Advancing Energy Efficiency in Calgary

Energy Savings Through Consumer Feedback Programs

February 2014

ALBERTA
Energy Efficiency Alliance

THE CITY OF CALGARY

Who we are

The **Alberta Energy Efficiency Alliance** is a multi-sector organization that collects and provides input on energy efficiency issues to the provincial government. Our members include energy utilities, municipalities, oil and gas companies, consulting firms, product and service providers and non-profits. All of these organizations recognize the important role energy efficiency has in responsible energy production and consumption.

You can find out more about us at **www.aeea.ca**.

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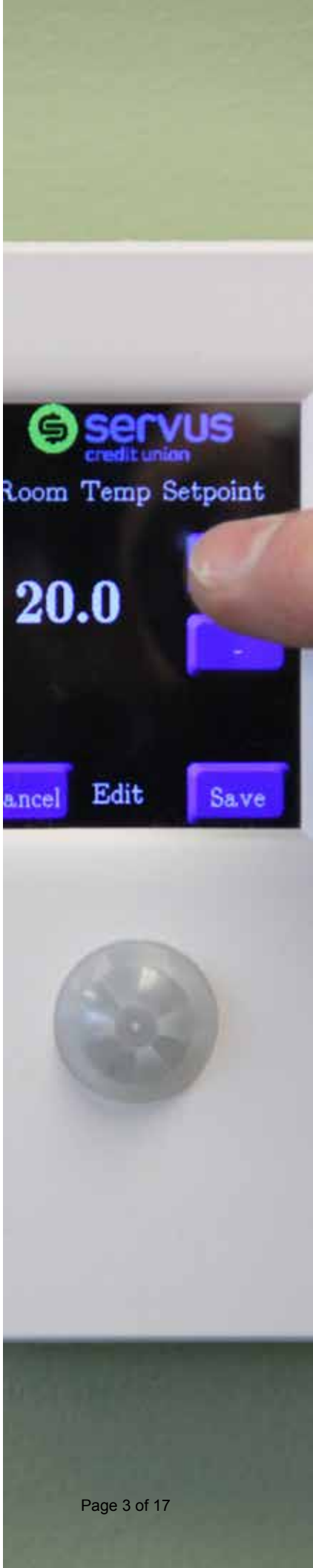

Background

Utility providers across the world have been testing different ways of providing feedback to their consumers as a method of encouraging energy savings. Unlike traditional technology- or standards-driven energy efficiency approaches, feedback programs are grounded in the idea that the availability of relevant comparative information can influence consumer-led behavioural changes. The design of programs that use different feedback mechanisms to promote energy reductions by consumers is predicated on two main concepts: first, that consumers who are well informed about their current energy use will be motivated to reduce consumption, and second, that consumers will all respond differently to the type of feedback provided (i.e. the amount of information, the way it's presented, and how frequently it's provided). The first concept forms the basis for understanding why feedback systems can promote energy savings, while the second can inform program design to increase the effectiveness of the overall energy reductions.

Typical feedback systems take one of two forms: direct feedback is provided in real time (or near real time) at the point of use, while indirect feedback is provided after consumption occurs.[1] Figure 1 provides an overview of some different variations of feedback programs, based on information availability and the cost to implement.

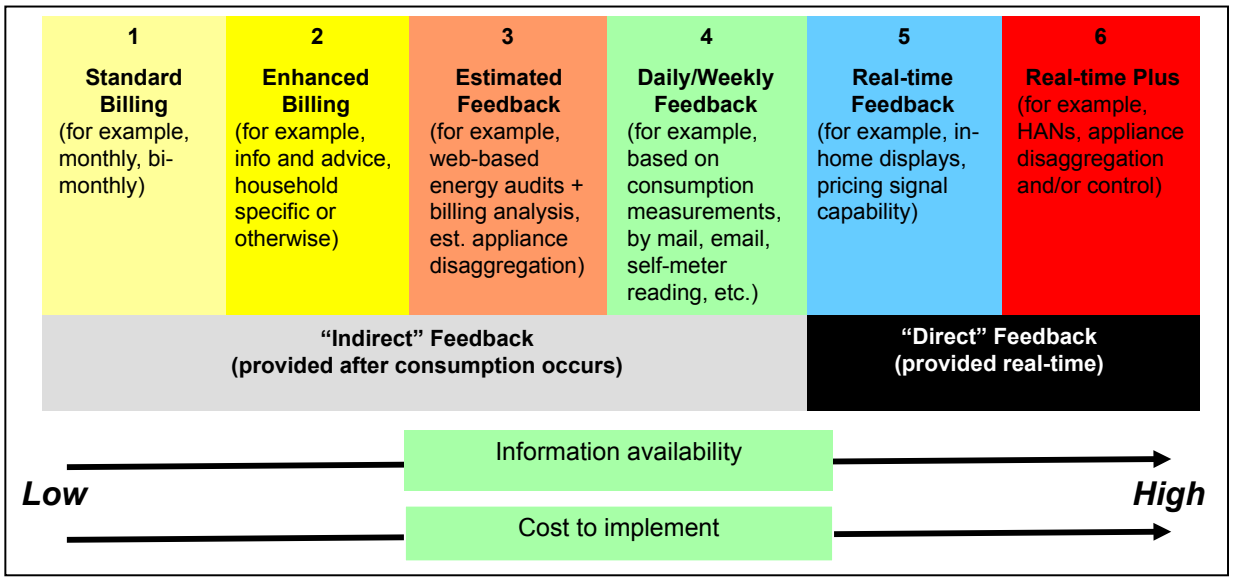

Figure 1 – Types of feedback systems for efficiency programs[2]

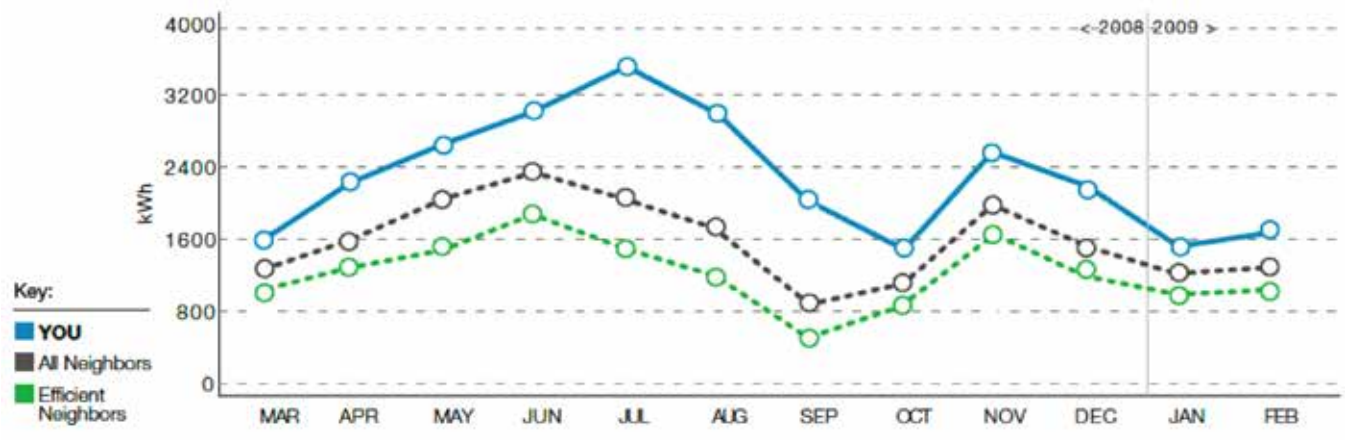

Figure 2 – Example comparative information on a utility bill (from an Opower Home Energy Report)

Indirect feedback systems

Indirect feedback refers to information that has been processed (typically by the utility company) before reaching the energy end user. Standard bills are a traditional source of feedback to households — in North American jurisdictions, consumption values used for billing are often a combination of actual meter readings and estimates, and are provided on a quarterly, bi-monthly or monthly basis.

Indirect feedback programs typically consist of some form of report, developed by the utility provider and given to the consumer, that details their energy usage and cost over a set period of time. As mentioned, traditional utility bills can be considered a type of indirect feedback as they provide information on the current cycle's usage and associated rates. Enhancing this feedback through various means, including more frequent billing cycles to provide greater detail in energy use comparisons, historical data and end use/per appliance energy use data, has been shown to assist in driving energy conservation efforts.[3,4]

Informative (or enhanced) utility bills are the most common form of indirect feedback programs, with utilities able to provide historical usage information to consumers. Another type of comparative report which is becoming increasingly popular is to use energy usage information from a representative sample of 'like' households. Opower provides this service to utility companies through their 'Home Energy Report' program, currently serving 80 utilities and over 15 million households worldwide. Figure 2 shows an example of historical and comparative representative information, based on a sample Opower report.

These types of reports focus on changing consumer behaviours through perceptions of social norms, where people are influenced by being provided with evidence of what others commonly do (called descriptive norms). Additionally, people can be influenced by injunctive norms, or knowing what others approve or disapprove of, although these norms may not influence energy efficiency efforts to a great degree.[5]

Direct feedback systems

Direct feedback systems, also called real-time or near-real-time feedback systems, provide energy information to consumers directly, typically from a meter or through a separate display monitor or software application. These systems have the ability to show instantaneous electricity consumption along with the cost per hour at a pre-programmed rate. The output provided by the systems varies widely — for example, some systems show carbon dioxide emissions, while others can sound a preprogrammed alarm when energy use rises above a certain amount.

At their most rudimentary, energy monitors provide a basic form of direct feedback to consumers. These displays can be installed by the consumer and are able to monitor and report energy usage in real, or near real, time. They operate by measuring the electric current passing through a home's power cable, which is then converted and displayed as power usage on an external display.

More complex "real-time plus" direct feedback systems are able to provide information with improved accuracy and detail. These can involve smart meters that allow two-way feedback between the utility and consumer, meaning they are able (with an additional display) to offer real-time energy usage information to the household, as well as the utility. Utility companies are then able to use the information to provide more accurate billing information to their consumers. "Real-time plus" systems also typically disaggregate consumption information by end use, which can offer additional benefits to utilities by providing them with highly granulated data sets to inform better targeted efficiency recommendations. This increased level of detail in home energy use could be aggregated at a larger scale to have a better understanding of which appliances have the greatest potential for energy savings — for example, through targeted awareness campaigns or rebate programs. Disaggregated information also aids consumers in identifying which appliances are consuming the most power in their house, providing guidance for energy-saving behaviours.

Figure 3 – GE offers an energy display that communicates with the utility smart meter to provide consumers with near real-time energy data.

Energy savings and costs

Potential energy savings

Numerous studies have been conducted on pilot and full-scale direct and indirect feedback programs to demonstrate their value in terms of realized energy savings. In general, direct feedback programs have been shown to reduce energy consumption to a greater extent than indirect systems. A meta-analysis of 23 different studies on aggregated, direct feedback across the United States and Canada estimated energy savings between 0.5 and 18%.[6] A review of studies analyzing the potential energy reductions associated with "real-time plus" programs that provided disaggregated energy consumption information to consumers showed savings up to 39%, with an average of 13.7%, although the highest savings were from studies with small sample sizes.[7] Simpler forms of direct feedback programs realized average savings of 8.6%,[8] based on a variety of programs of different size and scale.

Examining indirect feedback approaches, the largest study to date assessed 17 different programs established by various utilities across the United States and included approximately 600,000 homes that were provided with comparative feedback on their energy consumption through Opower's Home Energy Reports. Accounting for variances, this study concluded these systems have reduced energy consumption between 1.4% and 3.3%, with an average of 2% across those households studied.[9] A study of programs of similar design and scale programs showed savings in line with these estimates, delivering between 0.9% and 2.9% savings at the household level.[10] In general, these savings continued to be realized up to two years after the program's initiation. Results from indirect feedback programs were found to be consistent across varying regions, and did not seem to be climate-dependent, with savings in California ranging from 1.1–2.5%[11] and those in Minnesota ranging from 1.8–2.2%.[12]

Factors affecting potential energy savings

There are many factors that can affect potential energy savings from a feedback program. Most research into these factors has been done on indirect feedback systems (i.e., informative or enhanced billing); however, it is believed that direct feedback systems would be affected by a similar set of factors.[13,14]

For example, in Davis' study (2011), numerous variables were identified that might influence the potential treatment effect of an indirect feedback program. Some of these factors included:

- baseline usage
- square footage
- number of occupants
- age of head of household

As might be expected, an increase in the baseline energy use of a household resulted in increased energy savings. For each additional kilowatt-hour per day a household used, there was an expected increase of approximately 0.5% to the effect of the feedback program. This is consistent with results from an Opower pilot program initiated with the Sacramento Municipal Utility District, which saw energy savings of almost 3% in higher consumption households and 1.7% in lower consumption households.[15] Similarly, the Davis study showed that as the age of the head of household increased by 10 years, the treatment effect of the program increased by approximately 0.07%.

While both the age of the head of household and an increase in baseline usage from the average have been shown to increase the efficacy of the feedback program, the reverse has been shown to be the case for the other variables highlighted. For each additional occupant in a home, the effectiveness of the program

can decrease up to 0.6%, and a decrease of 0.9% was observed for each additional 1,000 square feet of housing.[16] As square footage increases, the burden on heating and cooling equipment rises and lighting requirements often increase, all of which mean energy conservation efforts can become more challenging. In addition to the greater number of appliances and other electricity-consuming products in a household with more occupants than average, additional occupants also mean more people who actually need to change energy-usage habits in these behaviour-based programs, which is often a difficult task.

Costs associated with feedback programs

The costs associated with different types of feedback programs vary greatly. Direct feedback systems typically tend to cost much more than indirect systems, mainly due to the additional technology (e.g. Smart meters, in-home displays) required to deploy them.

As shown previously in Figure 1, "real-time plus" feedback programs (i.e., direct feedback programs that provide disaggregated energy-use information to consumers) tend to be the most expensive to implement. These programs usually consist of some combination of measurement and diagnostic sensors, in-home energy displays, and utility load control devices, all of which contribute to initial set-up costs. One-off costs for these items can range from US$250 up to US$5000, depending on the technical sophistication and functional requirements of the devices used,[17] meaning substantial energy savings must be achieved for the program to be cost effective. Real-time feedback through in-home displays are more cost-effective than "real-time plus" systems, with initial costs between US$100 and US$250 per display.[18]

When determining the overall cost effectiveness of different feedback programs, it is important to consider both start-up and administrative costs over the program's life cycle. While there is less literature available on the cost-effectiveness of "real-time plus" programs, the cost for a real-time direct feedback program was estimated to be about $0.30/kWh saved for the first year, with expected reductions to $0.07/kWh saved after five years,[19] using a standard discount rate of 5%. By comparison, indirect feedback programs are estimated to cost between $0.013 and $0.054/kWh saved consistently through the life of the program.[20] These are significantly less than the average cost of electricity in the city of Calgary, with ENMAX's regulated rate ranging from $0.064 to $0.153/kWh in 2012.[21]

Factors affecting program effectiveness and best practices

The overall design of the feedback program itself is critical to achieving the end goal of reduced energy consumption. A number of factors should be considered before piloting or implementing either a direct or indirect feedback program, based on evaluations of previous initiatives. Some factors that have influenced the effectiveness of these types of programs in the past include:

- frequency of reporting
- types and format of information being provided
- consumer choice for participation in the program
- external motivation and other social norms

Frequency of reports — How often feedback is provided to consumers can have a strong influence on energy savings. While it has been found in numerous studies that more frequent feedback resulted in higher energy savings,[22,23,24] feedback programs should be designed with the consumer and feedback device in mind, as some programs with high frequency reporting observed decreases in consumer involvement over time.[25] Typically, indirect feedback programs have shown better results with monthly or bi-monthly reporting over quarterly reporting programs.[26]

Types of information being provided — The effects of disaggregated, appliance-level information provision have been less studied than aggregated data provision, although it is believed that such fine-scale feedback may be more effective.[27] Statistical analysis and estimation is currently used to provide a type of disaggregated energy-use information to consumers based on household characteristics and total energy use in direct feedback systems.

In addition to providing information about current energy use, many feedback systems and programs provide consumers with specific recommendations on how they might increase energy efficiency and savings. Studies have shown that there are certain behaviours that consumers are more likely to act upon to reduce their energy consumption — including choosing alternative technologies (e.g. installing compact fluorescent lighting) and implementing behaviour change (e.g. turning off lights, devices and electronics when not in use).[28] This implies that recommendations should be limited and targeted, based on housing type, and (if possible) occupant demographics and current energy use. For example, while homeowners may act on recommendations to upgrade major appliances, it is unlikely that consumers living in rental units will do so due to differences in incentives.

Consumer choice for participation in the program — Typically, most indirect feedback programs are designed as "opt-out" programs, meaning they are provided by the utility as a default service which consumers then have to choose to leave. Due to this design feature, these types of programs have very high participation rates over traditional direct feedback programs, which tend to use an "opt-in" approach. Programs that employ opt-out designs have achieved participation rates of over 85% while opt-in programs typically achieve participation rates well below 10%.[29] This can significantly influence the overall impact of the program; despite the fact that direct feedback programs typically achieve greater household energy savings over indirect programs, a much lower participation rate means that the overall program energy savings is likely to be much less.

Social norms — Feedback programs can often be enhanced through the incorporation of explicit motivational elements, including goal or commitment setting, competitions and social norms. Various research has shown the importance of both descriptive and injunctive norms in shaping household energy behaviours.[30] Using injunctive norms can help counter-balance the potential "rebound effect", where participants who believe they are doing better than average actually increase their energy use after receiving this feedback.[31]

Current landscape of feedback programs

Feedback programs are becoming increasingly common in the United States, with individual states developing mandates for utility companies to explore how best to provide information to their consumers in order to drive energy savings.

For example, the state of California passed the Energy Usage Information Act in 2009 that required utilities to provide residential customers with online access to their energy use information and to investigate the feasibility of implementing "comparative energy usage disclosure" programs that would let consumers compare their energy use to nearby or similar households.[32] The Massachusetts Green Communities Act of 2008 legislates utilities to develop pilot programs for smart meters in order to provide real-time direct feedback to consumers on energy consumption. Initial results from these pilot studies were positive, with more than half of participants believing they've reduced energy consumption by up to 10%,[33] although realized energy reductions have not yet been reported. In addition to these legislated feedback programs, utilities in many states are increasingly partnering with third-party companies that specialize in developing and administering feedback programs intended to reduce energy consumption. Opower is the most prevalent of these companies, currently working with over 80 utilities worldwide to give almost 15 million homes relevant and timely information through enhanced or informative billing to guide their energy decision-making. Similar to Opower, the company Efficiency 2.0 (recently acquired by C3 Energy) works with utilities and private companies to develop information-based programs that compare energy use among households. In addition, they offer additional incentives, including rewards points for saving energy that consumers can then use at national and local stores, providing an immediate financial incentive along with reduced monthly bills. An evaluation of an incentives-based Efficiency 2.0 program in Illinois found that residents achieved energy savings of more than 3% on average.[34]

Feedback programs to reduce energy consumption are also becoming much more prevalent in the Canadian landscape. Real-time, direct feedback programs have been piloted in Ontario, British Columbia, and Newfoundland and Labrador, with realized energy savings between 2.7 and 18.1%.[35]

The wide variation in the treatment effects of these programs is likely caused by the end energy use of the consumers and may be skewed due to small sample sizes. The largest energy reductions were found in participants of the Newfoundland and Labrador study, where an average energy savings of 18.1% was realized. This study, however, only focused on 68 households, and the highest realized savings were in homes that used electric water heaters who saw energy reductions of almost 23%.[36] Interestingly, when the same type of in-home displays were used for a study with a similar sample size in British Columbia, energy savings were significantly less — averaging 2.7%. These relatively low savings were buoyed mainly by savings during the winter months (average of 8.1%), an indication that seasonality can play a large role in energy savings. When larger direct-feedback studies are analyzed for savings, like the one conducted in Ontario in 424 households, average reductions in energy use were estimated to be 6.5%. This is comparable to the 8.6% average observed in a meta-analysis of similar programs across North America, and is likely more representative of the energy savings possible from a typical real-time direct feedback program featuring in-home displays.

Wide-scale indirect feedback programs are also being investigated in different Canadian jurisdictions, although they are less prevalent than direct-feedback

programs. Efficiency Nova Scotia is currently piloting an enhanced billing program with Opower in 90,000 homes across the province as a key component of their 2013-2015 Demand Side Management Plan. FortisBC is also looking at various options for incorporating indirect feedback into their energy efficiency engagement programs to assist their consumers with energy reductions. Similarly, HydroOne is currently developing a pilot program for their customers in Toronto. Due to the lower costs associated with these types of programs, it is often easier to develop and implement pilot programs. It is anticipated that many more indirect feedback programs will continue to be developed within Canada, similar to how they are spreading throughout jurisdictions in the United States.

Commercial feedback programs

The majority of feedback programs currently in use across North America are targeted towards residential consumers. Much less information is available on programs that specifically target commercial or industrial clients; however, it is predicted that this is a growing space for future energy savings.[37] It is often more difficult to design scalable programs that target these types of energy users specifically, due to the varying nature of end energy uses and building types. Two companies, Opower and C3 Energy, are currently testing direct and indirect feedback initiatives in the United States targeted at commercial and industrial energy consumers. Opower is in the process of instituting a pilot program of a modified version of their Home Energy Reports, targeted towards small and medium-sized businesses in the United States. C3 Energy has partnered with Pacific Gas and Electric Company (PG&E) — a large utility provide in California — to provide feedback programs to their residential, commercial/industrial, and small and medium-sized business clients. Their solution, which is mainly web based, incorporates statistical information on energy use from PG&E smart meters, along with weather data, ENERGY STAR information for the various businesses, and real estate information from different sources, to accurately identify and analyse energy use for PG&E's customers.[38] Due to the size and granularity of the data set being used, C3 Energy is able to provide benchmarking and

comparison information based both on geography and facility type, including relative information for different facilities within the same organization. An example of this type of report is provided in in Figure 4.

As these programs are in still in their early stages, it is difficult to estimate realized total energy savings due to the programs themselves. However, there is a definite opportunity for significant energy savings with commercial and industrial end users — ENERGY STAR, a program run by the U.S. Environmental Protection Agency, estimates that businesses can save up to 30% on energy costs without sacrificing quality or production rates.[39]

Figure 4 – Web-based Energy Portal from C3 Energy displaying the energy use of multiple facilities from one organization in a certain geographical area

Recommendations

Based on the research summarized in this report, it is believed that indirect feedback programs show the most promise for behaviour-based energy reduction initiatives in the near to medium term for residential consumers, based both on the potential for overall energy savings and cost effectiveness. While direct feedback programs do typically result in higher energy savings on a household basis, they do not necessarily have the same level of effectiveness when looking jurisdiction-wide. Table 1 below provides an estimate of potential energy savings for indirect and direct feedback programs, based on average energy use in the city of Calgary.

Table 1 – Estimated energy reductions for direct versus indirect feedback programs

	AVERAGE ENERGY REDUCTION (HOUSEHOLD BASIS)[40,41]	PARTICIPATION RATE (PROGRAM BASIS)[42]	POTENTIAL ENERGY REDUCTION PER YEAR (PROGRAM BASIS)[43]
Direct feedback program	8.6%	10%	23,220 MWh
Indirect feedback program	2%	85%	45,900 MWh

It is clear from Table 1 that an indirect feedback program holds the greatest potential for city-wide energy and associated greenhouse gas (GHG) emission reductions compared with a direct feedback program.

In addition to overall GHG reductions, the overall costs of indirect feedback programs have been demonstrated to be lower than direct feedback programs on a per-kilowatt-hour basis. Indirect feedback programs have reduced electricity use for a cost between $0.013 and $0.054/kWh saved in other jurisdictions. This is compared to about $0.07/kWh saved for direct feedback programs. Note that these savings are related to the residential sector only.

For the commercial and industrial sectors, there is little experience to date with jurisdiction-wide programs. It is recommended to wait until further pilots have been completed before pursuing a city-wide program for the non-residential sectors.

Therefore, the primary recommendation from the research presented in this report is for The City of Calgary to pursue the development of an indirect feedback program for residential consumers. This recommendation is supported by the largest meta-study to date on various feedback programs worldwide.[44] The main recommendation from the meta-study is for policymakers and utility providers to:

> *Provide all U.S. households with access to enhanced billing information immediately. Enhanced billing provides a low-cost means of reducing residential energy consumption by as much as 3.5% and could be implemented nationwide in an extremely short time frame without the need for technology investments.*

With that context, the following program elements should be considered when designing a new indirect feedback program to drive energy savings.

Participation choice: Opt-out

Participation rates are estimated to be greater than 85% for opt-out programs, which can lead to significant program-level energy savings.

Frequency of reports: Monthly for a mail-out system; more frequently for web or mobile-based users

Physical reports that are provided monthly have typically shown greater average savings over those that are provided over longer time frames. There is

limited research into the effects of more frequent mail-outs, although the cost effectiveness of this type of reporting would likely be prohibitive. Web or mobile-based reports should be provided on a more frequent basis for interested consumers . The information can also be provided online for consumers to access at their own convenience.

Granularity of data: Home-level data

It is difficult to provide source or appliance-level data with indirect feedback programs; however, by providing seasonal or historic information, consumers are typically able to understand their energy use changes over time and target energy reductions (e.g. air conditioning in the summer months, or increased heating during the winter months).

Social norms: Combination of descriptive and injunctive norms

Providing consumers with an understanding of how their energy use compares to similar households as well as how others might approve or disapprove of their energy use has been shown to be effective at driving energy savings.

Information medium: Combination of printed, mailed reports and web or mobile-based products

While mailed reports add a personalized touch to enhanced billing reports, some consumers are interested in tracking use and savings over time online or through mobile devices, so this should be considered as part of program design. A combination of both systems is likely to be the most effective, allowing consumers the ability to access daily energy data through an online portal, while also prompting energy savings through enhanced billing on a monthly basis. The format of reports in both cases would likely be similar, with the only difference being that the monthly reports would aggregate energy usage over the month, based on the daily usage information (which would be provided on the online portal).

Recommended actions: Targeted at the household level

Although unable to provide specific house-by-house recommendations for potential energy savings due to the lack of advanced metering technology, indirect feedback programs can provide targeted actions to different household groups (such as renters or homeowners), based on previous studies and historical information.

Motivational elements: Combination of goal-setting and competitions

Goal-setting can be done on either a household basis or as part of a community initiative towards energy reductions. It is important to note that regular updates must be given to consumers in order to track their progress towards their goals. Similarly, competitions can be used at the community or neighbourhood level to encourage energy savings. These elements can be incorporated into a web-based portal so that consumers can better understand the overall program impact and their place within it.

Next steps

In order to better understand the applicability and potential for impact of a residential indirect feedback program in the city of Calgary, a draft program design should be completed which includes the elements discussed above. This draft program should be presented to relevant stakeholders, including utility providers, relevant City staff, and possibly end-use consumers. Feedback gathered through this stakeholder engagement process will allow development of a more detailed project design tailored to The City of Calgary's needs. The business case for the detailed program could then be completed to understand the full costs and benefits (in terms of energy savings and associated greenhouse gas reductions) of the program. In addition, various strategies for implementing the drafted program should be considered. Once these activities are completed and reviewed by key stakeholders, the finalized program design and implementation strategy can be presented to The City of Calgary council as a possible new program to assist with energy and greenhouse gas reductions in the city.

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