Lower electricity use at certain key periods, which reduces peak demand and capacity constraints.

Almost 80 per cent of the quantified benefits delivered through the Smart Metering Program result from BC Hydro activities. If customers take advantage of the conservation tools to be implemented by the Smart Metering Program, the overall benefits increase significantly.

Positive Net Present Value

The Smart Metering Program business case has a net present value (NPV) of $520 million through F2033. The NPV remains positive even if all costs are incurred but only the BC Hydro operational efficiencies are realized. The NPV also remains positive if all benefits are achieved at the low end of the estimated benefit range.

The following table summarizes the key financial components of the Smart Metering Program business case, resulting in the positive NPV of $520 million.

BUSINESS CASE SUMMARY IN NOMINAL AND PRESENT VALUE

Business Case Summary	Nominal Value ($M)	Present Value ($M)
Gross Benefits attributable to Smart Metering Program, less costs related to the achievement of individual benefits	$4,658	$1,629
Less: Ongoing operating and maintenance expenses and incremental asset replacement capital	(745)	(330)
Less: Smart Metering Program Costs	(930)	(779)
Total Net Value for the period F2006 to F2033	**$2,983**	**$520**

Rate Analysis

Net benefits will flow into lower rates for customers, reducing them below what they would otherwise be in the absence of BC Hydro's investment in the program.

KEY TIMELINE FOR CUSTOMERS

Stage	Timeframe	Key Activities
Program Information	**Underway and throughout the program**	Customers have access—through the BC Hydro website, bill inserts, and community events—to information about the Smart Metering Program, the smart metering system that will be installed, how it works, and other topics of customer interest. Customers can share their feedback, concerns, and interest directly through calling, email, community events, and customer research.
Installation of Smart Meters	**Mid 2011 through 2012**	Customers receive information packages before smart meters are installed in their community[1].
In-home Feedback Tools	**2012 through 2014**	Customers receive information highlighting new options available to support their energy conservation efforts. Customers receive a rebate for a basic in-home display device that can be redeemed at select stores. Customers will have access to information about their electricity use, up to the previous day, through a secure Power Smart website.

[1] Smart meter installation will begin simultaneously in communities throughout the province.

INTRODUCTION

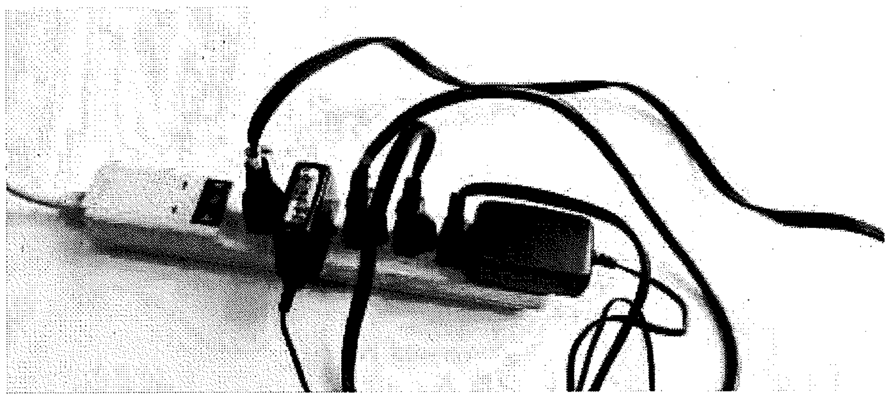
BC Hydro was created 50 years ago to plan, build and deliver a clean, reliable supply of electricity to homes and businesses throughout our growing province. Investments in dams, generating stations and transmission and distribution networks ensured a stable supply of electricity for generations of British Columbians that followed.

Thanks to this visionary planning and investment, BC Hydro has been reliably meeting our province's growing energy needs for the last 50 years. However, vitally important elements of our electricity system infrastructure are reaching an age when significant investment is required to keep our system reliable.

At the same time that our electricity system is aging, demand for power is growing. The latest forecasts show demand for electricity in British Columbia growing by as much as 40 per cent over the next 20 years. That's the equivalent of adding five more cities the size of Vancouver to our system.

The Need for Smart Metering

Home electronics, consumer products, and manufacturing automation are just a few examples of how technology has advanced, leading to more electricity use than ever before.



Customers are using more technology than ever before.

The electricity system that supplies the energy to support this demand hasn't kept pace. For example, meters—the devices that measure how much electricity customers are using—have not fundamentally changed since the 1950s. In fact, the electro-mechanical meter is becoming obsolete and will soon no longer be manufactured.

Today, BC Hydro's meters provide a one-way flow of information (from the customer to the utility) that is very basic and not timely. For example, residential and commercial customers might be surprised to learn that BC Hydro does not know of outages until, and unless, customers call to tell us the power is out.

The electricity system must be updated to ensure that BC Hydro can continue to provide customers with safe and reliable electricity.

Modernizing British Columbia's electricity system will also ensure that advances in technology can be accommodated. Without new investment in technology and systems the 20th century electricity system will be unable to support 21st century innovations such as solar panels, electric vehicles and increased customer service options.

Utilities around the world are upgrading their electricity systems and adopting smart meters to enhance customer service, improve reliability and make their operations more efficient. By 2015, 250 million smart meters will be installed worldwide[2].

In short, investing in smart metering infrastructure is as important as renewing and reinvesting in our dams and generating facilities.

Over the next three years, BC Hydro will be investing $2 billion per year to build and renew dams, generating facilities, and transmission and distribution networks to ensure a safe and reliable supply of power continues to flow to B.C.'s homes and businesses. A key component of this investment is the Smart Metering Program.

WHAT IS THE SMART METERING PROGRAM?

Smart meters are part of an integrated program that will pay for itself through reduced theft of electricity, energy savings, and operational efficiencies. This means that over the long term the Smart Metering Program will reduce customer rates below what they would otherwise be in the absence of BC Hydro's investment in the program.

BC Hydro's Smart Metering Program is an important foundational step in the modernization of BC Hydro's electricity system. It involves replacing existing customer meters with smart meters and upgrading the technology and telecommunications infrastructure that allows BC Hydro to manage the electricity system in a reliable, safe and cost-effective manner.

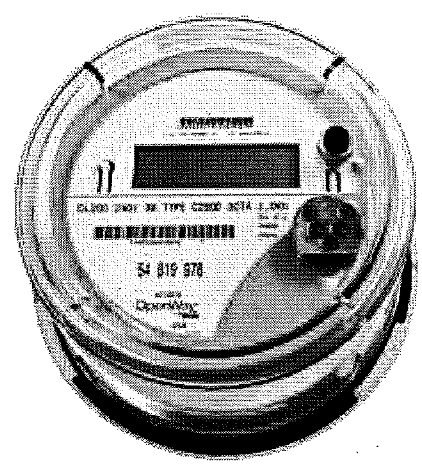
The program consists of:

- Smart meters are digital meters that allow two-way communications between a customer's meter and BC Hydro through a secure connection that captures the amount of electricity consumed and when. For more information about smart meter safety, security, and privacy, see Appendix 1..
- Optional in-home feedback tools to provide up-to-date energy consumption and price information directly to residential and commercial customers providing them with more choices to actively manage their electricity use.
- Systems and infrastructure to reduce electricity theft that will help to create safer communities and mitigate rate impacts borne by legitimate customers .
- Advanced telecommunications infrastructure to allow BC Hydro to more accurately measure the actual flow of electricity through the system and support advanced electricity system management and customer applications.
- Information technology systems to integrate meter reading data into BC Hydro's customer billing, load forecasting and outage management systems.

The broad scope of the Smart Metering Program is described further in Appendix 2.

Smart meter installation will begin in 2011 and will be complete by the end of 2012. Customers will be notified in advance when the meter exchange will take place in their community. While customers do not need to be home for the meter exchange, they do need to ensure technicians have access to their current meter. There will be a brief service interruption during the meter exchange, which takes only minutes. Once smart meters are installed, customers will have the option of adopting in-home feedback tools. For example:

- Customers can choose to take advantage of incentives to purchase an in-home display device that provides near real-time information about their energy use; and
- All customers will have access to a secure website that provides prior day consumption data and other tools to analyze electricity use.



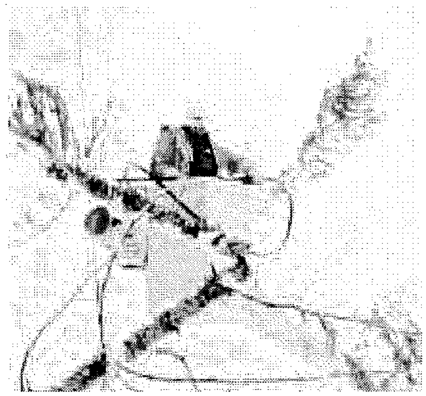
Your new smart meter will replace the existing meter on the outside of your home or in your meter bank if you live in a multi-dwelling unit. If you choose an optional in-home display, the smart meter can send real-time consumption and price information directly to you.

[2] Pike Research, November 2009

BENEFITS

BC Hydro's Smart Metering Program delivers substantial benefits to customers. Specifically, the program will:

- Improve safety and reliability;
- Enhance customer service;
- Reduce electricity theft;
- Improve operational efficiency and reduce wasted electricity;
- Support greater customer choice and control; and
- Help modernize British Columbia's electricity system.



Power line technician during a Campbell River snowstorm.

Improve Safety and Reliability

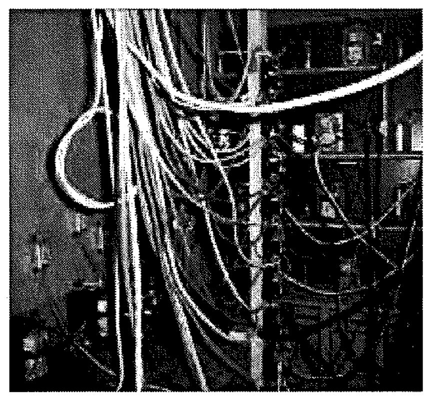
Keeping customers' power on requires BC Hydro to dispatch crews day and night, under all types of weather conditions to search for, assess, and repair faults on the electricity system. The current metering infrastructure does not provide any residential customer outage information to BC Hydro. In fact, BC Hydro is not aware of outages until customers call in to inform us that the power is out.

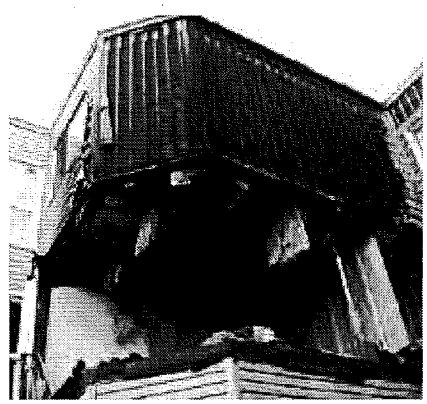
Due to this lack of detailed and specific outage information, field crews engage in significant travel to identify the location and cause of an outage, increasing personal risk as well as delaying restoration times. During storm season, the outages are frequently at multiple locations and the risk is even higher due to the need to drive and fly under adverse conditions.

In addition, theft of electricity is occurring in increasingly dangerous ways, posing major safety risks to the general public, first responders and BC Hydro employees through the threat of fire and electrocution. For example, in Surrey, approximately 50 per cent of marijuana growing operations inspected by the fire department involved diversion of electricity from BC Hydro distribution lines. Theft also causes strain on the distribution infrastructure resulting in an estimated 100 premature transformer failures a year.

The Smart Metering Program will deploy new technologies, better analysis and notification tools, and automated decision-making that will result in improved public and employee safety and shorter outage restoration times. Benefits include:

- **Faster outage notification**—Real-time outage notification provided automatically by smart meters will serve to pinpoint problems quickly and specifically, reducing the amount of travel required under adverse conditions and accelerating the restoration process.
- **Reliable restoration notification**—Allowing field crews to quickly confirm the outage has been addressed instead of driving along the electricity lines to look for secondary outage problems.
- **Reduced risk and fewer outages from electricity diversions**—By helping identify potential electricity diversions in a more consistent and automated way, the Smart Metering Program will reduce safety risks and customer outages that are caused by premature transformer failures.





Smart meters will decrease illegal electricity diversion (shown here), keeping neighbourhoods safe from fires like the one that destroyed this house.

Photo credit: Vancouver Fire and Rescue Services and Vancouver Police Department

Enhance Customer Service

Smart meters capture more accurate and detailed electricity use information, which will result in enhanced customer service including:

- **More accurate meter readings**—Anomalies in reported electricity use can be reconciled quickly and accurately with the use of hourly meter data rather than bi-monthly meter reads or estimated bills.
- **Elimination of estimated billing**—With smart meters in place, customer bills will be generated from actual electricity use, not from estimated readings based on profiles.
- **More streamlined moving procedures**—With automated meter reads available on request, customers can receive an accurate, up-to-date final bill and will no longer have to deal with transferring bill amounts when they move into or move out of a home or business.

Call centre agents will have more accurate information available to address customer questions related to their bills, electricity use, or opportunities for energy savings.

- **Better informed customer service representatives**—BC Hydro call centre employees will have substantially more accurate information available to address customer questions related to their bills, electricity use, or opportunities for energy savings.
- **Increased privacy and convenience**—Customers will no longer need to provide meter readers with regular access.
- **Reduced onsite visits**—Automated meter reading, automated connection services, and more information available for problem solving, will reduce the need for BC Hydro to send crews to customer homes and businesses resulting in direct savings that will be passed on to customers.

Reduce Electricity Theft

Legitimate customers bear the cost of electricity theft, which has grown significantly from approximately 500 GWh in 2006 to an estimate of at least 850 GWh today—that's enough power to supply 77,000 homes for a year and amounts to approximately $100 million a year in energy cost.

Although BC Hydro has identified over 2,600 electricity thefts over the past five years, identifying and confirming theft is a time-consuming, inefficient and expensive manual process. While BC Hydro cannot reasonably expect to eliminate all electricity theft, augmenting the current manual process with new technology will substantially reduce current levels of theft by:

- **Theft detection**—New distribution system meters (different from those to be installed at customer homes or businesses) located at key points on BC Hydro's system will measure electricity supplied to specific areas. Combined with software tools to enable electricity balancing analysis, distribution system meters will help BC Hydro identify electricity theft more accurately and address it more quickly.
- **Tamper detection**—Smart meters have a tamper detection feature that automatically notifies BC Hydro if they have been removed from the wall or otherwise manipulated.

Electricity theft results in higher rates for legitimate customers.

Reducing electricity theft delivers tangible financial benefits through increased revenue, revenue recovery (e.g. back-billing), and reduced cost of energy.

Improve Operational Efficiency and Reduce Wasted Electricity

Currently, BC Hydro transmits more electricity than needed by customers to ensure there is acceptable power quality delivered to every customer. Reducing wasted electricity benefits all customers through lower operating costs.

The amount of excess energy required can be substantially reduced with better monitoring and control over the distribution system including:

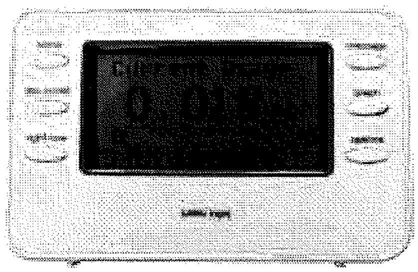
- **Voltage optimization**—Use voltage information collected from smart meters to make existing electricity control devices (voltage regulators, capacitor banks, and transformers) along the distribution system more efficient. Simply put, less electricity will be required to be transmitted to maintain expected power quality, resulting in less electricity having to be generated or purchased, which in turn, lowers costs.
- **Efficiencies in meter reading, meter sampling, distribution system maintenance, outage management, and load research—** Will significantly reduce operating costs.

Support Greater Customer Choice and Control

Today, customers have few tools to manage their electricity use because the current meters do not capture enough information. Without specific and timely information, it is difficult for customers to take advantage of new service options or make informed decisions to actively manage electricity in their own circumstances.

Research has shown that electricity is typically not something customers regularly think about, and that increasing customer awareness by enabling them to view their own consumption in a timely manner can achieve electricity savings of up to 15 per cent. See Appendix 3 for more information related to research.

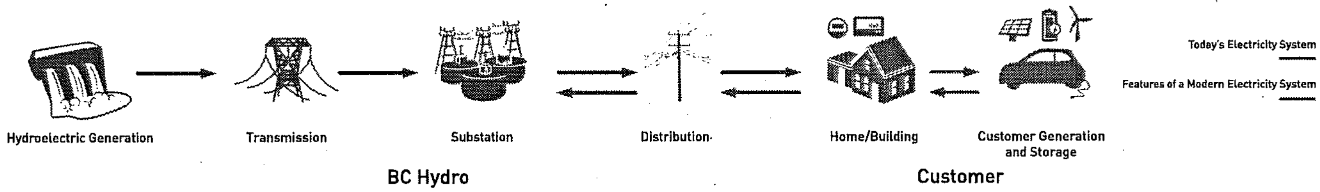
More information and control will help customers to save money—and help to achieve BC Hydro's goal of meeting two-thirds of incremental electricity demand through conservation by 2020.



Optional in-home feedback tools will provide customers with more choices and control.

The Smart Metering Program will enable customers to have greater choice and control of their energy use through:

- **Optional in-home feedback tools**—BC Hydro will provide incentives for customers to adopt market available in-home displays, programmable thermostats, and energy management software products.
- **Power Smart website**—Customers will also have the option of accessing their own secure consumption information through BC Hydro's expanded Power Smart website.
- **Rate Options—**Smart meters capture information that will enable BC Hydro to design new rate structures that encourage conservation during peak periods, such as voluntary time-of-use. The design of these rates will involve consultation with customers and will be subject to review and approval by the BC Utilities Commission.

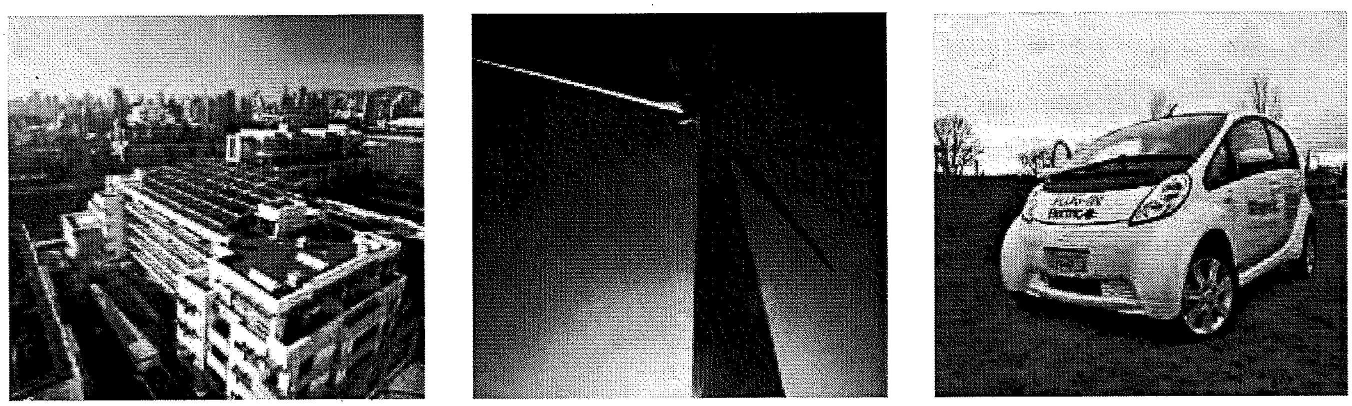


Help Modernize BC Hydro's Electricity System

BC Hydro's electricity system, including the current base of electromechanical meters, has changed very little over the past 50 years. These older style meters are becoming obsolete, as meter vendors switch to producing smart meters.

Upgrading to a smart metering system is a key foundational step in modernizing BC Hydro's overall electricity system. Additional measurement points throughout the electricity system combined with the ability to measure electricity to and from a customer site will enable:

- **Support for new customer applications**—Advanced telecommunications infrastructure will support advanced electricity system functions and emerging applications like customer generation and microgrids.
- **Support for large-scale clean energy initiatives**—Implementation of smart metering and network operations functions will help BC Hydro to manage new uses for the electricity system such as electric vehicles, electrification of public transportation, community-based generation, and integration of renewable fuel sources. For example, with a more modern electricity system, customers who invest in solar panels, or other clean sources of electricity, could sell excess power back to BC Hydro, or draw electricity from their electric vehicles during a power outage.



With a more modern electricity system, customers who invest in solar panels, or other clean sources of electricity, could sell excess power back to BC Hydro.

FINANCIAL ANALYSIS

The Smart Metering Program business case, originally developed beginning in 2006, was most recently updated in December 2010 and reflects updated benefit assumptions as well as increased cost certainty as a result of the procurement activity during 2010. This section summarizes the benefits, costs, and net present value included in the business case.

Quantified Benefits

The Smart Metering Program business case includes approximately $1.6 billion in quantified benefits (present value), to be realized over 20 years. These benefits are attributed to four primary areas including:

- **Operational Efficiencies**—More efficient use of distribution assets and streamlining of business processes, thereby reducing operational and future capital expenses;
- **Energy Savings**—Lower electricity use through improved distribution system control, efficiencies and reduced consumption by customers;
- **Revenue Protection**—Includes both recovery of revenue and prevention of future potential revenue loss through reduced theft; and
- **Capacity Savings**—Lower electricity use at certain key periods, which reduces peak demand and capacity constraints.

Almost 80 per cent of the quantified benefits delivered through the Smart Metering Program result from operational efficiencies within BC Hydro. If customers take advantage of the conservation tools offered through the program, the overall benefits increase significantly. Additional information regarding each specific benefit stream, including key assumptions, is provided in Appendix 4.

In addition to the quantified benefits, the Smart Metering Program will deliver numerous other benefits that have not been quantified in this business case or cannot be monetized. A summary of these additional benefits can be found in Appendix 5.

The operational savings delivered by the Smart Metering Program will benefit all BC Hydro customers. As a publically-owned cost-recovery utility, all benefits realized by BC Hydro are passed on to customers and will be reflected in rates. In addition, customers will not be billed separately for the cost of the new smart meters.

TABLE 1: PROGRAM BENEFITS AS OF DECEMBER 2010—IN PRESENT VALUE

Type of Benefit	Description	Expected Benefit ($ Million)	Sensitivity Range[3] ($ Million)
Operational Efficiencies, Avoided Capital	Meter Reading Automation	$222	$182–$247
	Meter Sampling	$61	$56–$66
	Remote Re-connect Automation	$47	$42–$52
	Distribution Asset Optimization	$15	$12–$25
	Outage Management Efficiencies	$10	$5–$15
	Continuous Optimization and Load Research	$6	$2–$10
	Call Center & Billing	($2)	($4)–$0
Energy Savings	Voltage Optimization—Commercial Customer Sites	$108	$48–$148
	Voltage Optimization—Distribution System	$100	$85–$150
Revenue Protection	Theft Detection	$732	$632–$832
Derived from BC Hydro Operational Efficiencies (~80%)		**$1,299**	**$1,060–$1,545**
Capacity Savings	Voluntary Time-of-use Rates	$110	$30–$250
Energy Savings	Conservation Tools (in-home feedback tools)	$220	$170–$270
Increased Customer Conservation (~20%)		**$330**	**$200–$520**
Total Quantified Benefits		**$1,629**	**$1,260–$2,065**

Benefits Realization

The Smart Metering Program is a large and complex project designed to deliver significant benefits from across several business groups at BC Hydro. The benefits described in this business case pay for the investment in the program. BC Hydro is implementing a formal benefit realization framework, base-lined with the benefit streams identified in this business case, to ensure accountability and transparency in the measurement and reporting of the benefits over time.

[3] Sensitivity ranges identified for each benefit bracket the probable benefit outcomes. The ranges are based on an assessment of the upside and downside in variability associated with the key drivers behind each benefit.

TABLE 2: SMART METERING PROGRAM BUDGET

			$ millions
Initiation Phase (Completed F2007)			**1.4**
Identification Phase (Completed F2008)			**8.9**
Definition Phase (Completed F2011)			**38.8**
Implementation Phase (F2011–F2014)			
Smart Metering System			
	Architecture and Design	8.6	
	Assets: Smart Meters, Telecommunications, Software	256.0	
	Deployment Activities	126.5	
Sub-Total: Smart Metering System			**391.1**
Solution Integration (Information Technology)			
	Architecture and Design	3.2	
	Assets: Meter Data Management System and Other Applications	7.9	
	Implementation Activities	49.8	
Sub-Total: Solution Integration (Information Technology)			**60.9**
Theft Detection			
	Architecture and Design	2.6	
	Assets: Distribution System Meters, Application Software	62.7	
	Deployment Activities	45.2	
Sub-Total: Theft Detection			**110.5**
Conservation Tools			
	Architecture and Design	2.4	
	Assets: In-Home Displays, Website, Software Supporting Rates	18.4	
	Rebate Program	42.0	
Sub-Total: Conservation Tools			**62.8**
Grid Modernization Infrastructure Upgrades			
	Architecture and Design	1.9	
	Assets: Advanced Telecom Devices and Applications	33.0	
	Deployment Activities	19.3	
Sub-Total: Grid Modernization Infrastructure Upgrades			**54.2**
Program Delivery Activities			
	Project Management and Controls	22.2	
	Safety, Security, Privacy Governance	1.1	
	Finance and Regulatory	2.4	
	Customer Research, Engagement and Outreach	8.6	
	Contract Management	2.7	
Sub-Total: Program Delivery Activities			**37.0**
Sub-Total: Implementation Phase			**716.5**
Interest During Construction			**14.4**
Contingency			**60.0**
Sub-Total			**840.0**
Reserve Subject to Board Control			**90.0**
Total: Program Authorized Amount			**930.0**

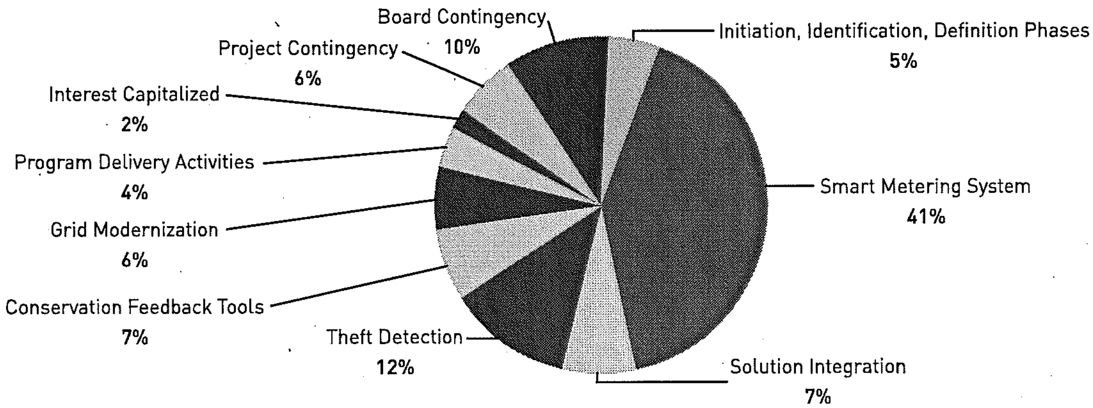


FIGURE 1: BUDGET COMPONENTS BY PERCENTAGE WITH SPECIFIC FOCUS ON THE IMPLEMENTATION PHASE

Program Costs

The total Authorized Amount for the Smart Metering Program is $930 million (nominal value) including contingency. The budget was developed using BC Hydro's standard project planning methodology, and is organized into four major phases (see Glossary for definition of phases):

- **Initiation Phase**—Completed in F2007
- **Identification Phase**—Completed in F2008
- **Definition Phase**—Completed in F2011
- **Implementation Phase**—Scheduled to be fully completed in F2014, with the installation of customer meters on track for the December 2012 date as legislated by the Province of British Columbia.

Net Present Value

The Smart Metering Program business case shows a net present value (NPV) of $520 million through F2033. The NPV remains positive even if all costs are incurred and only the BC Hydro operational efficiencies are realized. The NPV also remains positive if all benefits are achieved at the low end of the estimated benefit range. A more detailed discussion of the business case analysis can be found in Appendix 6.

The positive NPV of the Smart Metering Program will benefit all BC Hydro customers. These net benefits will flow, over time, into lower rates for customers, reducing them below what they would otherwise be in the absence of BC Hydro's investment in the program. See Appendix 7 for a discussion of the Smart Metering Program rate analysis.

RISKS

BC Hydro has put in place a Risk Management process to identify, assess, and mitigate risks that could significantly impact the Smart Metering Program. Appendix 8 provides a summary of the key risks and mitigation strategies. The procurement process employed by the program has also played a significant role in mitigating technology, cost, and schedule risk. More information about how BC Hydro has managed risk through procurement can be found in Appendix 9.

LESSONS LEARNED FROM OTHER JURISDICTIONS

BC Hydro has also managed risk through learning from others. By adopting smart meters after learning from the experience of other utilities, BC Hydro has the advantage of knowing what factors contribute to successful implementation and benefit realization. Some of these key learnings are included in Table 3.

TABLE 3: SUMMARY OF LESSONS LEARNED FROM OTHER JURISDICTIONS

Program Element	Experience of other utilities	Our approach
Technology	Some utilities were adopters of early smart metering technology which had limited capabilities and ultimately had to be replaced.	BC Hydro is taking advantage of the fact that metering technology has stabilized, and technology standards are now more open, robust and secure. BC Hydro is actively involved in numerous industry standards and policy groups as outlined in Appendix 10. BC Hydro has also included mandatory criteria in procurement packages to ensure only proven and scalable technology would be considered.
Meter Accuracy	In some jurisdictions, questions were raised about meter accuracy. Ultimately, it was determined that events such as heat waves occurring at the same time as meter installation were the main factors in perceived inaccuracies. Testing has confirmed smart meters are more accurate than electro-mechanical meters.	BC Hydro is governed by the testing requirements established by Measurement Canada, a federal agency. The installed base of meters in Canada has a very high degree of accuracy due to regular random testing.
Rates	Several utilities have chosen to implement time-of-use rates at the same time as smart meter installation, resulting in higher bills for customers.	BC Hydro will maintain existing rate structures at the same time as meter installation. BC Hydro will engage customers in the design of any new rate structures and any new or modified rates will be subject to review and approval by the BC Utilities Commission.
Customer Choice and Support	Some utilities provided few in-home feedback options and provided limited transactional information through their call centre, not offering customers adequate meter installation information or support for conservation efforts.	BC Hydro will offer incentives for customers to adopt conservation tools such as in-home displays that will provide near real-time feedback, and a secure web page that provides next day consumption data, with tools to help analyze patterns. Trained call centre agents will be available to answer specific customer questions during the meter installation period, and to provide advice on how to maximize conservation savings through the use of new in-home feedback tools when they become available.
Security and Privacy	In some cases, privacy and security considerations were implemented as an afterthought.	Privacy, security and safety features were key evaluation criteria in all procurement processes related to the Smart Metering Program. Privacy-by-Design and Security-by-Design processes are used for all design, development, and implementation activities. BC Hydro also has active and ongoing involvement with industry standards and policy groups, including those focused on security, privacy and safety standards.

KEY TIMELINE FOR CUSTOMERS

A key lesson learned from other smart meter initiatives is the importance of communication with customers. Accordingly, BC Hydro has developed a proactive approach to ensure open and frequent customer engagement. The following table provides highlights from the Smart Metering Program's customer engagement approach.

TABLE 4: KEY TIMELINE FOR CUSTOMERS

Stage	Timeframe	Key Activities
Program Information	**Underway and throughout the program**	Customers have access—through the BC Hydro website, bill inserts, and community events—to information about the Smart Metering Program, the smart metering system that will be installed, how it works, and other topics of customer interest. Customers can share their feedback, concerns, and interest directly through calling, email, community events, and customer research.
Installation of Smart Meters	**Mid 2011 through 2012**	Customers receive information packages before smart meters are installed in their community[4].
In-home Feedback Tools	**2012 through 2014**	Customers receive information highlighting new options available to support their energy conservation efforts. Customers receive a rebate for a basic in-home display device that can be redeemed at select stores. Customers will have access to information about their electricity use, up to the previous day, through a secure Power Smart website.

[4] Smart meter installation will begin simultaneously in communities throughout the province.

APPENDIX 1: SMART METER SECURITY, PRIVACY AND SAFETY

Security, privacy and safety have been considered key priorities throughout the development of the Smart Metering Program. The program redefines many of the existing business processes—and introduces new ones—requiring that security, privacy and safety are embedded in each and every aspect. The basic principles of Security-by-Design, Privacy-by-Design and Safety-by-Design have been incorporated throughout the planning of the program. Each of these disciplines are also intrinsically linked; for example, ensuring a security objective is achieved also enhances safety and privacy.

Procurement

Security, privacy and safety requirements are included throughout all of the Smart Metering Program Requests for Proposals (RFPs). Examples of specific requirements include:

- Ensuring vendors are provided with all BC Hydro safety standards and Smart Metering Program security and privacy specifications.
- BC Hydro's Safety-by-Design Practice referenced as a specification. Examples include the metering system specifications explicitly referencing:
    - Applicable American National Standards Institute (ANSI) and Institute of Electrical and Electronics Engineers (IEEE) safety standards; and
    - Generation Project and Service Delivery Practices: Safety-by-Design.
- In RFPs, proponents are required to describe their safety programs and how they propose to comply with BC Hydro safety principles.
- Vendors are required to document, in detail, how their solutions to smart metering security standards demonstrate security best practices.
- Security penetration testing is a mandatory deliverable before implementation of each component of the solution.
- Field Operations Safety and Work Methods staff members participated in vendor evaluation sessions where worker safety practices were thoroughly reviewed. This involvement will continue for future procurements associated with smart metering field devices and related work methods.
- Enhanced meter safety and security design criteria was included in the metering system RFP.

Security in the Smart Meter and Smart Metering System

There are a number of security and safety features within the smart meters themselves, including:

- Use of the end-to-end 128-bit Advanced Encryption Standard (AES) algorithm, which is the same as typical online banking systems;
- Use of an asymmetric key algorithm, which ensures the smart meter cannot read any information it generates once that information has been encrypted. This also means that a specific smart meter can not access or read any data generated by another smart meter; and
- Limited historical data is stored on the smart meters mitigating any exposure of a customer's private data. Additionally, BC Hydro has privacy requirements in place to ensure that employees protect the privacy of customers in accordance with the *Freedom of Information and Protection of Privacy Act.*

There are also security and safety features inherent in the smart metering system:

- Home Area Network (HAN) components, such as in-home display devices, utilize a secure communication system that works only for the local network (i.e. the specific home). Nearby in-home display devices will not be able to access information from another device.

- The smart metering deployment architecture is designed to use different access keys for each localized area to ensure the overall system remains secure—essentially, the smart metering system is broken up into many isolated units. Gaining access to one isolated unit does not provide access to the whole. In other words, devices with a localized area key do not have access to the entire network and no one device is capable of accessing the entire electricity system.
- When a customer moves to a home with an existing smart meter, BC Hydro will ensure that all current in-home device connections are cleared so that usage information from the previous home owner stays private.
- Field tools, used to configure smart meters when remote configuration is not possible, are managed through a secure isolated network. Access to field tools will be limited to necessary staff members using unique passwords. Field tools also carry limited customer meter data and will be purged after each use.

Smart Meter Privacy

- The Smart Metering Program has been focused on privacy concerns since its inception. BC Hydro's Freedom of Information Coordination Office (FOICO) has been central in the discussion of privacy-related issues and participated in all aspects of the requirements and RFP phases of the project.
- In addition to FOICO, resources with expertise in privacy are assigned to the Smart Metering Program to assess and ensure that privacy requirements are met through the life of the program.
- A Privacy Impact Assessment (PIA) is completed for the entire Smart Metering Program, each individual release, and specific security or privacy sensitive components. In all, more than thirty PIAs are anticipated and each PIA will require FOICO sign-off to ensure privacy requirements are effectively managed throughout the program.
- Security and privacy frameworks are being developed for each release of the program to ensure that BC Hydro standards for security and privacy meet or exceed compliance requirements and future expectations.

Smart Meters and Radio Frequency Safety

Smart meters will use radio frequency to communicate data to and from BC Hydro. The health effects of the frequencies employed have been thoroughly investigated by BC Hydro. In addition, many reputable health authorities such as the World Health Organization and Health Canada have conducted thorough reviews of all the different types of studies and research on electromagnetic fields and health. These health authorities have examined the scientific weight-of-evidence and have determined that when all of the epidemiological and experimental studies are considered together, the consensus is that there is no cause-effect relationship between exposure to electromagnetic fields and human health.

Specific to radio frequency exposure to the public, proposed Field Area Network devices must be certified by Industry Canada and in compliance with Health Canada's Limits of Exposure to Radio Frequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz [Safety Code 6]. BC Hydro will continue to monitor research related to radio frequency. General information and resources related to electromagnetic fields can be found on BC Hydro's website at:
bchydro.com/safety/electric_magnetic_fields/magnetic_fields_and_health.html.

BC Hydro will collaborate with customers who are concerned about radio frequency with the objective of identifying solutions that can be mutually supported.

There are three key factors that contribute to radio frequency safety: duration of the signal, signal strength and distance from the signal.

1. **Signal Duration**
   While the period during which a smart meter transmits data back to BC Hydro will vary depending on the specific metering system used, transmission is expected to last for only a few minutes per day.

2. **Signal Strength**
   The signal strength emitted by a smart meter is considerably less than visible light and exposure common to everyday living, such as laptops, cell phones and handheld radios. For example, if you are standing adjacent to the smart meter and it is transmitting continually for those few minutes, exposure is between 60 times and 600 times below the acceptable level identified in Safety Code 6.

3. **Distance from the Signal**
   Smart meters will be located in the same place as the existing meter on the outside of a customer's home, or in a meter bank in multi dwelling units such as town homes, condominiums or apartment buildings.

Standing 3 metres (10 feet) away from the meter while it is transmitting, exposure drops to 60,000 times to 600,000 times below the Safety Code 6 acceptable level. Excluding the built in safety factor in Health Canada's Safety Code 6, standing adjacent to a smart meter device, the radio frequency radiation is 60 times less than the Safety Code 6 acceptable level. This is assuming the smart meter device is transmitting 100 per cent of the time, which it does not.

Some customers have expressed concerns about the potential effect of radio frequencies on their unique personal health condition. Individuals who have concerns or questions are invited to contact us at **smartmeters@bchydro.com**.

The following table compares the radio frequency generated by items common to everyday life.

DEVICE RELATIVE POWER DENSITY IN MICROWATTS PER SQUARE CENTIMETRE (μW/cm²)

Distance from the Signal	Signal Strength
FM radio or TV broadcast station signal	0.005 microwatts
Smart meter device at 3 metres (10 feet)	**0.01 microwatts***
Cyber cafe (Wi-Fi)	10–20 microwatts
Laptop computer	10–20 microwatts
Cell phone held up to head	30–10,000 microwatts
Hand-held radio at head	500–42,000 microwatts
Microwave oven, 5 cm (2 inches) from door	5,000 microwatts
Summer sunlight at earth's surface	100,000 microwatts

*Adjacent to meter <10 microwatts

Design and Operation of Equipment

BC Hydro's Safety-by-Design practice addresses the design and operation of new and existing equipment throughout the system including:

- Safe placement of equipment in energized locations (e.g. collectors requiring a power source);
- Safe operation of equipment (e.g. vehicles used for deployment); and
- Designing new components (e.g. integration of distribution system meters) from a safety perspective.

An important component of the Smart Metering Program since 2008 has been the engagement of other utilities and research bodies throughout North America (e.g. Pacific Gas & Electric) to understand their safety challenges and experiences. BC Hydro is an active member of several industry groups where the focus is safety, security, and privacy standards.

BC Hydro has anticipated a possible risk of violence related to electricity theft from drug operations during the installation of smart meters. Measures to protect both employees and the public include:

- The establishment of a police coordination program;
- The development of policies to ensure employees do not engage in unsafe situations; and
- Violence risk assessment training for all installation technicians.

Internal Procedures

Internal procedures have been reviewed from a safety, security and privacy perspective. An outcome of this review is the development of enhanced and new training programs to reinforce safety awareness and safe work practices. Examples include:

- A Safety-by-Design Project Hazard Matrix will be implemented for all planned technologies and the physical placement of meters, telecommunications components and system meters.
- Standards design work is underway with the Distribution Engineering Standards department for the safe and secure placement of telecommunications components.
- Meter installer training programs will be reviewed by the BC Hydro Work Methods department and scrutinized for compliance with safe work practices.
- Mandatory safety requirements and qualifications for meter installation proponents include compliance with WorkSafeBC and the *Safety Standards Act*, with a specific focus on vehicle safety, and provision for safety audits of the installation work.
- Project team members are trained in, and will adhere to, applicable BC Hydro safe work practices in our field and laboratory environments.

Industry Standards Development

BC Hydro is participating in the National Electric Energy Testing Research and Applications Center (NEETRAC), testing and developing meter service connect/disconnect standards with respect to performance and safety. As part of BC Hydro's metering system procurement process vendors must provide formal documentation related to their compliance with the testing requirements and acceptance criteria of NEETRAC. Further, BC Hydro is working as a member of an American National Standards Institute committee on advancing service connect/disconnect standards. BC Hydro's commitment to service switch safety will enhance the safety of both customers and workers.

APPENDIX 2: PROGRAM SCOPE

For the past four years, BC Hydro has been defining the scope and approach for the Smart Metering Program. Key activities include:

- Developing a detailed set of specific functional, operational and technical requirements captured in a set of comprehensive use cases described later in this section.
- Actively participating in technology and industry standards groups focused on smart metering and the emerging smart grid sectors to ensure BC Hydro business needs are captured in industry standards.
- Monitoring the progress and results from utilities who were early implementers of smart metering projects—including Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, Duke Power, ENEL (Italy), and in Ontario—Hydro One, Toronto Hydro—and incorporating their "lessons learned" into BC Hydro's project planning.
- Tracking the market evolution of metering technologies, software products, and in-home energy management offerings to ensure BC Hydro's solution choices are based on proven, secure technologies.

The activities listed above resulted in the final Smart Metering Program scope which includes the following six major components. Each will be managed and implemented as part of a single, integrated program:

Smart Metering System—Captures and communicates consumption data and meter events, such as outages, to both the customer and BC Hydro;

Solution Integration—Designs, develops, and implements the software components, business processes, and ongoing support structures required to enable smart metering capabilities;

Theft Detection—Enables BC Hydro to better localize sources of electricity diversion;

Conservation Tools—Provide information enabling customers to make informed and timely decisions in relation to their electricity consumption;

Grid Modernization Infrastructure Upgrades—Provide the smart meter operations centre, and advanced technology and telecommunications infrastructure, to help improve the reliability and security of the electricity system; and

Program Delivery Activities—Provide the overall project management activities and responsibilities designed to ensure a quality implementation of each solution component included in the program scope.

Following is a more detailed description of each scope component.

Smart Metering System

Included as part of the Smart Metering System[5] are:

- **Smart Meters**—Digital meters—capable of two-way communications—with the ability to measure the incoming and outgoing flow of electricity from a specific location such as a customer's home or business. The two-way communication capability enables smart meters to provide use data to both customers and BC Hydro—in different formats. When paired with an in-home display, the smart meter can send real-time consumption and price information directly to the customer. Real-time customer use information will be transmitted through the Home Area Network directly to the customer and will not be available to BC Hydro. Smart meters will capture and store use on an hourly basis and transmit the data back to BC Hydro, through the Field Area Network and Wide Area Network, during short intervals (couple of minutes) at prescheduled times during the day.
- **Metering Telecommunications**—Consisting of two parts—the Field Area Network (localized to meters in the field) and the Wide Area Network connections (enterprise wide focus)—this communications infrastructure provides the physical devices required to enable two-way transmission of data between smart meters and BC Hydro. There are several different ways this field-based communications infrastructure can be implemented, depending on the metering system selected.
- **Automated Data Collection System**—This software application is designed to aggregate meter usage and event data from smart meters and manage the Field Area Network communications infrastructure. This software is provided by the metering system vendor.

[5] BC Hydro is currently in an active procurement process to select the Metering System vendor.

Solution Integration

In addition to the overall smart metering system, the Smart Metering Program is responsible for the business environment that supports smart metering including implementation of new business software applications, changes to existing information systems, enhanced data warehouse and analytics capabilities, and all of the business transformation activities that will help BC Hydro adapt to the new technologies and systems. Specific elements of scope include:

- **Meter Data Management System—**A software application that stores, validates, edits and analyses meter reading data prior to releasing it for integration into other BC Hydro operational systems such as customer billing, load forecasting and outage management.
- **Interfaces and Integration—**This systems integration work involves modifying existing applications to handle the enhanced automated meter reading information, and building interfaces between new and existing enterprise applications to support BC Hydro's end-to-end business processes.
- **Business Transformation—**The major elements of business transformation work involve development of new and modified business processes, design of organizational and job changes, rollout of training and knowledge management programs, employee engagement to facilitate cultural change, and effective transition to business operations for ongoing work.

Theft Detection

BC Hydro currently does not have the measurement devices and analytical tools to quickly and accurately identify where theft of electricity is occurring. A comprehensive theft detection solution, based on electricity balancing analysis, will be implemented as part of the program. Scope elements include:

- **Distribution System Meters—**New meters (different from those to be installed at customer homes or businesses) will be installed at key points on BC Hydro's system to measure electricity supplied to localized areas.
- **Theft Analytics—**A suite of software tools that support enhanced electricity network modeling methods, as well as the business rules required to analyze measurement data captured from new distribution system and smart meters.

Conservation Tools

Smart meters will enable customers to take advantage of new tools to save energy and money. These include:

- **In-home Display—**Customers will have the choice of whether or not they wish to acquire in-home display devices. BC Hydro will provide financial incentives to enable customers to acquire a basic market available in-home display device from their local retailer. In-home displays will be enabled through the Home Area Network, a communication channel between the smart meter and the customer's home or business. This secure channel, an attribute of the smart metering system, enables customers to view their consumption either on a real-time or accumulated basis, represented in both cost and kilowatt-hours.
- **Power Smart Website—**BC Hydro's existing secure Power Smart website will be expanded to include new interactive and informative applications—based on the hourly data captured from smart meters—designed to help customers better understand and model their energy use. Today, residential customer meters are read every two months, which provides little practical information for customers to determine which, if any, conservation actions they should pursue.
- **Rate Options—**The smart metering system infrastructure will enable BC Hydro to design new rate structures that encourage conservation during peak periods. While the implementation of new rates is enabled by the Wide Area Network, Field Area Network and web interface, the design and implementation of new rate structures is a separate initiative. Key functional and data requirements to support rate options will be enabled by the new smart metering system and the Meter Data Management System. The design of these rate options will involve consultation with customers and key stakeholders, and will be subject to full review and approval by the BC Utilities Commission.

Grid Modernization Infrastructure Upgrades

This program scope element involves two key components; the specific requirements of each will depend on the metering technology selected:

- **Advanced Telecommunications Infrastructure—**Involves the design and installation of additional secure and reliable Wide Area Network telecommunications infrastructure to support advanced electricity system functions and emerging customer applications like customer generation and microgrids.
- **Advanced Operational Support—**Involves the implementation of a smart metering and network operations function to support real-time operations of the metering system. This support function will likely be implemented as an extension of BC Hydro's distribution operations centre so that all real-time system and telecommunications operations can be managed seamlessly and efficiently.

Program Delivery Activities

Included in the scope of the Smart Metering Program are the overall program delivery activities and services which ensure all of the technical aspects of the project are successfully implemented, and accepted by BC Hydro's customers and stakeholders. These activities include:

- **Project Management and Controls—**Includes the personnel and support tools to manage and report on the overall delivery of all aspects of the Smart Metering Program, including scope, schedule, budget, quality, issues resolution, environment management, and transition to operations.
- **Security, Privacy and Safety—**This independent team ensures appropriate governance and compliance for all the physical security, cyber security, data privacy, and employee, vendor and contractor safety aspects of the program. Security, privacy and safety have been fundamental drivers of the program.
- **Finance & Regulatory—**This team provides financial oversight and regulatory support to the project team.
- **Customer Research, Engagement and Outreach—**Includes the resources required to support the Smart Metering Program with respect to research, community engagement, customer communications, employee engagement, and media.
- **Contract Management—**Includes the personnel and processes required to manage procurement and tendering activities, as well as manage contractual commitments and any contract issues that may emerge.

Use Cases

Use cases provide a starting point to inform the scope of complex, cross functional projects, and define the subsequent procurement requirements. Use case methodology is an industry-leading approach to matching functional needs to the appropriate technology and systems.

BC Hydro examined use cases from other utilities across North America involved in smart metering systems. From there the approach was expanded to create 17 individual use cases based on BC Hydro's unique business needs and context. For example, BC Hydro's requirements included enhanced customer service options and theft detection. The inclusion of these requirements improved program benefits and contributed to a stronger business case.

Organized into four main categories the use cases include: Customer Service, Distribution System Optimization, Home Area Network and in-home feedback, and network and meter management. Based on business scenarios the use cases capture the current and long-term (over 20 years) functional, operational and technical requirements for BC Hydro.

Category	Use Cases	Description
Customer Service	Customer Contact Collect Interval Data Remote Connect or Disconnect Pre-pay Services Bill an Account	These use cases describe the functional requirements and business processes required to achieve enhanced customer services through improved communications, more accurate account billing, automated meter data collection, remote connect and disconnect services, and new service offerings such as pre-paid options. Customer Service Representatives will be better equipped to handle all customer requests regarding account enquiries, billing and payments, as well as help customers to monitor and adjust their energy consumption.
Distribution System Optimization	Extending or Reconfiguring the Distribution System Analyzing Meter Data for Load Research, Planning and Rates Detection of Tampering or Theft Distribution System Optimization and Automation Outage Detection and Restoration Customer Generation	These use cases describe the functional requirements, business processes, and operational aspects required to optimize the distribution system with respect to implementation of a new smart metering system. This includes the impact on BC Hydro's network design and engineering processes to incorporate new features and capabilities. Current and historical data captured through the Meter Data Management System includes accumulated energy consumption, demand profiles, aggregated time-of-use information, voltage information, and metering events (e.g. tamper flags). This more detailed and timely information supports several distribution system business processes including outage detection and analysis, theft identification and mitigation, and customer generation.
Home Area Network	Home Area Networks Providing Demand Side Management Capabilities Plug-in Hybrid Vehicles	These use cases describe the functional and technical requirements, and the business processes required to enable a Home Area Network using new smart meters and various in-home feedback tools. This may include providing pro-active notifications to customers if they choose, and the ability to accommodate electric vehicles on the distribution network. As customers, especially industrial and commercial customers, become more interested in direct load control, they can use demand response capabilities included in the Smart Metering Program to configure, manage, monitor and settle various load programs.
Network and Meter Management	Meter Lifecycle Management Management and Recovery of the System Installation and Configuration of the System	These use cases describe the requirements to configure, manage, recover and maintain the various metering units within the product lifecycle. A typical life cycle of a smart meter is described, including the installation, replacement, and remote troubleshooting methods involved. Described within these use cases is the initial installation and configuration of the smart metering system including meter procurement, quality assurance testing, logistics and installation.

APPENDIX 3: RESEARCH

In addition to applying lessons learned from other utilities, BC Hydro has reviewed research findings, conducted customer research, and field tested theft detection devices to assist in shaping the delivery of the Smart Metering Program. Key results are included below.

Research on Energy Conservation Effectiveness of In-home Feedback

BC Hydro has estimated that customers who use in-home feedback tools will realize an average 4 per cent energy savings. This estimate is considered to be conservative, based on various research findings, as outlined below.

Research in relation to the effectiveness of in-home feedback tools includes both academic research related to behaviour change and actual pilots and trials that have been conducted worldwide. This research has informed the savings assumption above, as well as the overall approach BC Hydro will be taking related to in-home feedback. Key research findings have found that saving from direct and indirect feedback can range from 3–15 per cent and 0–10 per cent respectively[6].

Specific industry initiatives have also provided a point of reference for potential energy conservation for the Smart Metering Program. For example, customer energy conservation has been reported as follows:

- Pacific Gas & Electric states an average 6.5 per cent reduction in energy use when using an in-home display[7],
- Southern California Edison reports a 6.5 per cent reduction in energy use when using Home Area Network devices and a 2 per cent reduction in energy when using historical online feedback[8], and
- Commonwealth Edison reported a 2 per cent reduction in energy use when customers subscribed to monthly online reports[9].

Research on Customer Participation for In-home Feedback

Customer participation will depend on several factors, including the cost of in-home feedback tools, their overall appeal and simplicity of use, the marketing campaign that supports their distribution, and their effectiveness in helping customers save electricity. Also reported in Southern California Edison and Pacific Gas & Electric's application filing to the California Public Utilities Commission were their assumptions on participation. Southern California Edison assumes a 10 per cent penetration with 1 per cent growth per year for their online web pages while Pacific Gas & Electric assumes a 21 per cent penetration by 2030 for customer-purchased in-home displays.

BC Hydro qualitative focus group research, conducted with customers and employees, found there was strong interest in electricity feedback mechanisms. Based on focus groups completed in 2010, customers were optimistic that increased awareness via in-home feedback tools will help them conserve energy and save money. In general, most participants expressed interest in the program. In addition, it was found that 83 per cent of BC Hydro customers have at least one computer and 86 per cent had internet connectivity at home[10]. Given these statistics, the potential use of a secure online feedback website should be widespread.

Conservation Research Initiative

Important feedback was also derived from the Conservation Research Initiative, a program launched by BC Hydro in 2006. The goal of the Conservation Research Initiative was to examine how individual British Columbians could make a difference and help meet the growing demand for electricity in BC by conserving electricity in their homes.

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[6] The Effectiveness Of Feedback On Energy Consumption; Sarah Darby, Environmental Change Institute, Oxford University, April 2006; Residential Electricity Use Feedback: A Research Synthesis and Economic Framework; EPRI (Electric Power Research Institute), February 2009; Impact Of Informational Feedback On Energy Consumption—A Survey Of The Experimental Evidence; Ahmad Faruqui, Sanem Sergici and Ahmed Sharif, May 2009

[7] Application filed to CPUC December 12, 2007 App No 07-12-009

[8] Application filed to CPUC July 31, 2007 App No 07-07-026

[9] Pilot findings: http://usweatherizing.com/blog/?p=923

[10] Residential Customers Needs Survey F10 (February 2010)

This study was conducted in more than 1,800 residential homes across six communities: Vancouver, Burnaby, North Vancouver, West Vancouver, Campbell River and Fort St. John. The study tested time-of-use rates and smart meters to help BC Hydro better understand how adjusting the price of electricity at different times of the day influences electricity use by residential customers.

The results of the Conservation Research Initiative are summarized below:

- Overall consumption was reduced by 7.6 per cent.
- Energy use during peak hours was reduced by 11.5 per cent.
- 63 per cent of participants saved money by conserving and shifting their consumption to off-peak hours.

Theft Detection Pilots

Since 2005, BC Hydro has implemented four theft detection pilots using distribution system meters to conduct energy inventory balances with customer smart meters. All of these pilots have successfully demonstrated that the energy inventory balance approach, conducted at either the primary or secondary voltage level, can readily identify localized areas of the electricity system where theft is occurring. In total these pilots, which are still operational, covered over 800 homes, and resulted in the identification and termination of 22 electricity thefts. Where thefts have been identified and shut down quickly, there has been little recurrence. Further details regarding the theft pilots can not be released for security reasons. These theft detection pilots identified key requirements for the design of a scalable solution including the following three major components in addition to the basic smart metering system: distribution system meters; theft analytics software; and new investigation techniques and processes.

APPENDIX 4: QUANTIFIED BENEFITS AND KEY ASSUMPTIONS

This section provides a summary of the key sensitivities and assumptions for each benefit stream included in the Smart Metering Program business case.

Benefit Description	Present Value (PV) Millions (M)	Key Business Case Assumptions	Sensitivity Millions (M)
Meter Reading Automation Accenture Business Services for Utilities currently provides manual meter reading services. BC Hydro supplies the infrastructure including vehicles, facilities, meter reading software and hand-held equipment. This benefit represents a reduction in manual meter reading services, supporting infrastructure, and green house gas emission costs, based on an assumed Field Area Network coverage for 95 per cent of customers.	**$222 M** Range is: $182 M–$247 M	A Field Area Network will provide communications infrastructure to at least 95 per cent of customers. Costs to read the remaining 5 per cent of customers are estimated at 3 times higher than current costs.	Each per cent point over 95 per cent coverage adds $6 M to the PV.
Meter Sampling BC Hydro has ongoing processes to ensure customer meters are maintained and operated within the accuracy requirements mandated by Measurement Canada. Each year, a statistical sample of meter groups is removed and tested for accuracy. If a sample group does not meet the accuracy standards, that entire group of meters is removed from service. An average of 40,000 meters are replaced annually under this program. Smart meters will eliminate the need to sample and test meters for some period of time.	**$61 M** Range is: $56 M–$66 M	This benefit results from reduced operating costs for sampling processes and reduced capital expenditures to replace failed meter groups over a planned seven-year period following installation of smart meters. Health of meters in service will be monitored during the seven year suspension of sampling. Estimate of 1 per cent of meters replaced annually, based on increased accuracy of electronic smart meters.	Each per cent change in the meter failure rate results in a $3.4 M change in PV.
Remote Re-connect Automation Today, meter reconnections and disconnections are completed onsite by a meter technician or power line technician. The remote on/off switch provided within smart meters enables all connection related services to be completed remotely, safely and securely. This benefit is due to reducing the need for manual connects/disconnects for non-payment, and the associated vehicle expenses.	**$47 M** Range is: $42 M–$52 M	BC Hydro's policies and procedures for when service can and will be disconnected are not changed for this business case. Remote on/off switch will be included in all meters where it is technically feasible.	Each percentage point over 95 per cent coverage adds $0.23 M to the PV.

Distribution Asset Optimization Capital expenditures related to growth of the distribution system—driven by load growth, reliability improvements, customer connections and station expansion—are approximately $500 M per year for the foreseeable future. Smart Metering Program benefits from improved availability of assets and system performance data and information results in conservative capital budget savings of 0.3 to 0.5 per cent per year following implementation of all Smart Metering Program assets.	**$15 M** Range is: $12 M–$25 M	Does not include any distribution asset optimization benefits resulting from theft detection and reduction. Only includes incremental benefits due to new distribution system meters and smart meters.	Each 0.1 per cent change in the distribution system capital budget impact related to smart metering results in a $4.7 M PV change.
Outage Management Efficiencies Today, BC Hydro is only made aware of customer (residential/commercial) outages when they call 1 888 POWERON. Smart meters will provide automated outage notification, specific outage location information, and confirm when power has been restored. Smart Metering Program related benefits include improved time to restore outages, reduced visits to false outages, more rapid identification and restoration of embedded outages, and improved customer satisfaction.	**$10 M** Range is: $5 M–$15 M	Includes outage management improvements from both trouble-based outages (e.g. single customer calls) and storm-based outages (i.e. wide-spread outages due to a specific event).	Due to the high variability of outages from year to year, this benefit is based on an average, over the term of the business case.
Continuous Optimization and Load Research BC Hydro's Continuous Optimization Program targets operational savings in the commercial sector. The program provides consulting services to help identify actions to reduce energy use in buildings. With smart meters, the program will no longer have to retrofit the existing meter and install additional hardware on the customer's site to capture interval meter reading data. Smart meters will provide Load Research with load profile information in a more timely and accurate form, avoiding capital and operational costs.	**$6 M** Range is: $2 M–$10 M	Estimated savings in meter upgrades of $1,800 per Continuous Optimization site, plus savings of additional hardware and installation costs of $2,980 per site. Estimated annual operational savings for Load Research of $290 K, plus one-time capital savings of $2.2 M.	A 10 per cent change in the number of customers in the Continuous Optimization Program results in a change of $0.2M PV.

Call Centre and Billing With smart meters, customer calls related to estimated bills and meter reading access arrangements will be substantially reduced. Also, call centre agents will have much more information available to help address questions regarding meter reads, billing, payments, and energy conservation. BC Hydro expects call volumes to increase as smart meters are being introduced and this cost has been factored in to the overall business case.	**($2) M** Range is: $(4) M–$0 M	Call volumes estimated based on inquiries related to current Power Smart programs. Approximately 48 per cent of billing errors will be eliminated.	A change of 48,000 calls results in a change of $1 M in PV. Every 5 per cent change in billing exceptions changes the PV by $0.5 M
Voltage Optimization Voltage optimization or Volt-VAR Optimization (VVO) technology helps reduce the amount of electricity that must be transmitted in order to ensure sufficient power quality at customer sites. Smart meters will enhance BC Hydro's existing VVO program by providing significantly more measurement points along the distribution network, thus helping to manage voltage more effectively. Smart metering helps deliver VVO benefits for both the Distribution system and Customers: **Customers**—Extend the VVO program to a Power Smart Program for eligible commercial customers. **Distribution**—Enhance the effectiveness of the VVO program and enable the extension of the program to additional substations.	$108 M Range is: $48 M–$148 M $100 M Range is: $85 M–$150 M	At least 2,000 commercial customer sites have use characteristics that would benefit from voltage optimization. Benefit is net of the Demand Side Management Program costs to incent customers to install equipment.	Each increase/ decrease of 10 per cent in GWh/yr in energy savings results in $14 M increase/decrease in PV. For each 100 increase/decrease in the number of customer sites included into the VVO program, the PV increases/ decreases by $11 M.

Theft Detection The theft detection solution includes distribution system metering, business analytics, and an upgraded topology model to quickly and accurately identify where theft is occurring. This increased automation will shift BC Hydro from a reliance on public-generated tips to system-generated tips regarding suspected theft. Smart meters also have automated tamper alarms to alert BC Hydro. Benefits result from energy and capacity savings, additional revenue through prevention of theft, and back-billing to recover cost of stolen energy and investigation costs.	**$732 M** Range is: $632 M–$832 M	Estimated consuption by marijuana growing operations is 1,300 GWh/yr through F2033 (paid and theft), of which theft increases from 500 GWh/yr in F2007 to 850 GWh/yr in F2012. Realization of theft benefits is estimated at an initial 75 per cent, declining to about 67 per cent by F2027. Theft detection requires analysis and in-field investigation; the business case includes an incremental operations and maintenance increase of $10 M, declining to $7 M by F2015. Total portion of theft attributed to meter tampering is 5 per cent, with the rest attributed to diversion directly from distribution lines. An average of 16 per cent of back-billing for theft is collectible.	An increase/ decrease of 10 per cent in the amount of theft reduction achieved results in an increase/ decrease of $86 M PV.
Voluntary Time-of-Use Rates Reducing peak period demand for electricity can reduce the amount of capacity BC Hydro needs in the system, thus potentially deferring the need to build more generation, transmission, and distribution assets. The more detailed use information captured by smart meters enables BC Hydro to investigate different rate options including time-of-use. BC Hydro is in the early stages of rate design and will soon begin engaging with customers and stakeholders to receive feedback on different types of rates. No decisions have been made yet regarding specific rate designs and any final rate designs will be subject to approval by the BC Utilities Commission.	**$110 M** Range is: $30 M–$250 M	The business case benefits assume new time-of-use rates would be voluntary. Customer enrolment in time-of-use rate programs is expected to start slowly and build through 2015 to 30 per cent. Benefits are net of costs to design and implement the new rate structures. Price elasticity is assumed at -0.10.	A change in the participation rate of 1 per cent change results in a $5.2 M change in PV. The business case benefits translate to a 10 per cent shift from on-peak to off-peak usage by participating residential customers, on average.

Conservation Tools (in-home feedback) Offering customers opportunities to monitor their electricity consumption in new ways can lead to increased awareness of energy consumption and therefore increased conservation behaviour. Customers will be offered two feedback options: 1. Near real-time feedback delivered via an optional in-home display device; and/or 2. Hourly data, provided within 24 hours, through the Power Smart website.	**$220 M** Range is: $170 M–$270 M	BC Hydro will offer a rebate program to encourage customers to choose a basic, market available in-home display. Customer take-up of in-home display is assumed at 30 per cent. Energy savings from in-home displays are 4 per cent with eight year persistence. Website-based energy savings are 2 per cent, with 15 per cent penetration of residential customers.	An increase/ decrease of 1 per cent in customer participation translates to approximately $1.2 M in PV.

APPENDIX 5: ADDITIONAL NON-QUANTIFIED BENEFITS

In addition to the quantified benefits identified in the business case, the Smart Metering Program will deliver numerous other benefits that have not been captured in the business case to date. The following table provides a summary of these additional benefits.

Type of Benefit	Additional Benefits
Operational Efficiencies, Cost Savings and Other Benefits	Additional uses of metering (unrelated to theft detection) in distribution planning and operations, asset management, etc. Reduction of line losses unrelated to theft detection (e.g. street lights). Facilitation of screening process required to assess the impact of Distributed Generation and electric vehicles during planning. Increased data will significantly improve the precision and quality of load profiles. Reduce staffing needs, related facility space and office equipment. Reduction in carbon offset payment for emissions for the BC Hydro fleet vehicles used by Accenture Business Services for Utilities. Improved overall system efficiency through better ability to optimize supply and demand levels throughout the day.
Safety, Privacy and Security	Reduced employee and contractor exposure to potential accidents and injury due to reduction of time spent in the field. Improved public safety due to the reduction in electricity theft. Customer security and privacy will increase as meter readers will no longer be required to enter customer property to read, disconnect or reconnect meters.
Improved Customer Service and Convenience	Customer service representatives will have the ability to check current meter readings directly from the meter while the customer is on the phone to validate meter functionality, address billing complaints, and confirm whether an outage is on the customer side of the meter. Customers will no longer be required to unlock gates, keep dogs inside, provide keys for access, etc. On-demand meter reading when customers move in or out of premises will avoid adjusted billings between tenants, simplifying transactions for customers. Customers will have the option of signing up for automated outage notification. Customers can choose to receive rate related information through an in-home display. Customers who use the in-home feedback tools, whether it is a secure web page or in-home display, and conserve energy will benefit from lower bills. Better ongoing information for customers and quicker response to power outage situations will enable commercial customers to make better decisions and reduce down-time costs. Customers will benefit from faster service re-connection. Commercial customers will be better able to optimize commercial building systems, saving energy and money.

Environment	Facilitates conservation and energy efficiency. System efficiencies and increased automation within BC Hydro's operations will deliver some greenhouse gas emission reductions. Support for the large scale integration of electric vehicles and electrification of the transportation system could deliver further green house gas emission reductions. Smart metering benefits will help to achieve the Province's target to reduce the projected demand increase by at least 66 per cent through conservation. Supports BC Hydro's ability to pursue all cost-effective Demand Side Management.
Socio-economic	Employment opportunities related to the installation of meters, and creation of more information-based jobs. Opportunities for local business to build on the system and create new products and services that support a green economy. Opportunities to build on the new smart metering infrastructure to create made-in-B.C. technology solutions that support a green economy. Smart meters are the first step in enabling the large scale accommodation of electric vehicles, customer self generation and microgrids that will help communities throughout British Columbia become more self sufficient. Enables significant energy savings that can be used for other economic purposes.

APPENDIX 6: BUSINESS CASE ANALYSIS

A business case documents the economic justification to support an investment decision, such as acquiring assets. Business cases are based on forecasts of incremental cash flows, both benefits and costs, over a time horizon that reflects the economic lives of the assets acquired. These cash flows are then discounted resulting in a net present value (NPV).

A business case does not include non-cash financial impacts, such as depreciation, amortization, or write downs of existing assets. These are accounting transactions, included in appropriate financial reports, and are not a factor in the economic rationale to make a business investment.

The Smart Metering Program business case model includes all the inputs and assumptions required to complete a comprehensive financial analysis of costs and benefits over a 20 year term following the installation of the meters (through F2033). The Smart Metering Program business case analysis reflects those cash flows that are incremental to cash flows without the program. For example, the business case model captures total annual cash flows for capital expenditures, avoided and deferred capital benefits, operating expenses and operating benefits. The NPV of the cash flows over the evaluation period is then calculated. A positive NPV supports the proposed investment decision.

The table below provides a summary of the key financial modeling assumptions used in the Smart Metering Program business case model:

KEY FINANCIAL MODELLING ASSUMPTIONS

Category	Assumption	Sensitivity
Discount Rate and Inflation Rate	The present value of all costs and benefits has been calculated using the nominal (i.e., with inflation) BC Hydro discount rate of 8 per cent[11] per year.	A variation of 0.25 per cent (+/-) in the discount rate changes the NPV in the business case by approximately $30 M.
Value of Energy	Value of energy is the BC Hydro reference energy price based on the 2009 Clean Call for Power. This price is $124 per MWh for F2010 and adjusted for inflation annually.	A 10 per cent change in the assumed value of energy results in a change in the NPV of about $85 M.
Value of Capacity	Value of capacity is an estimate for the avoided cost of building generation, transmission and distribution assets. The capacity reference price is updated as part of the integrated resource planning process. For capacity benefits associated with energy savings in this business case, the value of capacity is $88 per kilowatt-year (as set in F2009 and adjusted for inflation annually).	A 10 per cent change in the assumed value of the capacity results in a change in the NPV of about $28 M.

[11] BC Hydro's discount rate (Weighted Average Cost of Capital) for business cases is based on BC Hydro's deemed capital structure, the allowed rate of return on equity—both of which are approved by the British Columbia Utilities Commission—and the forecasted average cost of debt. The Weighted Average Cost of Capital for F2011 is presently set at 8 per cent, and includes a 2 per cent rate of inflation.

Amortization period	Amortization periods for smart metering assets acquired are based on the estimated economic life of each asset type, as follows: • Smart Meters: 20 years • Telecommunications (Field Area Network): 20 years • Telecommunications (Wide Area Network): 35 years • Distribution System Meters: 15 years • IT Hardware: 5 years • IT Software: 10 years	These amortization periods have no impact on the NPV of the business case. Assumed amortization periods do, however, affect customer rate impacts attributable to the Smart Metering Program.
Asset Refresh	Assets are typically replaced based on the estimated economic life of each asset type. Where the economic life of an asset falls within the timeframe of this business case, the asset refresh cost has been factored into the financial analysis.	No sensitivity analysis required.

Business Case Summary

The following table provides a summary of the overall business case, including the key financial components resulting in the positive net present value (NPV) of $520 million. For greater clarity—and because benefits have typically been discussed in terms of present value and costs in terms of nominal value—both nominal and present value figures are provided.

The ongoing operating and maintenance expenses for the Smart Metering Program include any incremental costs required to operate and maintain the new assets—such as meter maintenance, software application support, and telecommunications operations and maintenance.

The capital cost to replace Smart Metering Program assets during the period to F2033, based on the economic life of each asset type, has been included in the overall NPV. This capital cost is adjusted for the un-depreciated net book value of assets remaining in service at the end of F2033.

The following table provides a net present value (NPV) scenario analysis, beginning with the base case of $520 million. The NPV remains positive even if all the benefits are achieved at the low end of the estimated benefit range. Conversely, if all benefits are achieved at the high end of the range, the NPV increases to $956 million.

BUSINESS CASE SUMMARY IN NOMINAL AND PRESENT VALUE

Business Case Summary	Nominal Value ($M)	Present Value ($M)
Gross Benefits attributable to Smart Metering Program, less costs related to the achievement of individual benefits	$4,658	$1,629
Less: Ongoing operating and maintenance expenses and incremental asset replacement capital	(745)	(330)
Less: Smart Metering Program Costs	(930)	(779)
Total Net Value for the period F2006 to F2033	**$2,983**	**$520**

Development of the Business Case

The Smart Metering Program business case has been updated and revised several times since the program was first initiated in 2006. Throughout the business case development process, BC Hydro has engaged a number of third party experts, including PricewaterhouseCoopers (PwC) and Enspiria Solutions, to review and validate costs, benefits, approach and methodology. As a result of the continued evolution of the smart metering industry and related technologies, BC Hydro undertook a full refresh of the business case in 2010.

APPENDIX 7: RATE ANALYSIS

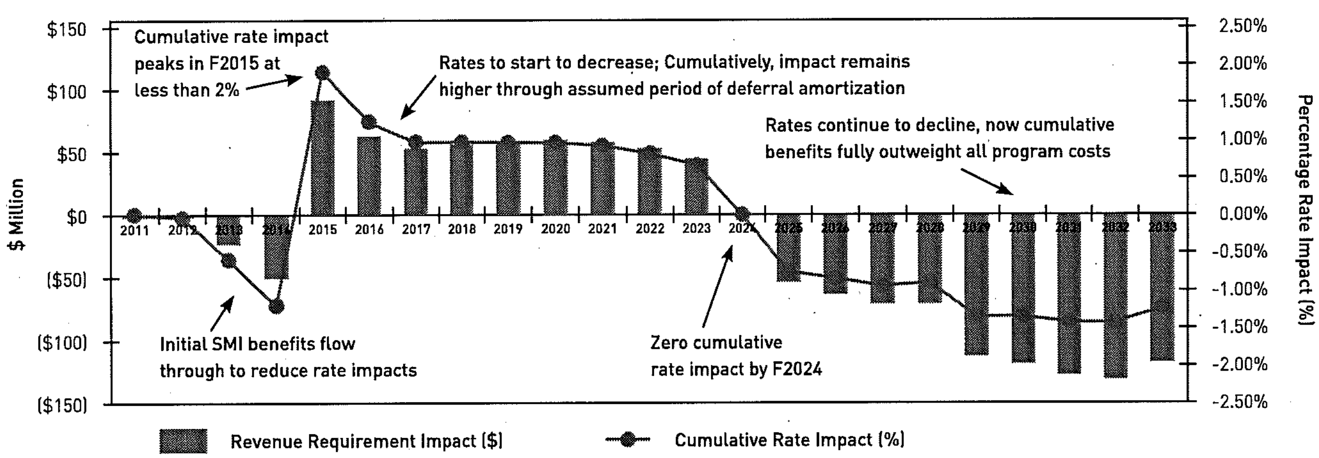
The Smart Metering Program pays for itself through reduced theft of electricity, energy savings, and operational efficiencies. Net benefits will flow to customers, reducing rates below what they would otherwise be in the absence of BC Hydro's investment in the program.

Similar to other capital projects, the Smart Metering Program has initial rate impacts which are reduced over time as the benefits accumulate. In order to better match the initial cost recovery to the timing of benefits realization, BC Hydro will seek BC Utilities Commission approval to "smooth" rate impacts.

The *Clean Energy Act* exempts the program from those sections of the *Utilities Commission Act* that specify BC Hydro's obligations to seek approvals from the BC Utilities Commission for capital projects. However, when BC Hydro seeks to recover Smart Metering Program expenditures in rates, the BC Utilities Commission will review the prudency of BC Hydro's decisions and actions in relation to the implementation of this program.

The estimated impact of the Smart Metering Program on BC Hydro's rates is based on the net cash flow benefits as presented in the business case, which are then incorporated into BC Hydro's regulatory accounting model to determine the incremental impact on BC Hydro's annual revenue requirements[12].

The graph below illustrates the projected rate impact of the Smart Metering Program over the term of the business case, before considering potential rate smoothing proposals. Specifically, the graph shows the annual impact of the program on BC Hydro's revenue requirements, as well as the cumulative rate impact which ultimately results in a sustained rate decrease of over 1.25 per cent (below what rates would otherwise be in the absence of the Smart Metering Program).



The green bars on the graph show the annual dollar impact (in millions) of the Smart Metering Program on BC Hydro's overall revenue requirement. The blue line on the graph illustrates the cumulative impact on rates over the term of the business case. To help manage current rate pressures, $75 million in benefits from the program will flow through to customers in F2012 through F2014—resulting in a cumulative rate decrease of just over 1 per cent by F2014.

Without the planned smoothing, in the first year following full implementation of the Smart Metering Program (F2015), there is an increase in BC Hydro's revenue requirement as the recovery of current—and previously deferred—costs starts. From F2016 through F2023, the additional revenue requirement due to the Smart Metering Program starts to drop.

[12] Revenue requirement refers to the total amount of money BC Hydro must collect from customers to pay all operating costs, energy costs, amortization, financing charges, and return on equity in a given year.

From F2024 on, the Smart Metering Program benefits reduce BC Hydro's annual revenue requirement, resulting in rates being reduced below what they would otherwise be without the program. Over the term of the business case, there is a total reduction in BC Hydro's revenue requirement of over $400 million.

This $400 million total reduction in BC Hydro's revenue requirement differs from the business case net present value of $520 million because the revenue requirement includes accounting impacts of non-cash transactions from a regulatory point of view. For example, the revenue requirement factors in the financial impacts due to timing of regulatory cost recovery and recovery of the un-depreciated sunk cost of existing meters—a non-cash item.

APPENDIX 8: KEY BUSINESS RISKS

SUMMARY OF KEY RISKS AND MITIGATION STRATEGIES

Risk	Description	Mitigation Strategies
Meter Supply Chain	Risk of the market's inability to meet meter supply chain requirements, and interdependencies with other vendors.	Procurement evaluation criteria considered the vendor's ability to meet the timeline. Incentive mechanisms are in place to align the related suppliers to deliver on time and on budget. Significant liquidated damages to be included in final contracts to ensure vendors meet their commitments.
Emerging Technology	Risk of technology continuing to evolve resulting in stranded assets.	All meter vendors under consideration in the procurement process have met minimum mandatory criteria which included having sizable deployments in other North American and European utilities, and based on proven technologies. Technology selection criteria were designed to meet current and expected future business needs. Procurement evaluation criteria included technology "future proofing" to ensure future business, technical and operational requirements were considered. Where technology risks may still exist, the successful vendor will be contractually committed to meeting BC Hydro's requirements by an agreed date. In addition, they will be required to provide full backward compatibility for selected products.
BC Hydro Resource Constraints	Significant resource constraints internally for telecommunications, field crews, and technology personnel—skills and head count—could impact the schedule.	The Smart Metering Program is a top corporate priority with broad executive oversight and commitment. Leverage meter and field contract labour market for peak resource requirements—including incentives for vendors to grow and create jobs in British Columbia.
Meter Deployment	Unable to complete meter deployment by the end of 2012.	Contract incentives are in place for solution integrator, meter system and meter deployment vendors to meet 2012 timeline. Use various strategies to deploy meters in multiple regions concurrently, including distributed warehouses.

Budget	Risk of exceeding project budget due to unforeseen costs or changes in scope.	Procurement approach designed to achieve cost certainty for at least 50 per cent of the project budget, including mechanisms like: • affordability ceilings • fixed price contracts • incentive mechanism shared with all vendors Rigorous control over scope elements implemented including: • formal change control process for any change in scope, timeline, or deliverables • project controls office in place to manage issues, risks, assumptions and changes Rigorous financial controls are being implemented including: • budget assigned to accountable managers and measured • financial performance tracking and forecasting tools
Safety/Security/ Customer Privacy	Risk of security or privacy breach impacting customers or system operations.	Safety, security and privacy were built into all procurement processes. Safety, security and privacy were built into end-to-end solution architecture and all business processes, which will be validated during solution acceptance testing. BC Hydro is an active participant in external standards setting groups, including committees focused on safety, security, and privacy. A dedicated smart metering safety, security and privacy office has been established. Formal penetration test plan including hiring external agencies to attempt to break into the system.
Customer Experience	Risk of limited customer awareness and public support of smart metering, and/or negative customer experience during meter deployment.	Customer research to discover baseline level of public awareness and to identify specific issues and concerns regarding meter deployment. Comprehensive Smart Metering Program communications plan developed and being implemented. Includes specific customer contact plans pre-, during, and post- meter deployment. Incorporating lessons learned from other utilities with respect to customer engagement.

APPENDIX 9: MANAGING RISK THROUGH PROCUREMENT

In 2008, BC Hydro initiated a procurement process for a single Solution Integration firm, which would in turn be responsible for selection and sub-contracting of the required technology components, meters, deployment services, and project implementation. Proposals submitted at that time were significantly over budget and did not achieve the risk transfer expected by BC Hydro.

In March 2010, BC Hydro decided to proceed with a "disaggregated" procurement approach to contract directly with proven industry vendors—ensuring BC Hydro retains direct control over the program while building business relationships that would extend over the economic life of the assets. Partnerships BC was engaged to provide expertise in structuring a comprehensive and open procurement process.

Specific project risk mitigation managed through procurement includes:

- **Minimum mandatory criteria:** a number of mandatory 'pass/fail' criteria were established to ensure only established, proven and scalable proponents are considered.
- **Affordability ceilings:** establishing the maximum value BC Hydro is prepared to pay for a product or service providing cost certainty.
- **Subject matter experts:** both internal and external subject matter experts have been involved to ensure a full understanding of proposed technologies.
- **Panel interviews:** because experienced professional resources are critical to the success of the project, panel interviews are conducted with key individuals proposed by vendors.
- **Fairness Advisor:** an independent and experienced Fairness Advisor participated in all procurement processes.
- **Due Diligence Committee:** a senior level independent advisory committee reviews procurement recommendations of the selection teams to ensure that the process was followed and the basis of recommendations is appropriately documented.

As of December 31, 2010, BC Hydro continues in active procurement or final contracting in four key procurement streams—Solutions Integrator, Metering System, Meter Data Management System and Meter Deployment Services. Announcements related to the successful proponents are expected in the near future.

APPENDIX 10: TECHNOLOGY AND INDUSTRY STANDARDS GROUPS

BC Hydro has been active with industry in North America for several years to understand and influence the technology and standards that will impact the success of the Smart Metering Program. This work has included participation on a number of committees and collaboration with various industry associations as outlined below:

Industry Association	Purpose	BC Hydro Participation and Value
Electric Power Research Institute (EPRI)	To advance innovation, research and utility solutions.	Active participation on power delivery programs including smart grid applications.
National Institute of Standards and Technology (NIST)	To advance industry standards. Currently working on priority action plans related to smart grid development.	BC Hydro is closely following the NIST guidelines and standards for security including NISTIR 7628 and Federal Information Processing Standards.
GridWise Alliance	To advance smart grid business and technology solutions, including policy and legislation.	Membership has provided direct access to the latest industry advancements.
National Electric Energy Testing Research and Applications Center (NEETRAC)	To test and validate industry solutions, particularly safety for metering services.	Involved in defining and testing the latest smart metering functionalities and applications.
Open Smart Grid (OpenSG)	Address delivery of utility smart grid and smart metering requirements and related key industry technology issues.	BC Hydro is actively involved in OpenSG efforts including smart grid security and applying best practices for protecting the smart metering network and smart grid.
Canadian Standards Association (CSA)	To certify the safety of electrical equipment.	Assist in the evaluation of new smart grid components to meet safety standards.
Canadian Electrical Association (CEA)	To represent the Canadian utility industry. Currently addressing metering standards and acceptance with Measurement Canada.	Committee work to support acceptance of future metering solutions.
Utilities Telecom Council (UTC)	To advance telecom solutions and set standards.	Participation to establish efficient smart grid communication solutions.
Canadian National Committee on Smart Grid Technology and Standards	To address appropriate standardization for smart grid in Canada.	Participation to guide Canadian standards in a global context.
Institute of Electrical and Electronics Engineers (IEEE)	To address international technology issues and set standards.	Participation on a variety of technical committees related directly to BC Hydro's program.
ZigBee Alliance	To develop open industry standards for low-power wireless communications.	Active participation in the "Smart Energy Profile" working group, which defines data communication standards for smart meters and in-home devices over a Home Area Network.
Health Canada	Responsible for helping Canadians maintain and improve their health, while respecting individual choices and circumstances.	Ensuring compliance with the protection of customers and workers related to electricity including electromagnetic fields (EMF).
SAP Lighthouse Council	To foster collaboration between SAP, major utilities and industry vendors to integrate Advanced Metering Infrastructure with utility Enterprise technology.	Exposure to leading practices that achieve integration of end-to-end processes between the meter and the backend systems, and to reduce a company's total cost of ownership for Advanced Metering Infrastructure.

GLOSSARY

Authorized Amount

Requested funding for a project inclusive of all contingencies and based on a fixed scope and in-service date.

British Columbia Utilities Commission (BC Utilities Commission)

An independent regulatory agency of the provincial government operating under and administering the *Utilities Commission Act*. The BC Utilities Commission's responsibility is the regulation of the energy utilities under its jurisdiction to ensure that the rates charged to utility customers for energy are fair, just and reasonable. The BC Utilities Commission is responsible for ensuring customers receive safe, reliable and non-discriminatory rates and shareholders receive a fair return.

Capacity

The maximum sustainable amount of energy that can be produced or carried at an instant. For example, a car engine's horsepower rating is its energy capacity.

Capital Refresh of Assets

The program assets are assumed to be replaced periodically based on the estimated economic life of each asset type.

Clean Energy Act

A long-term vision for BC to become a clean energy leader. This Act guides government, BC Hydro and the British Columbia Utilities Commission in advancing the province's ambitious sustainable energy vision.

Contingency

An amount provided in the estimate for a project having a fixed scope and in-service date to allow for potential costs which cannot be specifically identified at the time of estimate preparation but which experience shows will likely occur.

Customer Generation

Allows customers to generate power on a smaller-scale in order to provide an alternative to, or an enhancement of, the traditional electrical power system. It can take the form of solar panels, wind power, biomass, etc.

Definition Phase

Detailed investigation of the approved approach and preparation of a preliminary design, procurement, and Project Plan for Implementation Phase funding complete with business case. This phase also includes the securing of all key defining agreements.

Demand Side Management (DSM)

Actions that modify customer demand for electricity, helping to defer the need for new energy and capacity supply additions.

Direct Labour Cost

Labour cost without benefits or overhead loadings.

Distribution System

The portion of the power system that converts energy to the right voltage and delivers power to homes and businesses across the province.

Electrical Distribution System Optimization (EDSO)

Helps to reduce electricity usage and costs with no capital investment through matching voltage to equipment requirements.

Energy

How much is consumed (or produced) over a period of time.

Field Area Network

A secure two-way telecommunication network between customer meters, other end point devices, aggregation devices and network extenders.

Greenhouse Gas (GHG)

Gases that are thought to contribute to global climate change, or the "greenhouse effect," including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

Grid Modernization

An automated, intelligent power delivery system that supports additional services and benefits to customers, the environment and the economy.

Gross Benefits

The value of benefits before the deduction of related costs.

Home Area Network (HAN)

A data communications system contained within a premise, such as a residence, that can connect devices (e.g. in-home display device) in the premise to the smart meter.

Identification Phase

Review of conceptual alternatives, evaluation of feasibility, review of alternatives, and delivery of a project plan for Definition Phase funding. This phase ends with a decision on whether or not to proceed to the next phase.

In-home Display

A device that can communicate with a smart meter to show how much energy is being consumed and at what cost.

In-home Feedback Tools

Different ways through which customers can receive feedback about the electricity they are consuming, and the cost of that electricity, in their home, business or other location. In-home feedback can include an in-home display and/or secure websites, home energy management systems etc. that provide information about energy consumption.

Implementation Phase

Includes detailed design, material and equipment procurement, construction, testing and commissioning into service. The phase ends with a Post-Expenditure Review and a Project Completion Report.

Initiation Phase

Establishment of an initial project team, research and benchmarking. This phase ends with a decision to proceed on whether or not to proceed to the next phase.

Interest During Construction (IDC)

When an asset is constructed, there is often a considerable period between the start of a project and its completion. Because the cost of an asset should include all costs incurred to prepare it for use, interest costs related to the construction are generally included in the cost of the asset that is capitalized.

Interval Data Recording (IDR)

A record of energy consumptions, with reading made at regular interval throughout the day, every day.

Measurement Canada

A federal agency responsible for ensuring the integrity and accuracy of measurement in the Canadian marketplace, including the accuracy of electricity meters.

Meter Data Management System

The software applications and infrastructure required to support the integration of data from the smart metering system into other BC Hydro systems. The data is made available to the utility for a variety of business functions such as billing, energy diversion detection and outage tracking.

Microgrids

Small networks of generating sources capable of operating independently from the electricity system. Microgrids can switch quickly between operating on and off the system, allowing communities to become more self-sufficient.

Net Benefits

The value of the benefits after the reduction of related costs.

Net Present Value (NPV)

The difference between the present value of benefits and the present value of costs (including capital, operating, maintenance and administration costs) for a given discount rate.

Nominal Growth/Price

Growth or price measured in current dollars at the time the goods are produced; change includes the amount of inflation.

Ongoing Operating Expenses

The incremental operating costs required to operate and maintain program assets, such as meter maintenance and telecommunications and software application operating costs.

Present Value

Today's discounted value of future receipts or expenditures.

Price Elasticity

The price responsiveness of consumption, expressed as the percentage change in quantity per a 1 per cent change in price. For example, an elasticity of -0.10 means that a 1 per cent increase in real price would lead to a 0.1 per cent decrease in consumption.

Project Costs

The authorized amount for the Smart Metering Program is $930 million (nominal), and this reflects the costs to put the program's assets required by regulation into operation.

Project Plan

A document that sets out a strategy and course of action for meeting the project objectives.

Revenue Requirement

A revenue requirement is the forecast cost of doing business for a period of time and must be approved by the British Columbia Utilities Commission. BC Hydro can collect its required revenue through tariffs—the rate charged to customers.

Regulatory Account

Deferred amounts related to the Smart Metering Program will be recorded in the Smart Metering Program Regulatory Account. BC Hydro's accounting policies allow for the deferral of amounts that under Canadian generally accepted accounting principles would otherwise be recorded as expenses or income in the current accounting period. The deferred amounts are either recovered or refunded through future rate adjustments.

Smart Grid

A smart grid delivers electricity from suppliers to consumers using digital communications to save energy, reduce costs and increase reliability and transparency. A smart grid is made possible by applying sensing, measurement and control devices with two-way communications, making it possible to dynamically respond to changes in system condition. A smart grid includes an intelligent monitoring system that keeps track of all electricity flowing in the system. It also has the capability of integrating clean, renewable electricity such as solar and wind.

Smart Meter

Smart meters provide two-way communication between the customer's meter and BC Hydro, capturing the amount of power that is consumed and when.

Smart Metering and Infrastructure Program

The Smart Metering and Infrastructure Program or Smart Metering Program plays a key role in modernizing BC Hydro's electricity system. It involves the introduction of new digital smart meters and the supporting infrastructure.

Supervisory Control and Data Acquisition (SCADA)

Computer systems used to send and collect supervisory controls and monitor data through power lines.

Volt-VAR Optimization (VVO)

Optimizes the energy delivery efficiency on distribution systems using real-time information, minimizing power loss.

Smart meters will allow BC Hydro to continue to manage the electricity system in a reliable, safe, and cost-effective manner.

Utility Dive

Could reducing peak demand 5% be as simple as ... asking?

Inside Opower's behavioral demand response pilot

By Robert Walton | November 4, 2014

A pilot program completed over the summer turned up this: When utilities asked customers to turn down the thermostat, they did it.

Power providers looking to leverage the benefits of demand response face a big challenge—only about 5% of U.S. households participate in demand response programs. There are a variety of reasons, ranging from the time and difficulty in studying and getting demand response programs approved to ratepayer confusion over dynamic pricing. And while more coordinated, price-oriented and opt-in programs will show deeper savings on a per-meter basis, demand response provider Opower's work in so-called "behavioral demand response" is challenging the traditional route to demand response savings.

"It challenges the mindset that to get customers to do something, you have to pay them in return, or penalize them," said Kevin Hamilton, Opower's vice president of marketing.

"Some of the decisions we make are not entirely rational, and they are due to a lack of context," he said, "and by providing that context you can encourage individuals to adjust their usage in ways that can benefit both the customer and the utility as well."

Using targeted communication, Opower showed consistent peak load reductions across 3 states

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It's that "context" that lies at the heart of Opower's behavioral demand response program. Using targeted communication like phone calls—and no price signals or in-home devices—the company showed consistent peak load reductions (http://www2.opower.com/dr-resource-whitepaper) across a test that involved Consumers Energy in Michigan, Efficiency Vermont/Green Mountain Power, and Glendale Water & Power in California. The program reduced demand by an average of about 3% and by up to 5% on peak days (http://blog.opower.com/2014/10/behavioral-demand-response-5-percent/).

According to Opower, last year U.S. utilities spent $580 million on residential demand response programs, but the savings are potentially huge. The company estimates each kilowatt of demand avoided during peak hours is worth about $94 annually.

Opower estimated that if its behavioral demand response program were deployed nationally, associated peak load reduction could deliver 4,700 MW or 113% of the total capacity available today from existing residential demand response programs.

Leveraging smart meters

Utilities seeking to leverage the data collected from smart meters can look to behavioral demand response, Hamilton said. Because the program uses no price signals, tariffs or in-home device, the regulatory process is minimal. Last summer Baltimore Gas & Electric (http://www.utilitydive.com/news/how-opower-and-bge-are-pioneering-behavioral-demand-response/214824/) worked with Opower on a similar program, delivering targeted messaging to 300,000 customers enrolled in the utility's Smart Energy Rewards program.

Opower tested a new kind of messaging among customers, tempting them into reducing consumption based not on a price signal but by informing them of how their energy usage stacked up against that of their neighbors. "They didn't save as much, but they saved nearly as much," Hamilton said. "That was the first test of what we call 'pure behavioral demand response'—no price signal and no device in the home."

The idea that what your neighbor does can impact your energy actions is also being studied in the rooftop solar industry. Known there as "peer effects," a recent study (http://www.utilitydive.com/news/how-solar-power-spreads-among-neighbors-like-a-contagion/328602/) has found a strong link between one home's solar panel and the likelihood another nearby will go green.

"In some sense, it's the 'Keeping up with the Jonses' idea," said Kenneth Gillingham, a co-author of a recent study examining the phenomenon. "Green envy" is Gillingham's favorite way of explaining it. "People see their neighbors who are doing things that are green, and they are inclined to do it themselves," he said.

With demand response it's a bit more tricky, but Opower's targeted message and comparison to nearby energy consumers sets up a similar dynamic. And the opt-out nature of the program "is the most exciting part of it," Hamilton said. Considering that just 5% of the country's homes are enrolled in a residential demand response program, a utility's ability to engage vastly more customers is significant even if the savings per-meter are much lower, he explained.

Customers with no load control device dropped their usage 5% ... just through behavioral cuts.

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In Opower's test last summer, customers with BGE's existing direct load control program, PeakRewardsSM, reduced their consumption by about 23% on average. But customers with no load control device dropped their usage 5% as well, just through behavioral cues.

"If you look at an opt-in program in an average utility service territory being 5%, you might get 25% overall reduction in household usage with direct load control program but you're only reaching 5% of customers," Hamilton said. Behavioral demand response programs can reach substantially all of a utility's customers' who have smart meters (for data-rich, targeted communication), and return up to a 5% reduction.

The more recent test, with behavioral programs scaled up and deployed to more than 1 million homes across multiple utilities and ISOs, yielded similar peak demand responses.

Good for utilities, customer savings

For utilities, behavioral demand response can mean avoided costs and and a more reliable system—with fewer regulatory hurdles to overcome along the way.

"Pure behavioral demand response is not something that requires a regulatory change from a rate perspective," Hamilton said. "Clearly if you're going from a pilot program to a program that you're deploying to your entire service territory, you would file it as part of a demand response filing. But there are no additional regulatory hurdles compared to a traditional demand response program."

"If you're doing it with a price signal obviously there are years of testing that go into it, but pure behavioral demand response without a price signal or a device is not a tariff change or rate change or anything like that," he said.

For consumers, behavioral demand response programs can save them money without being enrolled in dynamic pricing programs and without in-home devices.

"We're getting them to think about their peak usage, which we think is a first step," Hamilton said.

Customers who respond well to a behavioral demand response program can be offered dynamic pricing programs, and then perhaps rebates on in-home load control devices if the utility offers the program. Hamilton said Opower views demand response as a continuum, where each program can save an engaged customer more money.

Some research, Hamilton said, has indicated 70% of power customers could benefit from a demand response program. "Once you get customers thinking about peak load as a concept, then you can introduce a dynamic pricing program, which perhaps gets you deeper savings," he said.

Top Image Credit: Flickr user Senator Mark Warner (http://www.flickr.com/photos/senatormarkwarner/6267055296/sizes/z/in/photostream/)

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Efficiency & Demand Response