

Green Energy Coalition (GEC) INTERROGATORY #1 List 1

Interrogatory

Issue 1.2, (OEB CDM Directives) Ex. A-17-1, page 1

In its Decision on HONI's 2006 rates case the Board stated at para. 2.3.9: "The Board expects Hydro One to provide a more sound analysis of CDM program details and reduction objectives in future applications." At 2.3.13 the Board went on to request bottom-up analysis of CDM Impacts and indicated an expectation of an LRAM proposal. The HONI response and exhibit references appear to provide no details of HONI initiated CDM in 2008 and no details of HONI delivered CDM in 2008 nor an LRAM proposal.

- a. Please provide details of all CDM programs that HONI is involved in or expects to be involved in during 2008 with load impacts.
- b. Please provide copies of all directions, or memorandum containing or describing government direction to HONI in regard to CDM received from 2006 to date.
- c. Please provide all information in HONI's possession concerning opportunities for cost-effective CDM among HONI customers that is not currently being pursued in OPA programs.
- d. OPA has indicated that it is prepared to receive proposals for funding for LDC initiated CDM programs that may have widespread application. What studies and applications has HONI made in this regard and what effort does HONI anticipate making in 2008?
- e. The OEB has indicated that it will consider rate funding of CDM for programs that are not funded by OPA and that are targeted at the distributor's customers. What studies or applications has HONI made in this regard and what effort does HONI anticipate making in 2008?
- f. Please provide details of staffing and resources committed to CDM in 2006, 2007 and 2008.

Response

Since HONI utilizes a forward rate year, CDM was adequately reflected in HONI's demand forecast and as such an LRAM application is unnecessary.

Hydro One has completed a bottom-up analysis of CDM impacts, which can be found as Attachment A in Exhibit H Tab 1 Schedule 105.

Please see the response to Exhibit H, Tab 2, Schedule 8 regarding HONI initiated CDM in 2008.

- a. Please see the response to Exhibit H, Tab 2, Schedule 8 regarding CDM programs in which HONI expects to be involved in 2008.

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- b. HONI has not received any directions, memorandum containing or describing government direction specific to HONI in regards to CDM from 2006 to date.
- c. Many of the programs already implemented by the OPA are programs that had been piloted, developed and offered by Hydro One. Other cost effective programs are under development by HONI and have been or will be submitted to the OPA as a 'custom program application'; see response to Exhibit H, Tab 2, Schedule 8. We have not commissioned any studies related to additional programs.

Attachment A is a report by Dean C. Mountain, Ph.D., Mountain Economic Consulting and Associates Inc. (Director of the McMaster Institute for Energy Studies) on the in home display pilot run in 2004-2005 under the regulated Price Plan and the results achieved. A subsequent pilot was conducted in 2007 to assess the benefit of in home displays under a TOU plan. The report summarizing these results is expected to be filed with the OEB in April 2008.
- d. Please see the response to Exhibit H, Tab 2, Schedule 8 regarding applications that HONI plans to make for custom CDM programs. HONI made an application to OPA for Double Return in October of 2007 that now will have to be resubmitted as part of the OPA custom application process in March 2008. Double Return is a successful customer initiated demand response program for commercial industrial sector that HONI developed and offered with MARR funding, achieving a summer peak reduction of 34 MW in 2007.
- e. The Minister of Energy has established a \$400 million fund for the express purpose of utility delivered CDM. HONI intends to apply for funding as outlined in the response to Exhibit H, Tab 2, Schedule 8. If any of these programs are turned down for funding by the OPA, HONI will consider applying to OEB at that time.
- f. The Strategy and CDM unit within HONI dedicated 4 full time regular staff to CDM, in 2006, and 6 full time regular staff in 2007, 2008. There are additional staff resources available within the company from various disciplines that also support the CDM team (e.g. law, communications, customer care, load forecasting, procurement).

**The Impact of Real-Time Feedback on
Residential Electricity Consumption:
The Hydro One Pilot**

Dean C. Mountain, Ph.D.

Mountain Economic Consulting and Associates Inc.

March, 2006

Executive Summary

A pilot study was undertaken by Hydro One to determine whether provision of a real-time feedback device is sufficient to empower residential customers with the information needed to reduce their electricity consumption. The pilot was intended to establish whether use of such a device can help customers save money and be an aid in promoting a “conservation friendly” culture. The objective of the pilot was to assess whether real-time feedback is effective and to determine from usage data if change in behaviour of the participants could be quantified as energy savings. In this study, we have determined a quantitative level of energy savings at the household level that can be linked to the provision of a real-time feedback monitoring device in the home.

In the summer of 2004, participants in Hydro One’s Real Time Monitoring Pilot began using real-time monitors. The monitor provided instantaneous feedback on a household’s electricity consumption. In comparison to previous pilots and demonstration projects regarding direct feedback provided by real-time monitors, the sample size of the Hydro One pilot is very large. Over four hundred pilot participants and control customers are followed over a 2.5 year period and the sample covers a wide variation in geography and weather. Within the sample there is a great variety of heating, cooling, water heating and appliance configurations, and a rich diversity of household income and demographic characteristics.

The pilot is unique in that only the impact of feedback on consumption information is being tested. Using a panel based econometric methodology, which controls for the traditional ongoing weather, appliance stock and demographic factors influencing electricity consumption, the kilowatt-hour impact of the real-time monitor is quantified.

The results are statistically significant and indicate a significant positive impact on customer usage. Overall, the aggregate reduction in electricity consumption (kWh) across the study sample was 6.5%. The response was persistent and does not decrease over time during the study period. Within the sample, the non-electric heating households showed energy savings of 8.2% with a range in response from 5.1% (for a non-electric water heating house) to 16.7% (for an electric water heating house). We observed that electric heating households are not responding in a significant way to real-time feedback. Separating out the feedback from the electric heating load and the rest of the load would be required to encourage conservation in this sector.

No other price or conservation incentives were given to sample participants. Therefore, the conservation results observed in the pilot are interpreted as the minimum to be garnered in the absence of other possible conservation incentives. Thus, if the real time monitor is used in conjunction with other conservation and/or price measures, an overall average reduction of between 7% and 10% is feasible.

Acknowledgements

This pilot and report has benefited significantly from the support and guidance of Jatin Nathwani. The suggestions and assistance provided by Jatin have been invaluable. The organization of the questionnaires and the preparation of the corresponding data sets were made possible by the careful attention of Carrie Aloussis. Jason Zalev provided valuable computer programming and data organizational support. Stan But has been instrumental in coordinating various administrative aspects of the pilot, beginning with the sample selection and leading to the provision of various data sets during the pilot. The pilot and this report have also benefited greatly from many helpful discussions with Stan But. Finally, the comments of Jim Hall have been very insightful.

Introduction:

The objective of the Hydro One pilot study is to determine whether real-time consumption feedback empowers users sufficiently to effectively reduce energy consumption. As part of this, a quantification of this reduction is undertaken. The Hydro One pilot is unique. It provides a relatively large sample size spread across very diverse geographic regions with respect to weather. It also covers a great variety of heating, cooling, water heating and appliance configuration. There is also a great diversity of household income and demographic characteristics. The pilot evaluation makes use of a relatively rich pre-experiment historical data set (approximately eighteen months) and a parallel control sample that is completely unaware of the pilot.

The principal focus is to test the impact of real-time feedback. Consequently, during the pilot no intrusions with the customer were initiated. Thus, there was no provision of conservation literature, no conservation goal setting, nor any rate incentives.

Customarily residential electricity consumers see their bill either on a monthly, bimonthly, or quarterly basis. Furthermore, even under regular billing there are lags between the billing date and the time of receiving the bill. By the time the customer receives billing information, the connection between the customer's actions with respect to electricity usage and resulting bill is most often lost. In addition, usually no breakdown of consumption by time of day is provided to the customer. And even though a customer has a meter which can be read periodically, it's probably not very accessible and may be perceived as difficult to understand. In fact, electricity is one of the unusual

commodities for which immediate feedback regarding actual consumption does not occur when used.

Our goal was to evaluate how consumers' behavior changes if the flow of consumption information were altered and direct feedback monitoring were provided. The purpose of this report is to quantify the change in kilowatt-hour consumption due to availability of direct feedback information. More specifically, the report evaluates the results of a pilot where customers received direct real-time feedback using the PowerCost Monitor™. The PowerCost Monitor™ involves a display unit that can be placed anywhere in the house. It shows exactly how much electricity is being used at that moment and what it costs. Among other things, it displays current kW and total monthly kWh of the total consumption of the house. The study tests the hypothesis of whether this display of information provides the necessary feedback encouraging conservation.

The feedback tested here falls into the category of “direct feedback” (see King and Delurey (2005)). While this particular pilot, the Hydro One pilot, focuses on an in-home type of display, other types of direct feedback could include displaying consumption on the internet, smart meters operated by smart cards and two-way communication systems showing consumption and cost information, prepayment meters and device monitors inserted between the plug and wall socket on appliances.

More indirect methods of providing feedback involve the utility processing the data and sending the data to the customer. Such methods could include more frequent bills,

sending actual bills (rather than estimates), or comparing year over year estimates normalizing for weather.

In the earlier literature the results of providing feedback information has been somewhat mixed. Many experiments showed success (e.g., McClelland and Cook (1979), Winett, Neale and Grier (1979)). Other studies (e.g., Becker (1978) and Seligman and Darley (1977)) showed failure.

Darby (2001) reviews about thirty-eight feedback studies. Twenty-one of the studies are direct feedback studies. Ten of the twenty-one studies show an impact of less than 10%. The highest savings – in the range of 20% - occurred using a table-top interactive cost and power display unit, a smartcard meter for prepayment of electricity; and an indicator showing cumulative cost of using an electric cooker. Where a special electronic or PC display was not used, direct feedback consisted of frequent readings of a standard household meter, sometimes accompanied by keeping a diary or chart following household use. Some of the feedback studies also provided advice or information regarding potential savings. There the resulting impact was as much as 10%.

For the current Ontario pilot no intervention occurred. Because the objective is to isolate the effect of the provision of more frequent feedback, no further advice or consultation with the household occurred regarding possible conservation actions.

A critical issue in feedback is the time interval between the actual behavior and the feedback information regarding the associated energy consumption. Generally it is felt, the shorter the time interval, the more effective the feedback information (Seligman and Darley (1977) and Winett and Kagel (1984)). Ester (1985) discovered that biweekly feedback is more effective than monthly feedback.

Real-time monitoring and electronic feedback provides feedback with the shortest of time intervals. This now allows implementation of experiments and programs on a large scale without human intervention. Compare this with providing charts and pamphlets (Winett et al. 1978) or Winett and Kagel (1984)). The usage of real time monitors is more cost effective, less disruptive and residents are able to receive feedback at their own discretion without being interrupted on some regular basis.

Once we move to daily and continuous feedback, results vary. McClelland and Cook (1979) show that daily feedback has a significant impact on heating and cooling. However, they found continuous feedback primarily affects energy uses other than heating and cooling. In fact, the greatest conservation occurred in months of moderate weather.

The Technology:

In the Hydro One Pilot the instantaneous feedback is provided by the PowerCost Monitor™ manufactured by Blue Line Innovations Inc. This monitor has many features designed to provide the homeowner with information regarding their electricity

consumption. The monitor that was used in this pilot displayed consumption in dollars per hour, total dollars and predicted dollars. Consumption was also displayed in current kWh, total kWh and predicted kWh. In addition to these features, the user was also able to view the current CO² emissions, total CO² emissions and predicted CO² emissions, as well as the temperature. The monitor is completely portable and can be carried from room to room.

In addition to the in-home device itself, the monitor, there is also a transmitter. The transmitter is attached to an existing electro-mechanical utility meter with a ring clamp. The transmitter tracks the electricity consumed by counting the turns of the meter disk. The transmitter continuously sends a wireless signal to the in-home device which displays the consumption in real-time.

The Pilot:

In order to quantify the impact with a desired level of statistical accuracy, a stratified random sample was designed to cover the geographic territory of Hydro One and to cover a wide variety of consumption patterns. The stratification was based on Dalenius Hodges and Neyman allocation techniques. Within each region, six kWh strata were chosen. The original sample is comprised of 500 customers who were to be given the real time monitor and 52 control customers who were not to be given the real-time monitor. The stratification is shown in Table 1. The sample size is sufficiently large such that even if the study is left with 50% usable data (due to attrition, technical difficulties, lack of

billing data or lack of customer information) accuracy at the 95% level of significance is guaranteed.

With previous annual billing data, a list of possible participants for the pilot, falling into each of the six strata, was used for telephone recruitment. Customers whose meters were not 7.2 kHz and also those who lived in apartments, condominiums, town homes and row homes were excluded from the pilot. During the telephone recruitment, additional screening was used to eliminate those customers who planned to move within six months, those who were seasonal customers, those who lived in a triplex, four-plex or six-plex, those who were renters, as well as those whose meters were located inside the house. After verifying that the customer was eligible (subject to the above restrictions), the real time monitor was offered to the customer. The original rejection rate was less than 2%. Real-time monitors were then given to the pilot participants between July, 2004 and September, 2004.

Evaluation:

In order to assess the impact of the real-time monitor on kWh usage, the kWh usage is monitored from the date of initial usage until September, 2005. To enhance accuracy of the kWh monitoring, once the real-time monitor was given to the customer, monthly reads of the meter occurred. Billing data was also collected for up to 18 months for all pilot participants prior to initial usage of the real-time monitor. However, during this pre-pilot period, generally the billing data was not collected as frequently; most often it was collected quarterly.

Table 1: Real-Time Pilot Stratification

Eastern Region-Peterborough			Northern Region-Timmins		
kWh	Real-Time Group	Control	kWh	Real-Time Group	Control
0 - 6000	23	2	0 - 4500	20	2
6000-10500	16	1	4500-9000	19	2
10500-16500	25	3	9000-13500	18	2
16500-24000	18	2	13500-22500	30	3
24000-40000	26	3	22500-35000	18	2
> 40000	<u>17</u>	<u>2</u>	> 35000	<u>20</u>	<u>2</u>
Total	125	13		125	13
Grand Total	138			138	

Western Region-Lincoln			Central Region-Barrie		
kWh	Real-Time Group	Control	kWh	Real-Time Group	Control
0 - 6000	23	2	0 - 6000	12	1
6000-10500	17	2	6000-12000	14	2
10500-16500	26	3	12000-19500	16	2
16500-24000	19	2	19500-30000	13	1
24000-40000	22	2	30000-50000	11	1
> 40000	<u>18</u>	<u>2</u>	> 50000	<u>14</u>	<u>1</u>
Total	125	13		80	8
Grand Total	138				

Central Region-Hydro One Brampton

kWh	Real-Time Group	Control
0 - 6000	7	1
6000-12000	8	1
12000-19500	9	1
19500-30000	7	1
30000-50000	6	0
> 50000	<u>8</u>	<u>1</u>
Total	45	5
Grand Total	50	

Because the customer is being followed, including the pre-experiment period, for around two and a half years, it is important that weather is controlled for, and that demographic and appliance changes in the residence are accounted for. With respect to weather, daily heating degree day and cooling degree day information, collected from the relevant local weather station, is matched with billing cycles of the pilot participants. As well, three questionnaires were administered, one at the beginning of the pilot, one at the midpoint and one at the end. All questionnaires sought information on dwelling characteristics (such as square footage, age of dwelling, etc.), appliance holdings, and demographic characteristics. The first questionnaire also looked back to obtain historical information covering previous years regarding appliance/demographic characteristics and changes during that time. Because the participants' billing consumption is continually monitored, it is critical that any change in dwelling/appliance/demographic characteristics are recorded over the pre-pilot and pilot period.

For the purpose of measuring possible conservation effects due to the use of the real-time monitor, it is important to specify a model which controls for other factors influencing electricity consumption in order that the real-time feedback effect can be isolated. There are three aspects which contribute to this. The first aspect is that each participant is being monitored on a before- and after- basis. The second aspect is that there is a parallel control sample who did not receive such a monitor. One reason for this parallel control sample, is that it allows control for possible conservation that may have occurred anyways during the sample time period. The third aspect is to construct a well-specified

model that controls for the electricity consumption responding to traditional factors such as weather, appliance configuration and household demographics.

Following the pilot and control participants through time provides us with panel data. The panel data provides the necessary input for analysis by an appropriately specified econometric model.

The Model:

Before describing some of the data considerations and the estimation procedure, a precise description of the model follows. The following description provides a description of a model of daily kWh consumption for household i at time t . Because the billing cycle varies through time for each participant and across participants, all billing data is normalized by number of days in the billing period.

Depending on the appliance and heating/cooling configuration of a household, the total consumption in the absence of the real time monitor is envisaged to be a function of variables influencing electric heating usage, electricity water heating usage, air conditioning usage, and other appliance usage. In addition there may be time trend related factors perhaps related to prices and overall conservation attitudes that may influence electricity usage. All of these factors described in the following specification are in the functions $f^1(\cdot, \cdot), f^2(\cdot, \cdot), f^3(\cdot, \cdot), f^4(\cdot, \cdot),$ and $f^5(\cdot, \cdot)$. Once the real-time monitor is used by the customer, further variables may come into play. They are captured in the function $g(\cdot, \cdot)$.

More precisely, the logarithm of daily kWh consumption for household i at time t is

$\ln y_{it}$, where $\ln y_{it}$ is decomposed as follows

$$\ln y_{it} = f^1(\tilde{x}_{it}^1, \tilde{\alpha}) + f^2(\tilde{x}_{it}^2, \tilde{\beta}) + f^3(\tilde{x}_{it}^3, \tilde{\gamma}) + f^4(\tilde{x}_{it}^4, \tilde{\delta}) + f^5(\tilde{x}_{it}^5, \tilde{\lambda}) + g(\tilde{z}_{it}, \tilde{\theta}) + \mu_{it}$$

for those households with some part of their heating load serviced by electricity,

$$f^1(\tilde{x}_{it}^1, \tilde{\alpha}) = \tilde{x}_{it}^1{}' \tilde{\alpha}, \text{ with parameter vector } \tilde{\alpha}, \text{ is a linear function of a vector of}$$

independent variables (\tilde{x}_{it}^1) influencing the electric heating load, in the absence of the

real time monitor;

for those households with electricity water heating load,

$$f^2(\tilde{x}_{it}^2, \tilde{\beta}) = \tilde{x}_{it}^2{}' \tilde{\beta}, \text{ with parameter vector } \tilde{\beta}, \text{ is a linear function of a vector of}$$

independent variables (\tilde{x}_{it}^2) influencing the electric water heating load, in the absence of

the real time monitor;

for those households with some air conditioning load,

$$f^3(\tilde{x}_{it}^3, \tilde{\gamma}) = \tilde{x}_{it}^3{}' \tilde{\gamma}, \text{ with parameter vector } \tilde{\gamma}, \text{ is a linear function of a vector of}$$

independent variables (\tilde{x}_{it}^3) influencing the electric air conditioning heating load, in the

absence of the real time monitor;

for all households,

$f^4(\tilde{x}_{it}^4, \tilde{\delta}) = \tilde{x}_{it}^4 \tilde{\delta}$, with parameter vector $\tilde{\delta}$, is a linear function of a vector of independent variables (\tilde{x}_{it}^4) influencing the remaining electricity loads, in the absence of the real time monitor;

for all households,

$f^5(\tilde{x}_{it}^5, \tilde{\lambda}) = \tilde{x}_{it}^5 \tilde{\lambda}$, with parameter vector $\tilde{\lambda}$, is a linear function of a vector of trend related independent variables (\tilde{x}_{it}^5) influencing the total electricity load, in the absence of the real time monitor;

for all households using the real time monitor,

$g(\tilde{z}_{it}, \tilde{\theta}) = \tilde{z}_{it} \tilde{\theta}$, with parameter vector $\tilde{\theta}$, is a linear function of a vector of independent variables (\tilde{z}_{it}) influencing the electricity load, in the presence of the real time monitor;

μ_{it} is a stochastic error with possible autocorrelation and heteroskedasticity.

Briefly, the various components reflect the critical factors that influence the corresponding usage.

Electric heating formulation:

For those houses with some part of the dwelling heated with electricity, we would expect the size of the house (measured in square feet), the age of the dwelling, the weather

(measured in heating degree days), the number of residents, and income to probably matter.

$$f^1(\tilde{x}_{it}^1, \tilde{\alpha}) = \tilde{x}_{it}^1 \tilde{\alpha} = (\alpha_0 + \alpha_1 NR_{it} + \alpha_2 IN_{it} + \alpha_3 A1_i + \alpha_4 A2_i + \alpha_5 A3_i + \alpha_6 A4_i + \alpha_7 A5_i + \alpha_8 A6_i) \bullet DF_{it} SQ_{it} HDD_{it}$$

where

DF_{it} is the proportion of the dwelling heated by electricity at time t ,

HDD_{it} is the normalized (per day) heating degree days (with reference temperature 18 degrees Celsius) measured during time t ,

SQ_{it} is the square footage of the dwelling,

NR_{it} is the number of residents in the household,

IN_{it} is household income,

$$A1_i = \begin{cases} 1 & \text{dwelling built between 1940 and 1969} \\ 0 & \text{otherwise} \end{cases},$$

$$A2_i = \begin{cases} 1 & \text{dwelling built between 1970 and 1986} \\ 0 & \text{otherwise} \end{cases},$$

$$A3_i = \begin{cases} 1 & \text{dwelling built between 1987 and 1990} \\ 0 & \text{otherwise} \end{cases},$$

$$A4_i = \begin{cases} 1 & \text{dwelling built between 1991 and 1993} \\ 0 & \text{otherwise} \end{cases},$$

$$A5_i = \begin{cases} 1 & \text{dwelling built between 1994 and 1998} \\ 0 & \text{otherwise} \end{cases},$$

$$A6_i = \begin{cases} 1 & \text{dwelling built since 1999} \\ 0 & \text{otherwise} \end{cases}.$$

Electric water heating formulation:

For electric water heating, the number of residents, the age composition, income and hot water related appliances matter.

$$f^2(\tilde{x}_{it}, \beta) = \tilde{x}_{it}' \tilde{\beta} = (\beta_0 + \beta_1 NR_{it} + \beta_2 APDW_{it} + \beta_3 APCW_{it} + \beta_4 IN_{it} + \beta_5 NAG1_{it} + \beta_6 NAG2_{it}) \bullet DW_{it}$$

where

$$DW_{it} = \begin{cases} 1 & \text{if dwelling has electricity water heating} \\ 0 & \text{otherwise} \end{cases},$$

NR_{it} is the number of residents in the household,

$APDW_{it}$ is the wattage of all dishwashers in the dwelling,

$APCW_{it}$ is the wattage of the clothes washing machines in the dwelling,

IN_{it} is household income,

$NAG1_{it}$ is the number of household members less than or equal to 14

$NAG2_{it}$ is the number of household members greater than or equal to 15 and less than or equal to 19.

Air conditioning formulation:

For air conditioning participants, the square footage, the weather (measured by cooling degree days), the number of residents and income may matter.

$$f^3(\tilde{x}_{it}^3, \tilde{\gamma}) = \tilde{x}_{it}^3 \tilde{\gamma} = (\gamma_0 + \delta_1 NR_{it} + \delta_2 IN_{it}) \bullet (DA_{it} SQ_{it} CDD_{it})$$

where

DA_{it} is the proportion of the dwelling air conditioned at time t ,

CDD_{it} is the normalized (per day) cooling degree days (with reference temperature 22 degrees Celsius) measured during time t ,

SQ_{it} is the square footage of the dwelling,

NR_{it} is the number of residents in the household,

IN_{it} is household income.

Other electricity load formulation:

For the other electricity component, the number of residents, the income, and the stock of appliances should matter.

$$f^4(\tilde{x}_{it}^4, \tilde{\delta}) = \tilde{x}_{it}^4 \tilde{\delta} = \delta_0 + (\delta_1 + \delta_2 NR_{it} + \delta_3 IN_{it}) \bullet APT_{it} + \delta_4 DPHE_{it} + \delta_5 APPP_{it} + \delta_6 APONM_{it}$$

where

NR_{it} is the number of residents in the household,

IN_{it} is household income,

APT_{it} is the total wattage of the following appliances: clothes dryer, dishwasher, freezer, microwave, mini-bar, personal computer, range, refrigerator, television, washing machine;

$DPHE_{it}$ is the wattage of an in-ground pool heater owned by household i at time t ,

$APPP_{it}$ is the wattage of the pool pump if owned by household i at time t ,

$APONUM_{it}$ is the total number of saunas, hot tubs and whirlpools

Trend related formulation:

The trend related formulation is very simple. There is a dummy variable for summer months, a dummy variable for winter months, and a time trend index. If there are conservation impacts happening, regardless of the usage of the real time monitor, the coefficient corresponding to the time trend index would be expected to be negative and statistically significant from zero.

$$f^s(x_{it}^s, \lambda) = x_{it}^s \lambda = \lambda_1 DSM_{it} + \lambda_2 DWN_{it} + \lambda_3 \sqrt{T_{it}}$$

where

DSM_{it} is the proportion of billing days for time t in the months of June, July and August,

DWN_{it} is the proportion of billing days for time t in the months of December, January and February,

T_{it} is a time index.

Real-time monitor impact formulation:

Variables influencing the feedback include the configuration of space heating, water heating and air conditioning, income, education and the age distribution of household members. Furthermore, it is desirable to test whether there is any attenuation of impact during the pilot. In other words, does the feedback response diminish or increase during the time of using the real-time monitor? Because of the extreme variation in cold weather across the sample in the winter months, in addition to modeling the feedback as a linear term involving heating degree days interacted with proportion of dwelling heating by electricity, a nonlinear term involving the square root of heating degree days is also added.

$$g(\underset{\sim}{z}_{it}, \underset{\sim}{\theta}) = \underset{\sim}{z}'_{it} \underset{\sim}{\theta} = \left(\begin{array}{l} \theta_0 + \theta_1 DF_{it} (1 - DSM_{it}) + \theta_2 DF_{it} HDD_{it} + \theta_3 DF_{it} \sqrt{HDD_{it}} + \theta_4 DW_{it} + \theta_5 DA_{it} CDD_{it} + \\ \theta_6 IN_{it} + \theta_7 ED_{it} + \theta_8 NAG4_{it} + \theta_9 \sqrt{TD_{it}} \end{array} \right) \bullet D_{it}$$

where

DSM_{it} is the proportion of billing days for time t in the months of June, July and August,

DF_{it} is the proportion of the dwelling heated by electricity at time t ,

HDD_{it} is the normalized (per day) heating degree days (with reference temperature 18 degrees Celsius) measured during time t ,

CDD_{it} is the normalized (per day) cooling degree days (with reference temperature 22 degrees Celsius) measured during time t ,

$$DW_{it} = \begin{cases} 1 & \text{if dwelling has electricity water heating} \\ 0 & \text{otherwise} \end{cases},$$

DA_{it} is the proportion of the dwelling air conditioned at time t ,

IN_{it} is household income,

$$ED_{it} = \begin{cases} 1 & \text{if the highest level of education in the household corresponds to either a college degree,} \\ & \text{a trades diploma, or a university degree} \\ 0 & \text{otherwise} \end{cases}$$

$NAG4_{it}$ is the number of household members 65 and over

TD_{it} is the time in days since the real-time-monitor was installed

Data Considerations:

After assembling the data, a number of issues had to be handled. During the initial phase of the pilot study, there were technical difficulties with the device that needed to be corrected.¹ For those observations, the affected data were dropped from the analysis. The billing period corresponding to installation is dropped because the observation is mixed in nature. The first part of the billing period corresponds to no usage of the real-time monitor and the second part of the billing period corresponds to usage of the real-time monitor.

Only actual meter reads were used. This is particularly relevant to the pre-pilot period where estimated bills were sometimes sent to customers. Moreover, there were some sample participants who did not respond in filling out any of the three questionnaires. If a participant responded to only the first or first and second questionnaires, they were

¹ Technical problems fell into the following categories: installation problems (15%), battery issues (30%), missing transmitter (1%), dropped receivers (3%), potting issues (29%), range issues (10%) and other and unknown (12%).

followed as long as questionnaire data was available. If a participant moved during the pilot, the participant was followed up until their departure. After the above data inspection there were 5015 usable observations. This consisted of 382 pilot participants and 42 control customers.

Because billing cycles are customer- and time-specific, all heating and cooling degree day information was matched precisely to the billing cycle.

For many of the already cited reasons, it becomes clear very quickly that the resulting data set is comprised of observations separated by multiple time lags. Even for one customer, sometimes (either due to variation in billing cycles, long periods between actual reads, dropped observations for reasons described above) the lags between midpoints of actual reads vary. For example, in looking at the distance between observations for one participant, there may be one month, two months or even three months.

The underlying error is assumed to be AR(1). That is $u_{it} = \rho u_{i,t-1} + e_{it}$. The selection of the model's parameters is based on maximizing the likelihood function. Where possible, except for starting observations, we formulate the model in differences between consecutive observations. The advantages of this technique with respect to handling possible selection bias are outlined in Ham, Mountain and Chan (1997). To account for the variation in lags across the sample, a concentrated likelihood function in the spirit of Beach and MacKinnon (1978) is formulated.

Denote $X'_{it} = (x^1_{it}, x^2_{it}, x^3_{it}, x^4_{it}, x^5_{it}, z_{it})$ and $\tau' = (\alpha', \beta', \gamma', \delta', \lambda', \theta')$.

Denote k_{it} as the distance in months between the observation at time t and $t-1$.

Denote A as the set of observations corresponding to the initial time period for which we have data on a household. Let the number of observations in set A be \bar{A} .

Denote B as the set of observations where the distance (measured in months) since the last observation corresponds to the lagged distance. Let the number of observations in set B be \bar{B} .

Denote C as the set of observations where the distance (measured in months) since the last observation does not correspond to the lagged distance. Let the number of observations in set C be \bar{C} .

The sets $A, B,$ and C are mutually exclusive and exhaustive. Thus the total number of observations in these three sets ($\bar{A} + \bar{B} + \bar{C}$) equals N , the total number of observations.

The concentrated likelihood function to be maximized (in terms of τ and ρ) is

$$\left[\frac{\bar{A} + \bar{C}}{2} \ln(1 - \rho^2) - 0.5 \sum_i \sum_{t \in C} \ln(2(1 - \rho^{k_{it}})) - 0.5 \sum_i \sum_{t \in B} \ln\left(\frac{1 - \rho^{2k_{it}}}{1 - \rho^2}\right) - \frac{N}{2} \left[\sum_i \sum_{t \in A} \left(\ln y_{it} - X'_{it} \tau \right)^2 + \sum_i \sum_{t \in B} \left(\left(\Delta \ln y_{it} - \rho^{k_{it}} \Delta \ln y_{i,t-k_{it}} \right) - \left(\Delta X'_{it} \tau - \rho^{k_{it}} \Delta X'_{i,t-k_{it}} \tau \right) \right)^2 + \sum_i \sum_{t \in C} \left(\Delta \ln y_{it} - \Delta X'_{it} \tau \right)^2 \right] \right]$$

Results:

Reasonableness of Model:

The above concentrated likelihood function is maximized using a grid search involving ρ . Before arriving at the final model, we tested whether the demographic/income and attenuation effects pertaining to the real-time monitor are zero.² That is, $H_0 : \theta_6 = \theta_7 = \theta_8 = \theta_9$. This hypothesis could not be rejected at the 5% level of significance ($\chi^2(4) = 0.92 < 9.49 = \chi^2(4)_{.05}^{crit}$). This is also consistent with the findings of Brandon and Lewis (1999), who also found for households in Bath that income and demographic factors had no impact on the responsiveness of the monitor.³ The estimated parameters corresponding to the maximum likelihood corresponding to the final model are in Table 2. The optimal ρ is -0.488. The autocorrelation is statistically significant at the 5% level of significance ($\chi^2(1) = 88.00 > 3.84 = \chi^2(1)_{.05}^{crit}$). We also tested for heteroskedasticity of the error (e_{it}), where the heteroskedasticity was modeled as a function of the electric heating/electric water heating/air conditioning configuration. Using White's test, it appears that heteroskedasticity is not present ($\chi^2(3) = 7.52 < 7.81 = \chi^2(3)_{.05}^{crit}$).

A quick look at the parameters of the model shows most parameters with relatively low standard errors. The model seems to be well specified. $R^2 = 0.9439$. This is a very good fit for such panel data.

² In some preliminary analysis an attitudes-conservation index interacted with the usage of the real-time monitor (D_{it}) was include as an explanatory variable. However, this variable was not statistically significant.

³ Like the results from this pilot, they found income and demographic factors were useful to predict historical energy consumption.

Table 2: Estimated Parameters of Final Model

	Scaling Factor	Parameter	Standard Error
Electric Heating Parameters (All variables interacted with $DF_{it}SQ_{it}HDD_{it}$)			
α_0	10^{-4}	0.5160	0.0454
$\alpha_1 : NR$	10^{-6}	-0.6208	0.2898
$\alpha_2 : IN$	10^{-10}	-0.4592	0.1077
$\alpha_3 : A1$	10^{-5}	-0.2638	0.0448
$\alpha_4 : A2$	10^{-5}	-0.2415	0.0444
$\alpha_5 : A3$	10^{-4}	-0.3290	0.0448
$\alpha_6 : A4$	10^{-4}	-0.2889	0.0461
$\alpha_7 : A5$	10^{-4}	-0.3254	0.0521
$\alpha_8 : A6$	10^{-5}	-0.1220	0.0674
Electric Water Heating Parameters (All variables interacted with DW_{it})			
β_0	10^0	0.4932	0.1191
$\beta_1 : NR$	10^{-1}	0.2615	0.3047
$\beta_2 : APDW$	10^{-2}	-0.1163	0.0256
$\beta_3 : APCW$	10^{-2}	-0.2062	0.1101
$\beta_4 : IN$	10^{-5}	0.1887	0.0665
$\beta_5 : NAG1$	10^{-1}	-0.7831	0.3572
$\beta_6 : NAG2$	10^{-1}	0.2531	0.3913
Air Conditioning Parameters (All variables interacted with $DF_{it}SQ_{it}CDD_{it}$)			
γ_0	10^{-3}	0.1607	0.0200
$\gamma_1 : NR$	10^{-6}	0.7212	3.3800
$\gamma_2 : IN$	10^{-9}	-0.5542	0.0794

Table 2 (continued)

	Scaling Factor	Parameter	Standard Error
Other Electricity Load Parameters			
δ_0	10^0	2.5464	0.0799
$\delta_1 : APT$	10^{-4}	0.8942	0.1774
$\delta_2 : NR \cdot APT$	10^{-4}	0.1679	0.0303
$\delta_3 : IN \cdot APT$	10^{-9}	0.1980	0.0888
$\delta_4 : DPHE$	10^{-1}	0.6936	0.5624
$\delta_5 : APPP$	10^{-3}	0.1522	0.0130
$\delta_6 : APONM$	10^0	0.1281	0.0235
Trend Related Parameters			
$\lambda_1 : DSM$	10^{-1}	-0.4691	0.1555
$\lambda_2 : DWN$	10^0	0.2041	0.0120
$\lambda_3 : \sqrt{T}$	10^{-2}	0.7852	1.3930
Real-time Monitor Impact Parameters (All variables interacted with D_{it})			
θ_0	10^{-1}	-0.5169	0.2770
$\theta_1 : (1 - DSM)$	10^0	-0.1193	0.0712
$\theta_2 : DF \cdot HDD$	10^{-2}	-0.7315	0.6196
$\theta_3 :$ $DF \cdot \sqrt{HDD}$	10^0	0.1049	0.0465
$\theta_4 : DW$	10^0	-0.1307	0.0428
$\theta_5 : DA \cdot CDD$	10^{-4}	-0.3141	0.1533

R^2 : 0.9439

Log of the Likelihood Function: -15833.42

Number of Observations: 5015

For the electric heating model pertaining to no presence of real time monitor, as expected, the higher the number of residents in the household, the lower is the consumption. This is an effect commonly observed in the conditional demand literature. Not unexpectedly, the age of the dwelling seems to matter in explaining electric heating consumption. Furthermore, the bigger the house, the more electricity is used (e.g., α_0 and the other α parameters are statistically significant from zero). Interestingly, the income coefficient is negative both in the electric heating submodel and in the air conditioning submodel. Perhaps, in economic terms, one could characterize the electricity required for heating and cooling is such a necessity that it is an inferior good. However, this may also be related to the idea that the higher the level of income, the more investment made by households in insulation and weather proofing of the dwelling (and for new home purchases, this means a more energy efficient dwelling in terms of heat or cooling loss), ultimately leads to less electricity used in heating and cooling.

For the air-conditioning submodel, the higher the number of residents and the higher the square footage, the higher is the air conditioning load. This is to be expected. The age profile of the dwelling was also examined (not shown) as a possible set of explanatory variables for air conditioning load. However, in our sample we found the age of dwelling didn't seem to matter regarding air conditioning load.

Going back to the electric water heating load, the number of residents and the level of income positively affect electricity usage. But, a negative adjustment must be made for the number of children less than or equal to fourteen. Interestingly, higher dishwasher wattage shows a significantly negative impact on electric water heating. Perhaps

dishwashers with higher wattage show more efficiency in conserving electric hot water. As well, there may be a high correlation with the dishwasher wattage and demographics in the house which we are not capturing explicitly.

For the other electricity load (base load) parameters, all coefficients of explanatory variables are positive and all but one is statistically significant from zero. Generally, the greater the number of appliances, the higher is the electricity consumption. In particular, the number of saunas, hot tubs and whirlpools along with the presence of a pool pump significantly increase household load. As well, as income and the number of residents increase, base load consumption increases.

With respect to trend related variables, while there is a significant seasonal impact aside from weather ($\lambda_1 < 0, \lambda_2 > 0$), there are no quantifiable underlying trend conservation effects.

The Impact of the Real Time Monitor

Does the real-time monitor affect consumption? This corresponds to testing $H_0 : \theta_0 = \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5$. This hypothesis is rejected at the 5% level of significance ($\chi^2(6) = 42.70 > 12.59 = \chi^2(6)_{.05}^{crit}$). The statistical significance of $\theta_0, \theta_1, \theta_2, \theta_3, \theta_4$, and θ_5 illustrates that the real-time monitor has a significant impact on customer behavior. Furthermore, the critical determinants of the responsiveness are the electric heating/electric water heating/air conditioning configuration. This is shown in Table 3. Table 3 shows percentage kWh savings and percentage impacts due to real-time

Table 3: Percentage Impact of Real-Time Monitor: By Heating-Water Heating-Air Conditioning Configurations

	Sample Estimates							
Electric Heating: (Percentage of house heated with electricity: DF)	100	100	0	0	0	0	0<DF<100	0
Electric Water Heating:	Yes	Yes	Yes	Yes	No	No	---	---
Air Conditioning: (Percentage of house cooled: DA)	100	0	100	0	100	0	0<DA<100	0 ≤ DA ≤ 100
<hr/>								
Sample Proportion	0.045	0.068	0.050	0.076	0.262	0.115	0.385	0.579
Square Footage	2876	1619	2191	1908	2404	1758	1912	2100
Number of Residents	2.99	2.79	2.94	3.00	3.23	2.91	2.78	3.04
Income	68822	70042	77706	71174	95165	62981	63889	79792
kWh before real-time monitor	34418	24219	16256	13960	12363	9945	17485	12106
Change in kWh due to real-time monitor	-298.6	-281.6	-2720.6	-2336.2	-624.6	-502.4	-1015.8	-987.6
Percentage Response (%)	-0.87	-1.16	-16.74	-16.74	-5.05	-5.05	-5.81	-8.16

monitoring. The impacts are calculated at sample averages. Sample averages for square footage, number of residents and income are reported. For example, when $DF=1$, $DW=1$ and $DA=1$ (an all-electric house) the impact is -0.87% . Contrast this with $DF=0$, $DW=1$ and $DA=1$ (electric water heating and air conditioning but no electric heating), where the impact is -16.74% .

Looking at the first six columns of Table 3, it is clear that the largest impact occurs for customers with electric water heating and without electric heating (-16.74%). Admittedly, the coefficients in Table 2 show that the extra conservation effect is statistically significant for air conditioning households in comparison to non-air conditioning households. However, numerically the difference is less than the second decimal point and consequently, the percentage impacts are not much different. The participants without electric water heating and without electric heating show reductions of 5.05% . Both of these impacts are statistically significant at the 95% level of significance. Notice that because of the log-linearity of the specification, and because the air conditioning response is numerically small, the conservation percentage impact for both electric water heating (and no electric heating) households is identical for customers with and without air conditioning. This is also true for non-electric water heating households, with and without air conditioning.

What is not significant is the response of electric heating houses. The seventh column shows the impact on participants with some portion ($<100\%$) of their house heated

electrically or with air conditioning. Here the impact is significant and is -5.81%. For those participants with no electric heating (either partial or complete) the reduction is 8.16%. Over the entire sample, the average reduction is 6.50%. Excluding the electric heating participants, these percentage responses are in the range of “5% or more” observed by Darby (2001) in her survey of direct feedback experiments.⁴ The Ontario pilot’s results are very consistent with the 7% self-monitoring impacts observed in the relatively small Maryland feedback sample (Winett, Neale and Grier (1979)).

The Ontario results are below the 10% reduction observed in four programs surveyed by Darby (2001) where information about conservation was provided to households. But again, it is to be noted that in the Ontario pilot no such conservation information was given to participants, and the Ontario pilot covers a relatively large diverse group of participants with respect to heating, cooling and water heating mix. However, this pilot’s estimate for electric heating response does not compare with the 12.9% savings observed by Dobson and Griffin (1992).

With respect to electric heating households, it appears that because the electric heating load completely overwhelms (maybe as much as 80% of the load in the winter) the rest of the dwelling’s electricity load, the participant is probably unable to detect any of their non-heating conservation actions. Consequently, the feedback provides no indication of reward for conservation efforts. The Dobson and Griffin (1992) pilot provided the

⁴ On the other hand, the Ontario pilot’s response is below the 12.3% reduction found in the electronic gas monitoring experiment in the Netherlands (Van Houwelingen and Van Raaij (1989)) where in addition to receiving daily feedback about natural gas use the customer receives comparisons with conservation goals set at the beginning of the pilot.

customer with instant feedback on individual sub-metered loads (e.g., heating, water heating, air conditioning, range, etc.) The results of the current pilot together with the Dobson and Griffin (1992) study would probably suggest that while submetering of all loads is not necessary, at least separating the feedback from electric heating load from the rest of the loads would be worthwhile for the customer.

Table 4 provides another perspective. Here, there is a comparison of the savings for a house of identical size and identical demographics and appliance configuration in each of the geographic regions of the pilot. For example, in Lincoln (the southern most region of our sample), while the electric heating household show conservation impacts of 3.37%, the non-electric heating impact averages 6.67%. The reason that these electric heating households show more of a conservation impact is that they have relatively less heating degree days than the rest of the sample. Again, the electric water-heating participants show an impact of 16.74%. The remaining part of Table 4 examines the impacts in each of the other five regions. With the exception of Brampton, the impacts for non-electric heating houses are greater than those of Lincoln. As we move to colder and colder climates (i.e., to Peterborough and Timmins), the impact on electric heating houses becomes insignificant (either insignificantly negative or positive). This is in keeping with the findings of McClelland and Cook (1979) in their examination of twenty-five North Carolina all-electric homes. Furthermore, extremes in weather across regions are much more in Ontario. For example, in Lincoln region annual heating degree days is 3650.5, whereas in Timmins annual heating degree days are about 58% greater, totaling 5765.9.

Table 4: Percentage Impact of Real-Time Monitor: By Heating-Water Heating-Air Conditioning Configurations

By Region in Ontario									
Electric Heating: (Percentage of house heated with electricity: DF)	100	100	0	0	0	0	0	0 < DF < 100	0
Electric Water Heating:	Yes	Yes	Yes	Yes	No	No	---	---	---
Air Conditioning: (Percentage of house cooled: DA)	100	0	100	0	100	0	0 < DA < 100	0 ≤ DA ≤ 100	> 100

Lincoln									
Square Footage	2099	2099	2099	2099	2099	2099	2099	2099	2099
Number of Residents	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08
Income	74692	74692	74692	74692	74692	74692	74692	74692	74692
Annual Heating Degree Days	3650.5	3650.5	3650.5	3650.5	3650.5	3650.5	3650.5	3650.5	3650.5
Annual Cooling Degree Days	166.6	166.6	166.6	166.6	166.6	166.6	166.6	166.6	166.6
kWh before real-time monitor	29720	27400	17684	15391	12298	10704	16835		12598
Change in kWh due to real-time monitor	-1000.1	-689.6	-2959.8	-2575.8	-621.5	-540.7	-946.0		-839.7
Percentage Response (%)	-3.37	-2.52	-16.74	-16.74	-5.05	-5.05	-5.62		-6.67

Table 4 (continued): Percentage Impact of Real-Time Monitor: By Heating-Water Heating-Air Conditioning Configurations

By Region in Ontario								
Electric Heating: (Percentage of house heated with electricity: DF)	100	100	0	0	0	0	0 < DF < 100	0
Electric Water Heating:	Yes	Yes	Yes	Yes	No	No	---	---
Air Conditioning: (Percentage of house cooled: DA)	100	0	100	0	100	0	0 < DA < 100	0 ≤ DA ≤ 100

Barrie								
Square Footage	2292	2292	2292	2292	2292	2292	2292	2292
Number of Residents	2.98	2.98	2.98	2.98	2.98	2.98	2.98	2.98
Income	75225	75225	75225	75225	75225	75225	75225	75225
Annual Heating Degree Days	4220.7	4220.7	4220.7	4220.7	4220.7	4220.7	4220.7	4220.7
Annual Cooling Degree Days	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4
kWh before real-time monitor	30294	29342	15642	14726	10825	10190	16416	11757
Change in kWh due to real-time monitor	-332.9	-224.7	-2617.9	-2464.4	-546.9	-514.8	-1210.8	-1025.7
Percentage Response (%)	-1.10	-0.77	-16.74	-16.74	-5.05	-5.05	-7.38	-8.72

Table 4 (continued): Percentage Impact of Real-Time Monitor: By Heating-Water Heating-Air Conditioning Configurations

By Region in Ontario

Electric Heating: (Percentage of house heated with electricity: DF)	100	100	0	0	0	0	0	0 < DF < 100	0
Electric Water Heating:	Yes	Yes	Yes	Yes	No	No	---	---	---
Air Conditioning: (Percentage of house cooled: DA)	100	0	100	0	100	0	0 < DA < 100	0 ≤ DA ≤ 100	

Brampton

Square Footage	2714	2714	2714	2714	2714	2714	2714	2714	2714
Number of Residents	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38
Income	107640	107640	107640	107640	107640	107640	107640	107640	107640
Annual Heating Degree Days	3851.8	3851.8	3851.8	3851.8	3851.8	3851.8	3851.8	3851.8	3851.8
Annual Cooling Degree Days	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7
kWh before real-time monitor	36125	34673	20009	18600	13230	12298	19160		13464
Change in kWh due to real-time monitor	-828.5	-653.3	-3348.7	-3112.7	-668.4	-621.3	-621.2		-774.4
Percentage Response (%)	-2.29	-1.88	-16.74	-16.74	-5.05	-5.05	-3.24		-5.75

Table 4 (continued): Percentage Impact of Real-Time Monitor: By Heating-Water Heating-Air Conditioning Configurations

By Region in Ontario

Electric Heating: (Percentage of house heated with electricity: DF)	100	100	0	0	0	0	0	0 < DF < 100	0
Electric Water Heating:	Yes	Yes	Yes	Yes	No	No	---	---	---
Air Conditioning: (Percentage of house cooled: DA)	100	0	100	0	100	0	0 < DA < 100	0 ≤ DA ≤ 100	

Peterborough

Square Footage	1998	1998	1998	1998	1998	1998	1998	1998	1998
Number of Residents	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64
Income	63096	63096	63096	63096	63096	63096	63096	63096	63096
Annual Heating Degree Days	4400.5	4400.5	4400.5	4400.5	4400.5	4400.5	4400.5	4400.5	4400.5
Annual Cooling Degree Days	93.6	93.6	93.6	93.6	93.6	93.6	93.6	93.6	93.6
kWh before real-time monitor	29724	28666	15257	14240	10606	9899	18336		12386
Change in kWh due to real-time monitor	-220.5	-112.3	-2553.4	-2383.1	-535.8	-500.0	-1541.7		-1423.8
Percentage Response (%)	-0.74	-0.39	-16.74	-16.74	-5.05	-5.05	-8.41		-11.50

Table 4 (continued): Percentage Impact of Real-Time Monitor: By Heating-Water Heating-Air Conditioning Configurations

	By Region in Ontario							
Electric Heating: (Percentage of house heated with electricity: DF)	100	100	0	0	0	0	0 < DF < 100	0
Electric Water Heating:	Yes	Yes	Yes	Yes	No	No	---	---
Air Conditioning: (Percentage of house cooled: DA)	100	0	100	0	100	0	0 < DA < 100	0 ≤ DA ≤ 100

	Timmins							
Square Footage	1675	1675	1675	1675	1675	1675	1675	1675
Number of Residents	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97
Income	73368	73368	73368	73368	73368	73368	73368	73368
Annual Heating Degree Days	5765.9	5765.9	5765.9	5765.9	5765.9	5765.9	5765.9	5765.9
Annual Cooling Degree Days	45.3	45.3	45.3	45.3	45.3	45.3	45.3	45.3
kWh before real-time monitor	30389	29990	15304	14926	10506	10246	15146	10001
Change in kWh due to real-time monitor	547.8	-575.1	-2561.2	-2497.8	-530.8	-517.6	-668.5	-771.7
Percentage Response (%)	1.80	1.92	-16.74	-16.74	-5.05	-5.05	-4.41	-7.02

Customers' Attitudes and Perceptions Regarding the Real Time Monitor:

Having quantified the conservation impact of the real-time monitor, it is now worthwhile to compare this with the participants' attitudes toward the real-time monitor and their perceptions of their behavior.

Tables 5 to 7 indicate a very high level of satisfaction with the real-time monitor. According to questionnaire statistics, 60.5% of the participants felt the monitor made a difference in their homes. The majority of the participants, 65.1%, reported that they planned to continue using the monitor after the pilot was complete. When asked how useful they found the monitor in helping them conserve energy, 63% of the participants ranked the monitor 3 or greater on a scale of 0 to 5. If we decompose the sample into houses heated entirely by electricity versus all other houses, participants in electrically heated houses see the monitor as a little less useful (59.9% with a rank of 3 or greater) than those in non-electricity heated houses (64.5% with a rank of 3 or greater). This lends support to the distinctly lower responsiveness for electric heated houses.

Table 8 provides an indication of how often participants consulted their real-time monitor. Our findings indicated that 38.9% of the participants consulted the monitor either daily or multiple times per day. Nevertheless, this does mean that over 60% of the participants consulted the real-time monitor less than on a daily basis. Thus, while the potential of feedback is always available, it does not mean that everyone is making use of this information.

Table 5: Overall Evaluation

Did The Monitor Make A Difference In Your Home

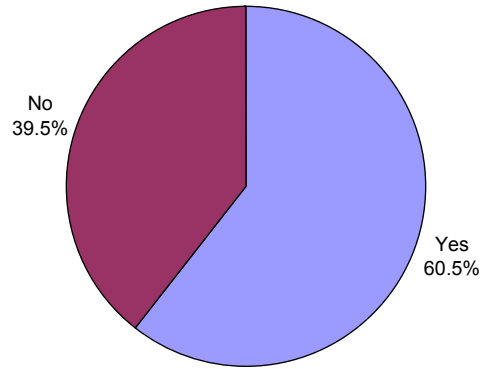


Table 6: Permanence of Usage

Do You Plan To Continue Using The Monitor Once Pilot Complete

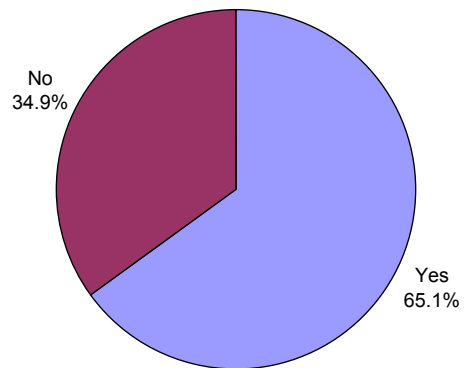


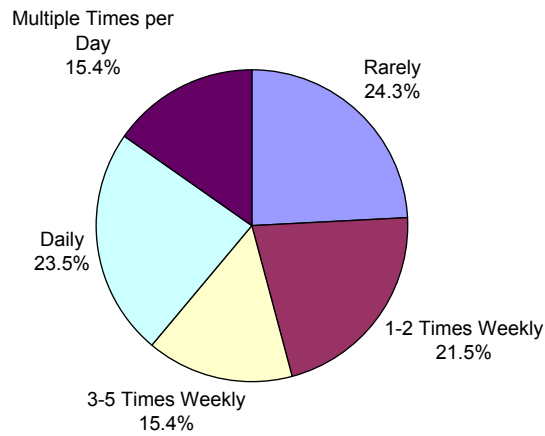
Table 7: Usefulness of Monitor (0 - Not Useful; 5 - Very Useful)

Percentage (%)

Usefulness	Heated Entirely by		Total Sample
	Electricity	Other Houses	
0	3.5	5.6	4.9
1	16.5	12.2	13.6
2	20.0	17.8	18.5
3	23.5	25.0	24.5
4	18.8	22.8	21.5
5	17.6	16.7	17.0

Table 8: Consultation of Monitor

How Often Do You Consult Your Monitor



The questionnaires also analyzed participants' perception of their savings. Interestingly, when the questionnaire statistics were compared with the actual measured savings there is a mild understatement of participants' expected savings as illustrated in Table 9. While the empirical results suggested an overall reduction of 6.5%, 52.1% of the sample saw their potential savings to be between 0% and 5%. Only 17.5% of the sample saw their savings greater than or equal to 10%. Overall, it would seem that in aggregate participants' perceptions of their savings are not that far from their actual savings. It appears as though the perceptions of the participants are very accurate.

Again, lending further support to reduced conservation in electric heating households, Table 9 shows that 57.1% of electrically heated houses saw their savings in the range of 0% to 5%; whereas, for non-electricity heated houses, 49.7% saw their savings in the 0% to 5% range.

Table 9: Households' Perceived Expected Savings

Percentage of Households (%)

Percentage Saved	Heated Entirely by		Total Sample
	Electricity	Other Houses	
0-5	57.1	49.7	52.1
5-10	28.6	31.2	30.3
10-15	7.8	12.7	11.1
15-20	6.5	4.5	5.1
> 20	0.0	1.9	1.3

Conclusions:

1. A primary finding of the pilot study is that real-time feedback of energy consumption is effective in promoting conservation. The results are statistically significant and support the hypothesis that real-time monitors encourage conservation.

- This is based on a very comprehensive study conducted over a long time period.

In comparison to previous pilots and demonstration projects regarding direct feedback, the sample size for this pilot study is very large comprising 5015 billing observations that were used in the analysis. Pilot participants and control customers were followed over a 2.5 year period.

- The experimental design consisted of a stratified random sample, spread across a wide geography, diversity of weather regions, a wide variation in the heating, cooling, water heating and appliance configurations, and a large variety of household income and demographic characteristics.

2. Overall, the average reduction in energy consumption across the whole sample was 6.5%.

- Within this sample, non-electric heating households are showing a significant conservation impact or reduction in energy consumption of 8.2%. Within the non-electric heating group, the range in reduction is from 5.05% (for a non-electric water heating house) to 16.74% (for an electric water heating house).

- We also observed that electric heating households are not responding in a significant way to real-time feedback. Separating out the feedback from the

electric heating load and the rest of the load would be required to encourage conservation in this sector.

3. The results indicate a persistent response over the study time period and this finding is important for larger deployment of such a device. No reduction in conservation response was detected through the duration of the pilot. Furthermore, the qualitative feedback from participants was positive: they were generally very pleased with the performance and usefulness of the real-time monitor in helping them reduce energy consumption and manage their costs.

4. An overall average reduction of between 7% and 10% is feasible if the real time monitor is used in conjunction with other conservation and/or price measures.

- The overall reduction of 6.5% observed in the study corresponds only to the impacts of real-time feedback. In this pilot no other price and/or conservation incentives accompanied the real-time monitor. Thus, these results are interpreted as the bare minimum impacts.

- If the real-time monitoring is used in conjunction with other price and/or conservation measures, the conservation impact will be larger.

References

Beach, Charles M. and James G. MacKinnon (1978) "A Maximum Likelihood Procedure for Regression with Autocorrelated Errors," **Econometrica**, 46, 51-58.

Becker, Lawrence J. (1978) "Joint Effects of Feedback and Goal Setting on Performance: A Field Study of Residential Energy Conservation," **Journal of Applied Psychology**, 63 (4), 428-433.

Brandon, Gwendolyn and Alan Lewis (1999) "Reducing Household Energy Consumption: A Qualitative and Quantitative Field Study," **Journal of Environmental Psychology**, 19, 75-85.

Darby, Sarah (2001) "Making it Obvious: Designing Feedback into Energy Consumption," in **Energy Efficiency in Household Appliances and Lighting**, edited by Bertoldi et al, Springer.

Dobson, John K. and J.D. Anthony Griffin (1992) "Conservation Effect of Immediate Electricity Cost Feedback on Residential Consumption Behavior" **Proceedings, American Council for an Energy-Efficient Economy**, 10.33 – 10.35.

Ester, Peter (1985) **Consumer Behavior and Energy Conservation**, Dordrecht, the Netherlands: Reidel.

Ham, John C., Dean C. Mountain and M.W. Luke Chan (1997) "Time-of-Use Prices and Electricity Demand: Allowing for Selection Bias in Experimental Data," **The Rand Journal of Economics**, Vol. 28, S113-S141.

King, Chris and Dan Delurey (2005) "Efficiency and Demand Response: Twins, Siblings or Cousins?", **Public Utilities Fortnightly**, 54-61.

McClelland, Lou and Stuart W. Cook (1979) "Energy Conservation Effects of Continuous In-Home Feedback in All-Electric Homes," **Journal of Environmental Systems**, 9(2), 169-173.

Seligman, Clive and John M. Darley (1977) "Feedback as Means of Decreasing Residential Energy Consumption," **Journal of Applied Psychology**, 62(4), 363-368.

Van Houwelingen, Jeannet H. and W. Fred Van Raaij (1989) "The Effect of Goal-Setting and Daily Electronic Feedback on In-Home Energy Use," **Journal of Consumer Research**, 16, 98 – 105.

Winett, Richard A. and John H. Kagel (1984) “Effects of Information Presentation Format in Resource use in Field Studies”, **Journal of Consumer Research**, 11 (September), 655 – 667.

Winett, Richard A., John H. Kagel, Raymond C. Battalio and Robin C. Winkler (1978) “Effects of Monetary Rebates, Feedback, and Information on Residential Electricity Conservation”, **Journal of Applied Psychology**, 63(1), 73-80.

Winett, Richard A., Michael S. Neale and H. Cannon Grier (1979) “Effects of Self-Monitoring and Feedback on Residential Electricity Consumption”, **Journal of Applied Behavior Analysis**, 12 (Summer), 173-184.

Green Energy Coalition (GEC) INTERROGATORY #2 List 1

Interrogatory

Issues 1.2, 3.11, 4.9 (Line Losses & OEB Directives) Ex. A-17-1, page 3

The Board at para. 4.3.10 of its 2006 Rates Decision directed that HONI file a work plan for implementing the Kinectrics proposals that were not undertaken in 2006 or justify otherwise. In Exhibit A-15-3 attachment A, pages 28-29 Kinectrics updates their recommendations and proposes spending and further studies. At A-15-3, page 12 HONI indicates that no additional line loss reduction efforts are currently planned beyond those routinely pursued and at D1-3-5, page 37, table 10 no amounts appear for CDM capital spending in 2008. Please clarify which Kinectrics recommended initiatives (including work programs and studies) HONI is undertaking in 2008 and to what extent (or has completed in prior years) and which it is deferring or not pursuing in whole or part, if any.

Response

Please see the response provided in Exhibit H, Tab 1, Schedule 97.

Hydro One has addressed all cost-effective line-loss reduction suggestions recommended by the Kinectrics' update study report.

1 **Green Energy Coalition (GEC) INTERROGATORY #4 List 1**

2
3 **Interrogatory**

4
5 Issue 5.3 (accounting treatment of revenue and expenses for OPA funded CDM)

6
7 Please provide a summary of spending and revenue by program for all OPA funded,
8 HONI delivered, CDM programs in 2006, 2007 and expected for 2008 and indicate if
9 these amounts have been eliminated from utility revenues and expenses or how they are
10 being accounted for.

11
12
13 **Response**

14
15 There were no OPA funded, HONI delivered CDM programs in 2006. In 2007, HONI
16 delivered four OPA programs as detailed in the interrogatory response at Exhibit H, Tab
17 2, Schedule 7. The 2007 OPA programs had \$7.6 million in expenditures with matching
18 revenues. The 2007 OPA program schedules have been extended into 2008 and a further
19 \$2.1 million of expenditures is anticipated under these schedules in 2008.

20
21 HONI's anticipated funding for the 2008 OPA Core Program Schedules for which
22 information is available is approximately \$11.3M, as shown in the interrogatory response
23 at Exhibit H, Tab 2, Schedule 8.

24
25 As per the Ontario Energy Board's "Guidelines for Electricity Distributor Conservation
26 and Demand Management" issued March 28, 2008, the costs and revenues of OPA-
27 funded programs are not part of the regulated Distribution Business and are to be kept
28 separate from the distributor's revenue requirement.

29