Using In-Home Energy-Use Displays to Promote Conservation and Demand Management

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Pilot Objectives

- Establish the efficacy of direct feedback monitors in helping consumers reduce their electricity consumption
  - Behavioural changes
  - kWh savings

- Establish whether customers are willing to use such a monitoring device
  - Technical feasibility
  - Merits of available devices and approaches for energy conservation

- PowerCost Meter includes a display unit that can be placed anywhere in the home

- Shows exactly how much power is being used and what it costs
  - $/hr
  - Total $
  - Predicted $
  - Temperature
  - Current kW
  - Total kW
  - Predicted kW

- Shows users the immediate effects of conserving

hydro one

Value of Instantaneous Feedback

- Does real-time feedback empower residential customer with information needed to reduce their electricity consumption?
- To date, pilots have only tested value of immediate information feedback (no price or conservation incentives)

Instantaneous Feedback Pilots

- 4 pilots to date

Hydro One (2004-2005): over 400 pilot participants

- Barrie
- Brampton
- Lincoln
- Peterborough
- Timmins

Newfoundland & Labrador (2005-2006): 100 pilot participants

- Central
- East
- West

Pilots (continued):

British Columbia (2005-2006): 100 pilot participants

- Lower Mainland
- Vancouver Island

London Hydro (2005-2006): 70 pilot participants

- London

Statistical Measurement of Instantaneous Feedback

- Using billing records, must separate out conservation effect due to instantaneous feedback from other effects such as weather, demographics and dwelling characteristics
- Have both pre real time monitor data (around 2.5 years) and kWh data after usage of real time monitor

Model Specification

- $\ln y_{it}$: the logarithm of daily kWh

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

- Where

$f^1(\underset{\sim}{x}^1{}_{it}, \underset{\sim}{\alpha}) = \underset{\sim}{x}^1{}_{it}{}' \underset{\sim}{\alpha}$: electric heating in absence of real time monitor

$f^2(\underset{\sim}{x}^2{}_{it}, \underset{\sim}{\beta}) = \underset{\sim}{x}^2{}_{it}{}' \underset{\sim}{\beta}$: electric water heating in absence of real time monitor

Model Specification (cont'd)

- Where

$f^3(\underset{\sim}{x}^3_{it}, \underset{\sim}{\gamma}) = \underset{\sim}{x}^{3\,\prime}_{it} \underset{\sim}{\gamma}$: air conditioning in absence of real time monitor

$f^4(\underset{\sim}{x}^4_{it}, \underset{\sim}{\delta}) = \underset{\sim}{x}^{4\,\prime}_{it} \underset{\sim}{\delta}$: other electricity loads in absence of real time monitor

$f^5(\underset{\sim}{x}^5_{it}, \underset{\sim}{\lambda}) = \underset{\sim}{x}^{5\,\prime}_{it} \underset{\sim}{\lambda}$: trend related variables

$g(\underset{\sim}{z}_{it}, \underset{\sim}{\theta}) = \underset{\sim}{z}^{\prime}_{it} \underset{\sim}{\theta}$: real time monitor effect

μ_{it} : stochastic error

Explanatory variables for electric heating, electric water heating, air conditioning and other electricity load include:

- normalized heating degree days
- normalized cooling degree days
- square footage
- proportion of dwelling cooled
- dwelling age
- number of residents
- age distribution of residents
- household income
- seasonal indicator variables

Explanatory variables (continued):

- wattage of dishwashers
- wattage of clothes washing machines
- wattage of other appliances
- number of saunas, hot tubs & whirlpools

Explanatory variables for trend component include:

- real price of electricity
- seasonal indicator variables
- time index

Explanatory variables for real time monitor effect:

- normalized heating degree days
- normalized cooling degree days
- proportion of dwelling heated
- proportion of dwelling cooled
- seasonal indicator variables
- water heating ownership

Real Time Monitor Explanatory Variables (Continued):

- household income
- number of residents over age of 65
- education levels of household members
- time since real time monitor installed

Hydro One:

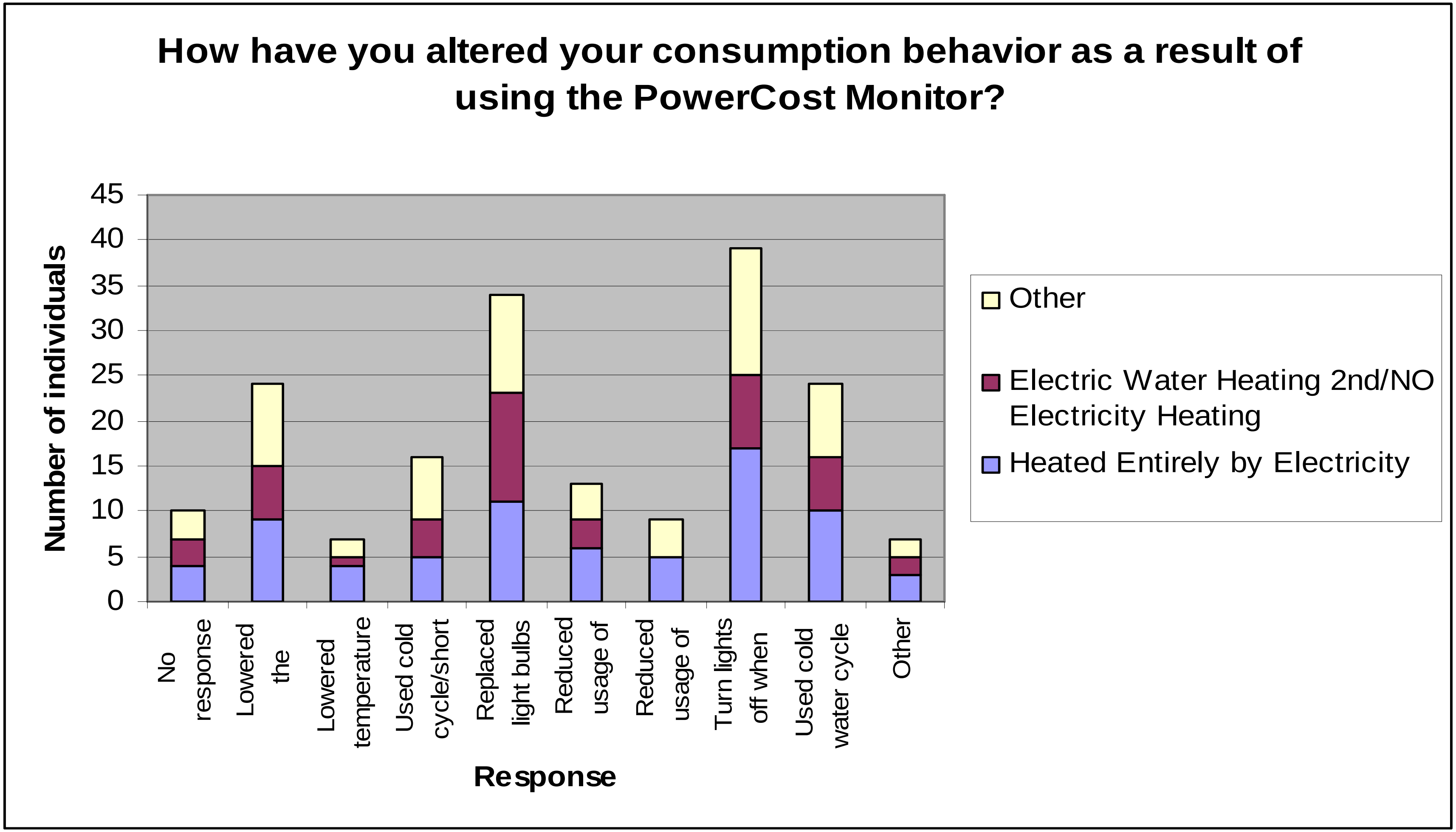
- Average reduction of 6.5%
- Response was persistent and did not decrease over time
- Non-electric heating and non-air conditioning households showed savings of 8.2% with a range of 5.1% (for non-electric water heating household) to 16.7% (for an electric water heating household)

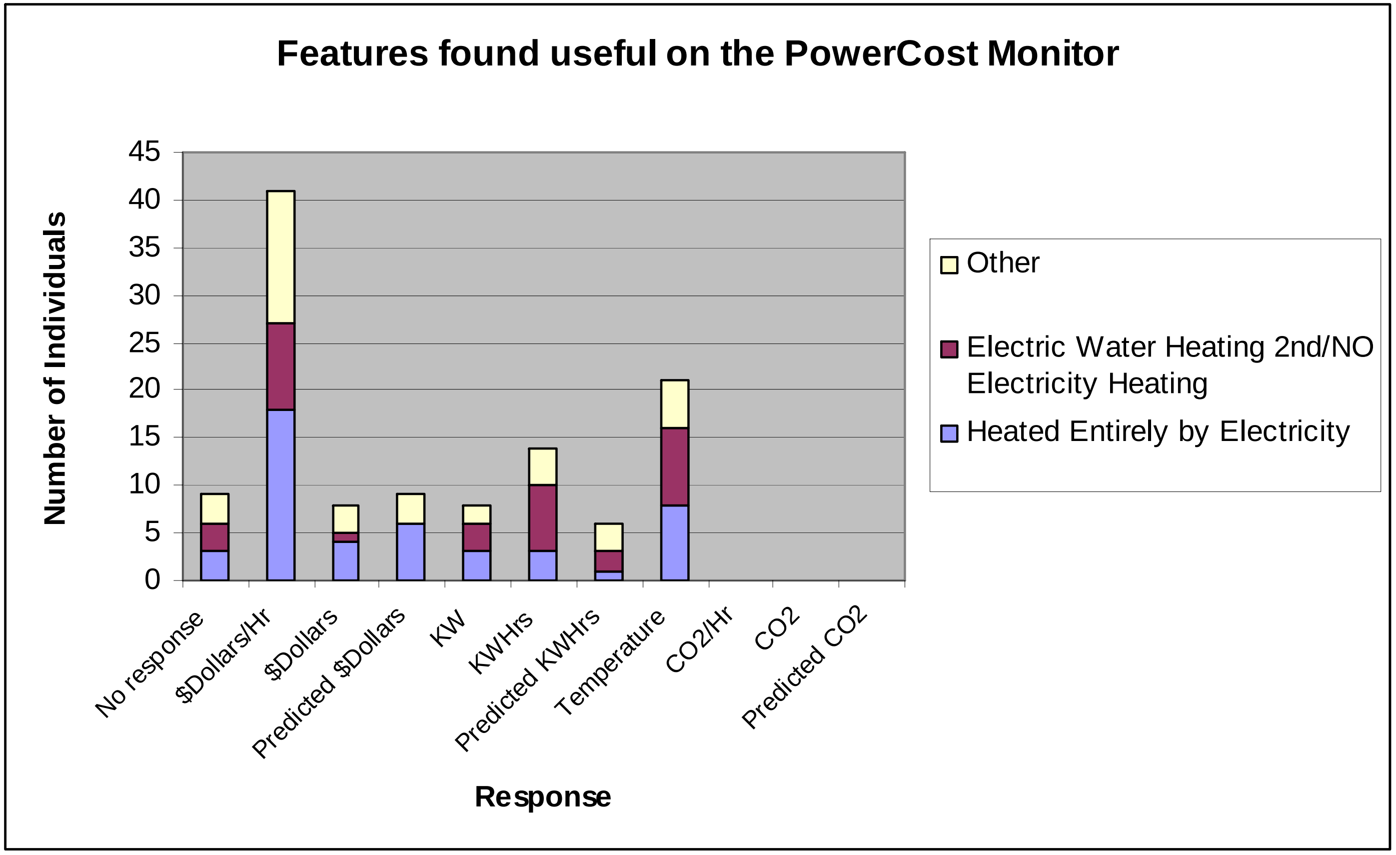
Hydro One (continued)

- Electric heating household not responsive in a significant way to real time feedback
- 38.9% of participants consulted monitor daily or multiple times per day

British Columbia

- Average reduction of 2.7%
- Response persistent and does not decrease over time
- Education played a significant roll in affecting responsiveness
- Reduction in winter as high as 9.3%
- 38.6% of participants consulted monitor daily or multiple times per day


How have you altered your consumption behavior as a result of using the PowerCost Monitor?
Number of individuals
45
40
35
30
25
20
15
10
5
0
No response
Lowered the
Lowered temperature
Used cold cycle/short
Replaced light bulbs
Reduced usage of
Reduced usage of
Turn lights off when
Used cold water cycle
Other
Response
Other
Electric Water Heating 2nd/NO Electricity Heating
Heated Entirely by Electricity



Features found useful on the PowerCost Monitor
Number of Individuals
45
40
35
30
25
20
15
10
5
0
No response
$Dollars/Hr
$Dollars
Predicted $Dollars
KW
KWHrs
Predicted KWHrs
Temperature
CO2/Hr
CO2
Predicted CO2
Response
Other
Electric Water Heating 2nd/NO Electricity Heating
Heated Entirely by Electricity

Newfoundland and Labrador

- Average reduction 18.1%
- Response is persistent and does not decrease over time
- Electric water heating households showed significantly larger percentage reductions than non-electric water heating households

Newfoundland and Labrador (continued)

- Senior citizens showed less responsiveness
- Predisposition to conservation increased responsiveness
- 54.1% of participants consulted monitor daily or multiple times per day

London Hydro

- Analysis is underway

Hydro One 2004 – 2005 Over 400 pilot participants No price or conservation financial incentives	Controlled for demographics, weather, dwelling characteristics	6.5% avg reduction 5.1% savings for non-electric HWT 16.7% savings for electric HWT Electric heating household not responsive Response persistent 38.9% read monitor 1+ times/day
British Columbia 2005-2006 100 pilot participants No price or conservation financial incentives	Controlled for demographics, weather, dwelling characteristics	2.7% avg reduction 9.3% winter reduction Education and seasonality played significant role Response persistent 38.6% read monitor 1+ times/day
Newfoundland and Labrador 2005-2006 100 pilot participants No price or conservation financial incentives	Controlled for demographics, weather, dwelling characteristics	18.1% avg reduction EH showed 19.8% reduction HWT showed 22.5% reduction Senior citizens showed less responsiveness Predisposition to conservation increased responsiveness Response persistent 54.1% read monitor 1+ times/day
London Hydro 2005-2006 70 pilot participants No price or conservation financial incentives		Analysis underway

Next Steps:

- Program Implementation is already underway
- Provide feedback on load components (e.g., electric heating)
- Combine Instantaneous feedback with

  - load control

  - time-of-use rates

  - more innovative rates (e.g., day ahead notice, critical peak pricing, etc.)

  - conservation incentives