BC hydro
FOR GENERATIONS

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January 14, 2015

Ms. Erica Hamilton
Commission Secretary
British Columbia Utilities Commission
Sixth Floor – 900 Howe Street
Vancouver, BC V6Z 2N3

Dear Ms. Hamilton:

RE: British Columbia Utilities Commission (BCUC or Commission)
British Columbia Hydro and Power Authority (BC Hydro)
2004/05 and 2005/06 Revenue Requirements Application
BCUC Decision: Order No. G-96-04, October 29, 2004, Directive 66 (page 197)

BC Hydro writes to submit its F2014 Demand Side Management Milestone Evaluation Summary Report (**the Report**), dated January 15, 2015 in compliance with Directive 66 (page 197) of the Commission Decision dated October 29, 2004. Directive 66 directs BC Hydro to file the executive summaries of its milestone evaluation reports and full final evaluation reports for all its Power Smart programs. The Report summarizes the impact evaluations completed during F2014 for the following:

1. Residential Inclining Block (**RIB**) Conservation Rate: F2009 - F2012
2. Large General Service (**LGS**) and Medium General Service (**MGS**) Conservation: Calendar Years 2011 – 2012
3. Product Incentive Program (**PIP**): F2011 – F2013
4. Workplace Conservation Awareness (**WCA**) Initiative: F2011 - F2012

BC Hydro notes that the Report has been prepared for the purpose of this compliance filing.

For further information, please contact Geoff Higgins at 604-623-4121 or by email at bchydroregulatorygroup@bchydro.com.

Yours sincerely,

Original signed by Fred James

(for) Janet Fraser
Chief Regulatory Officer

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Demand Side Management Milestone Evaluation

Summary Report F2014

January 2015

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1.0 Introduction

This report summarizes the milestone evaluations of demand-side management (**DSM**) initiatives completed by BC Hydro in fiscal year 2014 (F2014). It is filed in compliance with Directive 66 of the British Columbia Utilities Commission (**BCUC**) decision on BC Hydro's F05/F06 Revenue Requirements Application (dated October 29, 2004), which "*directs BC Hydro to file the executive summaries of its milestone evaluation reports and full final evaluation reports of all its Power Smart programs*" (page 197).

BC Hydro evaluates its DSM initiatives to improve its estimates of realized DSM electricity savings and to improve their effectiveness and efficiency.

DSM evaluation activities are guided by the following six principles:

- Objectivity and Neutrality: Evaluations are to be objective and neutral.
- Professional Standards: Evaluation work is guided by industry standards and protocols.
- Qualified Practitioners: BC Hydro employs qualified staff and consultants to conduct evaluations.
- Appropriate Coverage: BC Hydro strives to achieve defined coverage levels for its evaluation of DSM initiatives.
- Business Integration: The evaluation function is integrated into BC Hydro's DSM business process of planning, implementation, reporting and evaluation.
- Coordination: BC Hydro evaluation work is coordinated with FortisBC and other DSM partners where feasible.

BC Hydro DSM evaluations are subject to an independent oversight process to ensure that they are neutral and unbiased, of sufficient quality for their intended purposes, and consistent with industry standards and protocols.

1.1 Completed Evaluations

Impact evaluations summarized in this report include the following:

- Residential Inclining Block (**RIB**) Conservation Rate: F2009 - F2012
- Large General Service (**LGS**) and Medium General Service (**MGS**) Conservation: Calendar Years 2011 – 2012
- Product Incentive Program (**PIP**): F2011 – F2013
- Workplace Conservation Awareness (**WCA**) Initiative: F2011 - F2012

2.0 Conservation Rates

2.1 RIB Rate:[1] F2009 - F2012

2.1.1 Introduction

The RIB rate is a two-step rate structure, where BC Hydro's residential customers pay a lower per-unit rate for electricity consumption below a 1350 kWh bi-monthly threshold, and a higher per-unit rate for electricity consumption above the kWh threshold.

In August 2008 the BCUC determined that it was in the public interest for BC Hydro to implement the new RIB rate and required the new RIB rate structure go into effect October 1, 2008. The Step 1 to Step 2 threshold was set at 1,350 kWh per billing period, which was approximately 90 per cent of the median consumption of BC Hydro's residential customers. The Step 2 rate was established at BC Hydro's estimate of the cost of new energy supply, grossed up for losses and the Step 1 rate was calculated to achieve revenue neutrality for the residential class.

This study is an evaluation of the impacts and customer response to the RIB rate, net of Power Smart and natural conservation over the first four years. The evaluation period covers F2009 through F2012.

2.1.2 Approach

The overall objective of this study is to evaluate the customer response to the RIB rate and to estimate energy and associated peak demand savings resulting from the rate. The table below summarizes BC Hydro's evaluation objectives and research questions to be addressed.

[1] This summary differs from the report included as Appendix C to the 2013 RIB Rate Re-pricing Application (Exhibit B-1; copy available at http://www.bcuc.com/ApplicationView.aspx?ApplicationId=419). It has been updated to reflect the information presented in the BC Hydro responses to Information Requests (IRs) in that proceeding (refer to the response to BCU IRs 1.21.1 and 1.21.2 and BCPSO IR 1.26.1) and for consistency in presentation with the other summaries in this report.

Table 2.1.1 Evaluation Objectives and Research Questions

Evaluation Objective	Research Questions
1. Estimate price elasticity.	What is the price elasticity of Step 1 and Step 2 consumption? What is the price elasticity of the class average in response to general rate increases?
2. Estimate the conservation impacts of the RIB.	What were the energy savings due to BC Hydro's RIB rate from F2009 to F2012? What were the associated peak demand savings due to BC Hydro's RIB rate from F2009 to F2012?
3. Analyze differences in price elasticity by customer characteristics.	Are there differences in price elasticity by region? Are there differences in price elasticity by dwelling type? Are there differences in price elasticity by space heating type? Are there differences in price elasticity by consumption level?
4. Evaluate the customer response and understanding of the RIB Rate.	Are there differences in the characteristics or demographics of customers who are never billed in Step 2 compared to those who are sometimes or always billed in Step 2? What is the level of customer awareness and understanding of the RIB rate? To what degree do electricity prices provide an incentive to manage electricity consumption? To what extent does the total electricity bill amount provide an incentive to manage electricity consumption? What is customers' understanding of their prevailing electricity price under the RIB rate? To what extent does the RIB rate provide an incentive to manage electricity consumption? Did the RIB rate encourage customers to modify their energy-use behaviours? Did the RIB rate encourage customers to make investments in energy efficient equipment? Did the RIB rate encourage customers to increase participation in Power Smart programs?

The individual evaluation objectives and a summary of the methodology for each are listed below.

Objective 1: Estimate Price Elasticity.

Price elasticity was estimated with econometric models that explain how electricity consumption per account might have changed in response to the RIB rate, after controlling for the effects of factors such as weather, region, electric heating, and income. These models were based on linear regression specifications commonly used in the residential electricity demand literature.

Objective 2: Estimate the Conservation Impacts of the RIB Rate.

Energy and associated peak demand savings due to the RIB rate were estimated using the following steps:

1. Estimate total conservation, measured by the change in total Step 1 and Step 2 consumption using estimates of the RIB price elasticity, the change in Step 1 and Step 2 prices and the previous year's Step 1 and Step 2 consumption levels.
2. Estimate natural conservation (the baseline scenario) using a class average price elasticity for general rate increases, the change in the equivalent flat rate price (Rate Schedule 1151), and the total consumption for the entire RIB rate class.
3. Estimate structural conservation of the RIB rate as the difference between total and natural conservation.
4. Multiply total energy savings by a load shape factor to estimate associated peak demand savings.

Objective 3: Analyze Differences in Price Elasticity by Customer Characteristics.

The data used to estimate Step 1 and Step 2 elasticity was partitioned by region, space heating type and dwelling type to enable estimates of the price elasticity of the different groups. To analyze elasticity by consumption level, customers were divided into five size categories based on their average bi-monthly consumption levels. Consumption level elasticity estimates were then found by estimating a separate per-account consumption regression for each size category.

Objective 4: Evaluate the Customer Response and Understanding of the RIB Rate.

Examination of the customer response and understanding of the RIB relied on the customer survey data and billing data. Customer surveys were used to collect information on customer awareness, understanding and decision making related to the RIB rate, opinions on electricity pricing, and behaviours around energy use, along with additional demographic and housing parameters to inform the evaluation.

The table below summarizes the data sources and methods employed in this study for each evaluation objective.

Table 2.1.2 Summary of Evaluation Objectives, Data Sources and Methodology

Evaluation Objective	Main Data Sources	Methods
1. Estimate price elasticity	Aggregate BC Hydro bi-monthly billing data from April 2004 to March 2012, including consumption, heating type, region and dwelling type by account BC Hydro Residential Rate Tariffs (historical prices) BC Hydro records of expenditures on DSM from April 2004 to March 2012 Statistics Canada Consumer Price Index data from April 2004 to March 2012 BC Stats records of personal real disposable income from April 2004 to March 2012 BC Hydro records of heating and cooling degree days by region from April 2004 to March 2012	Econometric models - linear regression using Ordinary Least Squares.
2. Estimate the conservation impacts of the RIB Rate	Data and results from Objective 1 BC Hydro rate class load shape	Arithmetic
3. Analyze differences in price elasticity by customer characteristics	Same as Objective 1	Same as Objective 1
4. Evaluate the customer response and understanding of the RIB Rate	Customer Surveys (n = 2,831) BC Hydro monthly billing data from April 2011 to March 2012	Cross Tabulations of Survey Responses Linking of survey responses to respondent billing history Difference of Means Tests using Analysis of Variance

2.1.3 Results

Objective 1: Price Elasticity

An estimate of Step 1 elasticity could not be precisely estimated due to the limited variation in the flat rate price prior to the RIB rate implementation and the Step 1 price after the RIB rate was introduced after adjusting for inflation over the time period analyzed.

Three different econometric models, all plausible and selected based on theoretical and statistical merit, estimated a range of Step 2 price elasticity between -0.08 to -0.13. Step 2 price elasticity estimates were very sensitive to the inclusion of weather and economic variable specifications; hence it was prudent that the evaluation adopted a range estimate of price elasticity rather than a single definitive value.

Absent conclusive results to reject the original assumption of -0.05 for class average price elasticity, the evaluation used the same assumption for estimating the baseline rate impacts (natural conservation) in the scenario of general price increases under a flat rate.

Objective 2: Conservation Impacts

Since the modeling to estimate Step 2 price elasticity resulted in a range of plausible elasticities, the RIB rate structure impacts derived from them are also presented as a range estimate. The following table compares reported and evaluated incremental annual savings from the RIB rate structure. The low estimate and high estimates assume a Step 2 elasticity of -0.08 and -0.13 respectively.

Table 2.1.3 Reported versus Evaluated Incremental Annual Electricity Savings Impacts

Fiscal Year	Energy Savings (GWh)			Associated Peak Demand Savings (MW)		
	Reported	Evaluated Low	Evaluated High	Reported	Evaluated Low	Evaluated High
F09	92	57	94	20	12	20
F10	230	94	202	49	20	43
F11	26	11	41	6	2	9
F12	101	33	86	22	7	18

The evaluated incremental annual conservation impacts as a result of the RIB rate ranged from a low of 11 GWh in F2011 to a high of 202 GWh in F2010. The average total impacts per BC Hydro customer account ranged between 7 kWh and 124 kWh for the four year period. The range of the RIB rate's structural conservation impacts represent approximately 0.1 per cent - 1.2 per cent of the total annual residential class consumption during the time period evaluated.

The annual associated peak demand savings were estimated at between 2 MW and 43 MW assuming an average residential sector peak-to-energy ratio (capacity factor) of 0.214 MW/GWh across the four years based on the residential rate class load shape.

Objective 3: Price Elasticity by Customer Characteristics.

Based on the results from the three different models, the low and high estimates for Step 2 price elasticity associated with different types of customer segments are summarized in the following table. While these estimates show that Step 2 price elasticity varies by region, dwelling type, space heating type and total consumption, the estimated ranges suggest that customer Step 2 price responsiveness is reasonably close to the initial assumption of an average Step 2 price elasticity of -0.10, except for customers on Vancouver Island and the North, those living in row/townhouses or apartments, or those with consumption above 2400 kWh.

Table 2.1.4 Step 2 Price Elasticity by Customer Characteristics

Customer Segment	Step 2 Elasticity – Low Estimate	Step 2 Elasticity – High Estimate
Region		
Lower Mainland	-0.11	-0.13
North	-0.12	-0.15
Southern Interior	-0.08	-0.12
Vancouver Island	-0.15	-0.15
Dwelling Type		
Single Family Dwelling	-0.08	-0.14
Row/Townhouse	- 0.06	-0.07
Apartment	-0.03	-0.04
Mobile Home	-0.10	-0.10
Other	-0.05	0.09
Space Heating		
Electric	-0.10	-0.14
Non-Electric	-0.08	-0.09
Consumption		
1350 kWh –2400 kWh	-0.13	-0.13
2400 kWh and above	-0.16	-0.18

Objective 4: Customer Understanding and Response

In total, 35 per cent of all customer households in the survey sample ‘never’ (0 months) incurred Step 2 consumption in F2012, 40 per cent ‘sometimes’ (1-11 months) incurred Step 2 consumption, and 25 per cent ‘always’ (12 months) incurred Step 2 consumption. This distribution – based on actual consumption – very closely reflected the actual distribution of all RIB qualified accounts in the billing system.

Regionally, households on Vancouver Island were the most likely to have incurred Step 2 consumption in F2012. Considering space heating, the incidence of any Step 2 consumption measured 72 per cent among households with electric space heating and compared to 61 per cent among those with non-electric heat. Considering water heating, the incidence of any Step 2 consumption measured 85 per cent among households with electric hot water heaters, 66 per cent among those with non-electric hot water heaters, and just 28 per cent among those who rely on hot water from a central system.

The total amount of their bills emerged to be assessed by customers as being a greater incentive to manage electricity than electricity prices. Over nine in ten customers reported that the total dollar amount of their electricity bills serves as either a ‘major incentive’ (48 per cent) or a ‘minor incentive’ (42 per cent) to manage their household’s consumption rather than ‘no incentive at all’. This compares to just over eight in ten customers who indicated that they believe BC Hydro’s electricity prices serve as either a ‘major incentive’ (41 per cent) or a ‘minor incentive’ (43 per cent). Customer households that 'always' or 'sometimes' incurred Step 2 consumption in F2012 were more likely than those that 'never' did so to view both price and the total bill amount as having a 'major incentive' on their management of electricity.

A total of 50 per cent of customers demonstrated that they were previously aware they were charged for electricity on an inclining block rate. A total of 31 per cent of customers believed their household's use of electricity was charged on a flat rate (as it was for many years prior to October 2008) while 2 per cent of customers believed that their consumption was charged on a declining block rate (a rate structure not used since the early 1990s). A total of 17 per cent reported not knowing how they were charged for their consumption of electricity. Statistical analysis showed that awareness of the inclining block rate does not directly lead households to having lower consumption as strictly compared to households unaware of the rate.

For customers who identified that their household's consumption of electricity was charged on an inclining block rate, when asked what they perceive to be their price of electricity under the RIB rate, 43 per cent considered each of the Step 1 and Step 2 prices as being their household's price of electricity, depending on the point in time in the billing period and/or their consumption in the billing period.

Customers who correctly identified that their household's consumption of electricity was charged on an inclining block rate were no more likely to have participated in BC Hydro's Power Smart programs, and were less likely to have purchased and installed energy-efficient lamps – such as CFLs and LEDs. Customers previously aware of the inclining block rate did outperform all other customers on energy conservation behaviours related to space heating, laundry, dishwashing, lighting and other plug-load behaviours.

2.1.4 Findings and Recommendations

Findings

Objective 1: Estimate Price Elasticity

1. The estimated range of Step 2 price elasticity (-0.08 to -0.13) encompasses the Step 2 elasticity assumption for in the BC Hydro 2008 RIB application of -0.10 for forecasting the RIB impacts.

2. Price elasticity for BC Hydro's small residential customers with only Step 1 consumption was not able to be measured due to the limited variation in real prices over time.

3. The class average elasticity due to general price increases under a flat rate was not able to be estimated using empirical data. The evaluation used the assumption of -0.05 as the class average price elasticity to determine the natural conservation baseline.

4. Price elasticity is very sensitive to various factors affecting electricity consumption that were included in the econometric models, including weather, disposable income, dwelling type, space heating fuel and total account consumption.

Evaluation Objective 2: Estimate Conservation of the RIB

1. The evaluated incremental annual energy savings of the RIB rate from F2009 to F2012 ranged between 11 GWh and 202 GWh during the four years evaluated.

2. The evaluated incremental annual associated peak demand savings ranged between 2 MW and 43 MW during the four years evaluated.

Evaluation Objective 3: Differences in Price Elasticity by Customer Characteristics

1. Price elasticity was generally higher for customer segments with higher consumption.

    - Price elasticity was higher on Vancouver Island and the Northern region than the overall average.

    - Price elasticity was higher for single family dwellings compared to other dwelling types.

    - Price elasticity was higher for households with electric heat versus non-electric heat.

2. Large residential users consuming more than 2,400 kWh bi-monthly show a substantially higher than average response to higher prices.

Evaluation Objective 4: Customer Response, Awareness, and Understanding

1. The approximate proportions of residential customers that 'never', 'sometimes' or 'always' saw the Step 2 price in F2012 were 35 per cent, 40 per cent and 25 per cent, respectively.

2. A total of 50 per cent of residential customers appear to be aware of the RIB rate as of February 2012.

3. The total amount of the household electricity bill serves as the greatest incentive to manage electricity consumption among residential customers, followed by electricity prices.

4. A total of 79 per cent of residential customers aware of the RIB rate believed it serves as an incentive to manage electricity consumption.

5. There are small but statistically significant differences in the prevalence of energy conservation behaviors among customers who are aware of the RIB rate compared to those who are not.

6. Awareness of the RIB rate does not appear to have significant influence on customer investments in energy-efficient equipment or participation in Power Smart programs.

7. Higher consumption is correlated with both higher awareness of the RIB rate and higher price elasticity, however no firm conclusions can be drawn about how RIB rate awareness is related to the customer price response.

Recommendations

1. **Continue to attempt to estimate Step 1 and the class average price elasticity.** Future evaluations will likely be improved by accumulation of empirical data and price variation over time and the exploration of alternative methods to estimate the class average elasticity.

2. **Future RIB rate evaluation may benefit from the complementary econometric analysis of a select sample of customers.** This would require additional data collection on changes (stock

turnover) in major household energy end-uses (e.g., appliance replacements, heating system upgrades), changes in economic and demographic circumstances (e.g., occupancy) and participation in other DSM programs to attempt to further isolate the effects of electricity prices on consumption.

3. **Consider ways to increase awareness of the RIB rate, particularly targeted at customer segments that have shown the largest response to price.** The evaluation results indicate there are correlations between RIB rate awareness and energy conservation behaviours. While causation is unclear, this could mean that increasing RIB rate awareness will lead to increases in energy conservation behaviours and corresponding energy savings.

2.1.5 Conclusions

The RIB rate appears to be achieving its overall objective of encouraging conservation through the customer response to higher marginal prices – particularly amongst the customer with the highest consumption.

2.2 LGS and MGS Conservation Rates:[2] Calendar Years 2011 - 2012

2.2.1 Introduction

The purpose of this study is to provide a comprehensive evaluation of the impacts and customer response to BC Hydro's LGS and MGS conservation rate structures for the period January 1, 2011 through December 31, 2012. The scope of this study includes electric energy conservation effects as well as customer understanding and experience with the LGS and MGS rates.

BC Hydro's LGS and MGS rate classes are made up of all BC Hydro accounts that purchase electricity at distribution voltage and have a monthly peak demand above 35 kW. MGS refers to general service accounts with a monthly peak demand that is equal to or greater than 35 kW but less than 150 kW, or whose energy consumption in any 12 consecutive periods is less than or equal to 550,000 kWh. LGS refers to general service accounts with a monthly peak demand equal to or greater than 150 kW, or whose energy consumption in any 12 month-period is greater than 550,000 kWh.

This diverse group of customers includes a wide range of facility types, such as hospitals, manufacturing facilities, office buildings, retail, and the common areas of multi-unit residential buildings. The total electricity purchases of these rates classes was approximately 13,000 GWh in calendar year 2010, covering approximately 23,000 accounts.

Prior to the implementation of the conservation rate structures, LGS and MGS customers were all served under a declining block energy charge. Starting in January 2011, conservation rate structures were introduced that were designed to encourage customers to conserve electricity. Under the LGS and MGS conservation rate structure, this encouragement is provided through a bill credit when consumption is lower than historical average consumption, and an additional charge when consumption is higher.

To support the implementation of the LGS and MGS rates, BC Hydro undertook consultations with relevant customers and conducted a variety of information and advertising activities. These activities included the development of a dedicated website, letters to customers, bill inserts, and online tools.

[2] This summary differs from the report included as Appendix A to the January 1, 2014 LGS and MGS Three-Year Report (Compliance with BCUC Order No. G-110-10 Directive 3). It has been updated for formatting consistency in presentation with the other summaries in this report.

To evaluate the impact of the conservation rates, and with the approval of the BCUC, BC Hydro assigned 400 accounts to control groups before the implementation of the conservation rate structures. Two hundred accounts were drawn from the MGS population, and 200 from the LGS population. The control group accounts were maintained on the pre-existing rates but increased each year by general rate increases. The remaining population of accounts (called the treatment groups in this report) started transition to the conservation rate structures on January 1, 2011.

LGS customers transitioned as one group to the conservation rate structure on January 1, 2011. MGS customers were divided into three groups for the purpose of transitioning to the conservation rate structure. The MGS1 treatment group started on an interim rate shaping stage on January 1, 2011 and transitioned to the conservation rate structure April 1, 2012. The MGS2 and MGS3 treatment groups started on an interim rate shaping stage in January 1, 2011, and transitioned to the conservation rate structure April 1, 2013.

2.2.2 Approach

Table 2.2.1 summarizes the evaluation objectives and research questions for this study.

Table 2.2.1 Evaluation Objectives and Research Questions

Evaluation Objective	Research Questions
1. Assess the effectiveness of the LGS and MGS control groups for the evaluation of energy savings.	Were the treatment and control groups equivalent in the year prior to the introduction of the conservation rate structures (calendar year 2010)? Are the control groups representative of the treatment groups? What is the relative precision of the control groups?
2. Estimate the energy and associated peak demand savings attributable to the LGS and MGS conservation rate structures.	What are the energy and associated peak demand savings due to the LGS conservation rate in 2011 and 2012? What are the energy and associated peak demand savings due to the MGS rate shaping in 2011 and 2012? What are the energy and associated peak demand savings due to the MGS conservation rate structure in 2012?
3. Assess customer awareness, understanding and acceptance of the LGS and MGS rate structures.	What is unaided awareness of the energy and demand charges? Has there been a change in unaided awareness? What is aided awareness of the energy and demand charges? How easy or difficult is it to understand how the rate works? How did customers first become aware of the conservation rate? Which communication method did customers find most useful in understanding the rate? What best reflects customers' understanding of the basis for the conservation rate? How much support do customers have for the energy charge?
4. Assess customer response to the LGS and MGS conservation rate structures.	How much of an incentive to conserve do the energy and demand charges provide? How easy or difficult is it for customers to manage their energy consumption? How much of an effort do organizations put into minimizing energy charges? What are the key enablers and barriers to energy conservation? Is awareness of the conservation rate structure required for a conservation response?

Table 2.2.2 summarizes, for each of the evaluation objectives, the evaluation data and methods used.

Table 2.2.2 Evaluation Objectives, Data and Methods

Evaluation Objective	Main Data Sources	Methods
1. Assess the effectiveness of the LGS and MGS control groups for the evaluation of energy savings.	BC Hydro billing data from January 2010 to December 2012 Power Smart program tracking data BC Hydro account data by region	Statistical tests Stratified sampling design analysis
2. Estimate the energy and associated peak demand savings attributable to the LGS and MGS conservation rate structures.	BC Hydro billing data from January 2010 to December 2012	Experimental design with randomized controlled trial Difference-in-differences Rate class average peak to energy ratio
3. Assess customer awareness, understanding and acceptance of the LGS and MGS rate structures.	2010 customer survey (n = 504) 2012 customer survey (n = 421)	Cross tabulations Z-tests
4. Assess customer response to the LGS and MGS conservation rate structures.	2010 customer survey (n = 504) 2012 customer survey (n = 421) BC Hydro billing data from January 2010 to December 2012	Cross tabulations Z-tests Analysis of variance Regression

Because of the availability of a valid control group, and the complexity of the LGS and MGS pricing scheme, experimental design was used to estimate quantitative impacts. Experimental design with a randomized control trial is considered the strongest research method across many fields because it controls for all factors aside from the treatment of interest.

The individual evaluation objectives and a summary of the methodology for each are listed below.

Objective 1: Assess the Effectiveness of the Control Groups.

The key to conducting a valid cause and effect analysis through experimental design is to construct a control group that is equivalent to the treatment group on all factors that impact the variable of interest in the base year period. For this study the variable of interest is energy consumption, and the base year is calendar year 2010, which is the year prior to the introduction of the conservation rate structures.

The following steps were used to assess the effectiveness of the control group:

1. Identify remaining valid control group accounts. Valid control accounts were defined as those accounts that remained on the pre-existing rate schedule and for which consecutive three-year consumption data during 2010 to 2012 was available.

2. Test the remaining valid control group accounts for equivalency to the treatment groups on the following basis:

    a. Average base year consumption by rate class and demand classification.

    b. Average base year consumption by account sector.

    c. Average base year consumption by BC Hydro service territory region.

    d. Base year consumption distribution by percentile (from 10 per cent to 90 per cent).

e. Two year Power Smart program participation rates.

3. Post-stratify the remaining valid control group accounts and estimate their relative precision. Post-stratification is a statistical method for assessing the variance of a sample,[3] after the completion of an experiment, which can then be used to estimate relative precision. Relative precision provides an estimate of how closely the sample can predict the population.

4. Identify control accounts that have corporate parent and/or sister accounts in the treatment groups (e.g., chain stores, government buildings). Test for control group contamination[4] at these sites by comparing their change in consumption to control accounts that are not associated with treatment accounts.

The primary data for the analysis was energy consumption and data on account characteristics obtained from the BC Hydro billing system and Power Smart program tracking systems, for the time period January 2010 through December 2012. The analysis was conducted on only those accounts with continuous electricity consumption records between January 2010 and December 2012.

Objective 2: Estimate Energy and Associated Peak Demand Savings.

Energy and associated peak demand impacts were estimated through the difference-in-differences method which relies on comparing the consumption between treatment and control accounts before and after the introduction of the conservation rate, according to Equation 3.2.1.

Equation 3.2.1

$$DDE = (Treatment_{Post} - Treatment_{Pre}) - (Control_{Post} - Control_{Pre})$$

Where,

The difference-in-differences estimator (**DDE**) is the estimation of the difference between the two groups

$Treatment_{Post}$ is the average electricity consumption for the treatment group in the time period after the introduction of the conservation rates.

$Treatment_{Pre}$ is the average electricity consumption for the treatment group in 2010 before the introduction of the conservation rates.

$Control_{Post}$ is the average electricity consumption for the control group in the time period after the introduction of the conservation rates.

$Control_{Pre}$ is the average electricity consumption for the control group in 2010 before the introduction of the conservation rates.

[3] Variance is assessed by partitioning the population into distinct groups such that the variance of each group is minimized. For this study groups were selected on the basis of 2010 electricity consumption, across the entire rate class. Groups with larger variance will need a larger number of control accounts in order to reach a given precision level. Once the variance of each group was known, relative precision can be calculated based on the actual number of control accounts.

[4] Control group contamination occurs if the control group is influenced by the treatment, which could occur if head office directs energy management activities for a number of different sites, in a manner that is consistent with the assumption that all are under the conservation rate structures.

The method described above provides an estimate of evaluated net savings, on a cumulative run rate basis.[5]

Associated peak demand savings were calculated by applying a peak-to-energy ratio of 0.139 MW/GWh. This ratio is calculated from a rate class load shape.

Objectives 3 and 4: Assess Customer Awareness, Understanding, Acceptance and Response.

Customer surveys were used to collect information on customer awareness, understanding and decision making related to the LGS and MGS conservation rates, opinions on electricity pricing, and behaviours around energy use, along with additional business-specific parameters to inform the evaluation. Detailed customer surveys of LGS and MGS customers were conducted prior to the implementation of the conservation rate in July 2010. In July 2012, 18 months after the implementation of the LGS rate, a second round of surveys was conducted. The survey was customized for the various rate groups.

With the permission of survey respondents, survey responses were linked to billing history in order to conduct analysis of variance and regression, to determine the relationship between responses and consumption.

A quasi-experimental design was used to assess the impacts on customer conservation actions. The LGS and MGS1 customers who were exposed to the conservation rates at the time of the customer survey in July 2012 are the treatment groups. The MGS2/3 customers who were not yet exposed to the conservation rate at the time of the survey in July 2012 are the comparison group.

2.2.3 Results

Objective 1: Effectiveness of Control Groups

Of the 400 control accounts assigned in 2010, 320 were found to still be valid at the time of this study. The other 80 accounts were lost from the control group either because of account closure, or migration to a different rate class as a result of significant changes in account consumption.

Effective control groups will be equivalent to their treatment groups on all factors that are expected to impact electricity consumption, with the exception of their electricity rate. Analysis of the factors listed below was completed in order to test the effectiveness of the control groups.

- Average electricity consumption in the year prior to conservation rate implementation.
- Distribution of consumption by percentile.
- Representation by major account sector (industrial, commercial, and multi-unit residential).
- Representation by region.
- Power Smart program participation.
- Relative precision.
- Potential for control group contamination resulting from accounts with parent corporations outside the control group.

The results indicate that the control groups are equivalent to their treatment groups on the basis of electricity consumption in the year prior to conservation rate implementation, and are representative of the treatment groups by account sector and region, at a 90 per cent confidence level. Further, the

5 Run rate savings refers to the rate at which energy is saved at a given point in time, expressed in units of GWh/year or kWh/year. Cumulative run rate savings provides the annualized rate of all savings achieved since the start of the initiative.

distribution of annual electricity consumption, and the level of Power Smart program participation, were found to be similar between the control and treatment groups. The relative precision was found to be good for MGS control group and fair for the LGS control group. Finally, control account consumption was not influenced as a result of having a corporate parent or sister accounts in the treatment groups.

Objective 2: Energy and Associated Peak Demand Savings

Shown below are the combined energy and associated peak demand savings for the LGS and MGS conservation rate structures and MGS rate shaping, in calendar years 2011 and 2012. Evaluated net savings are statistically significant at the 90 per cent confidence level.

Table 2.2.3 Comparison of Cumulative Reported and Evaluated Net Impacts

Calendar Year	Energy Savings (GWh/year)		Associated Peak Demand Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
2011	286	144	40	20
2012	616	200	86	28

All evaluated net savings resulted from the LGS conservation rate structure with no statistically significant savings from the MGS1 conservation rate or from rate shaping. Note these results are based on an analysis timeframe encompassing only 9 months with the LGS Part 2 price at the long-run marginal cost (LRMC),[6] only nine months of MGS1 customers being exposed to the conservation rate, and the initial customer baselines[7] were set higher than they would be under normal operation of the rate. An increasing response is observed for LGS customers over time, with relative savings increasing from 1.33 per cent in 2011 to 1.82 per cent of annual consumption in 2012.

Objective 3: Customer Awareness, Understanding and Acceptance of their Rate Structures

Customers were asked about several dimensions of rate awareness. Unaided awareness was measured by asking survey respondents to identify their rate structure from a list of possibilities. About 33 per cent of LGS customers, 20 per cent of MGS1 customers, and 7 per cent of MGS2/3 correctly identified the structure of their energy charge. Aided awareness was much higher. Aided awareness was measured by describing their rate structure to survey respondents and then asking them whether they were previously familiar with it. Aided awareness was 81 per cent of LGS customers, 69 per cent of MGS1 customers and 30 per cent of MGS2/3 customers.

To examine ease of understanding of their rate, customers were provided with a detailed description of the conservation rate structures and then asked how easy or difficult they found it to understand. About 66 per cent of LGS customers said that it was very easy or somewhat easy to understand as did 70 per cent of MGS1 customers and 67 per cent of MGS2/3 customers.

Customers were asked if they support the rate. About 57 per cent of LGS customers indicated that they strongly or somewhat support the rate as did 45 per cent of MGS1 customers and 28 per cent of MGS2/3 customers.

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6 Part 2 refers to the credit / charge mechanism of the conservation rate structure. LRMC used in the context of the Part 2 rate refers to the levelized weighted average plant-gate price for firm energy from BC Hydro's F2006 Call for Tenders (grossed up to account for line losses and inflation) as a proxy. The conservation rate design intent is for the Part 2 rate to be valued at the LRMC. A transitional value was temporarily applied to Part 2 starting January 2011 before moving it to LRMC in April 2012.

7 The conservation rate structure includes the setting of unique customer baselines. The baseline level is a determining factor in the calculation of the Part 2 Credit or Charge.

Objective 4: Customer Response to the Conservation Rate Structures

Most customers felt that the rate had an impact on their energy conservation efforts. About 84 per cent of LGS customers said their rate had a major or a minor incentive effect, as did 70 per cent of MGS1 and 52 per cent of MGS2/3 customers.

To examine customers' ease of managing their accounts, customers were asked "assuming your organization wanted to do so, how easy or difficult is it to currently manage this account to minimize total energy charge on the bill?" Responses were similar across the three customer groups. About two-thirds of respondents indicated it would be very or somewhat difficult to respond, with the balance indicating it would be very or somewhat easy to respond.

Customers were asked about the major drivers of energy conservation. For all customer groups, the top three drivers of energy conservation were: "want energy costs to be as low as possible"; "right thing to do"; and "overall level of electricity prices". Responding to the conservation rate structure was cited as a driver of conservation for 35 per cent of LGS customer respondents.

Analysis of variance revealed that customers who are aware of the LGS or MGS conservation rates on an unaided basis have a higher mean annual consumption than customers who are not aware. Regression analysis indicated that awareness of the rate structure is not required for a conservation response.

2.2.4 Findings and Recommendations

Findings

The study has six key findings, which are summarized as follows.

1. The control groups closely matched the treatment groups in a number of important ways, and they are therefore valid and effective control groups for the purpose of evaluating the LGS and MGS rate structures. Significant control group attrition has already occurred. Twenty per cent of control accounts were lost over three years. The relative precision of the control groups, while fair overall, could be improved by increasing the number of large LGS control accounts.

2. Unaided awareness and understanding of the LGS and MGS rate structures were relatively low. Awareness and understanding increased significantly following an explanation of the conservation rate structures.

3. The top three drivers of energy conservation were: "want energy costs to be as low as possible"; "right thing to do"; and "overall level of electricity prices". Awareness of the conservation rate structure is not required for a conservation response.

4. The LGS rate structure resulted in energy savings of 144 GWh/year by December 31, 2011, increasing to 200 GWh/year by December 31, 2012. This is considerably less than forecast energy savings. Note the timeframe evaluated incorporated only 9 months of data with the Part 2 price at the LRMC-based rate and the initial customer baselines were set higher than they would be under normal operation of the rate.

5. There were no measurable savings for MGS rate shaping in 2011 and 2012.

6. There were no measurable savings for those MGS customers (MGS1) that transitioned to the conservation rate structure April 1, 2012. Note the timeframe evaluated included only nine months of data with MGS1 customers exposed to the two-part conservation rate.

Recommendations

Listed below are recommendations related to the management of the LGS and MGS conservation rate structures (1 to 3) and the evaluation of the rate structures (4 to 7).

1. To promote a conservation response, focus communication and advertising on energy costs, “doing the right thing”, and energy prices.

2. If customer awareness and understanding of the rate is of value, consider simplifying the rate structure or expanding advertising and communication efforts.

3. Revisit the savings forecast method in light of the variance between evaluated and forecast savings.

4. Consider using focus groups or structured interviews to better understand the mechanism by which customers respond to the rates, given the finding that awareness of the rate is not required for a conservation response.

5. Request approval of the BCUC to maintain existing control accounts and to assign a proportion of new accounts to control group status to preserve an effective control group for future evaluation of the LGS and MGS conservation rate structures.

6. Request approval of the BCUC to assign an increased proportion of new, large accounts to control group status, specifically LGS customers expected to have consumption above 6.5 GWh/year.

7. Consider re-evaluating the conservation rate structures after all conservation rate design elements are fully implemented and customers have had time to respond to them.

2.2.5 Conclusions

The study conclusions are as follows.

1. The LGS rate structure is achieving its objective of encouraging conservation in the LGS rate class. However, evaluated savings achieved are significantly lower than forecast.

2. In 2012, the MGS rate structure had not achieved its objective of encouraging conservation in the MGS rate class.

3.0 Commercial Programs

3.1 PIP: F2011 - F2013

3.1.1 Introduction

BC Hydro's PIP is a multi-year energy acquisition initiative that encourages small and medium-sized commercial and institutional customers to undertake energy-efficient investments in existing facilities. This evaluation covers two program offers: the Rebate and Direct Install offers. The Rebate offer provides rebates for a range of qualifying energy efficient products, focusing primarily but not exclusively on lighting. The target market for the Rebate offer has evolved over time and during the evaluation time period encompassed small and medium commercial customers, as well as the common areas of multi-unit residential buildings. The Direct Install offer funds the full cost of the installation of energy efficient lighting projects for qualifying customers. The target market for the Direct Install offer is the very small, hard-to-reach commercial customers.

The objectives of PIP were to: (1) generate energy savings for BC Hydro via replacing inefficient technologies with newer energy efficient products; and (2) increase energy efficiency awareness by actively communicating product options and educating customers on the benefits, thereby contributing to market transformation. This report includes an impact evaluation and elements of process and market evaluation for F2011, F2012 and F2013.

3.1.2 Approach

For this study, the objectives were to evaluate: (1) customer and trade ally feedback; (2) determinants of investment decisions; (3) market analysis; (4) free ridership and spillover; and (5) energy and associated peak demand savings. For each of the evaluation objectives, there were several specific research questions, as summarized in the following table.

Table 3.1.1 Evaluation Objectives and Questions

Evaluation Objective	Research Questions
1. Customer and trade ally feedback	How important are, and how satisfied are customers and trade allies with, the various program components? How aware are customers of the program? What are customer and trade ally ratings of the various program components? How knowledgeable are customers of the program? How knowledgeable are customers with respect to various energy-efficient technologies? What are the main sources of awareness for the program?
2. Determinants of investment decisions	What is the most typical circumstance for equipment replacement? What are the key drivers and barriers of energy use management? What are the drivers and barriers of retrofit installation?
3. Market analysis	What are trade ally views of recent trends in prices of energy efficient products? What are trade ally forecasts of sales of energy efficient products? What is the market share among program participants of incandescent and halogen lamps prior to program participation?
4. Free ridership and spillover	What is the free rider rate for the Rebate and Direct Install offers? What is the spillover rate for the Rebate and Direct Install offers?
5. Energy and peak associated demand savings	What are the net evaluated energy and peak associated demand savings of the Rebate and Direct Install offers?

The objectives, data sources and methods used for this evaluation are summarized in the following table.

Table 3.1.2 Evaluation Objectives, Data Sources and Methods

Evaluation Objective	Main Data sources	Method
1. Customer and trade ally feedback	Rebate offer participant surveys (n = 908) Rebate offer non-participant survey (n = 169) Direct Install offer participant survey (n = 150) Direct Install offer non-participant survey (n = 150) Trade ally survey (n = 35)	Cross tabulations, z-tests
2. Determinants of investment decisions	Same as Objective 1	Same as Objective 1
3. Market analysis	Program tracking data Trade ally survey (n = 35)	Same as Objective 1
4. Free ridership and spillover	Rebate offer participant survey (n = 908) Rebate offer non-participant survey (n = 169) Direct install offer participant survey (n = 150)	Net to gross algorithms
5. Energy and associated peak demand savings	Program tracking data Metering studies Peak to energy ratio	Engineering algorithms

Objectives 1 and 2: Customer and Trade Ally Feedback & Determinants of Investment Decisions

Detailed customer surveys of program participants and non-participants as well as a survey of trade allies provided the main sources of data for objectives one and two. The surveys for the Direct Install offer were conducted by telephone in September and October 2011. The surveys for the Rebate offer were conducted via an online survey in March to April 2013. The survey of trade allies was conducted by telephone in August to September 2013.

Objective 3: Market Analysis

Program tracking data on the levels of product installation by product type was the main data source for the market analysis. The trade ally survey results were also used for the market analysis.

Objective 4: Free Ridership and Spillover

Free ridership and spillover were estimated separately for the Rebate and Direct Install offers and calculated on the basis of survey responses to a series of questions designed specifically to measure free rider and spillover effects.

Objective 5: Energy and Associated Peak Demand Savings

Gross energy savings were estimated using Equation 2.2.1, where W_{pre} and W_{post} are the wattages of the original and replacement products, hours of use refers to hours of lighting or equipment use for the relevant space type, and area refers to the area of the relevant space type. The summation is over areas. Hours of use were obtained through metering studies, whereas wattages and space type shares were obtained from program tracking data.

Equation 2.2.1

$$\text{Gross Evaluated } kWh_{savings} = \sum (W_{pre} - W_{post}) * \text{hours of use}_{area} / 1000.$$

Net savings were estimated using Equation 2.2.2. The inputs to the algorithm were obtained through the steps previously described, with the exception of the Cross Effects factor which was obtained from the relevant Power Smart Standard.

Equation 2.2.2

$$\text{Net Evaluated } kWh_{savings} = \text{Gross Evaluated Savings}*(1 - \text{free rider rate} + \text{spillover rate})*(1 - \text{cross effects}).$$

Net associated peak demand savings were estimated by using the ratio of average kWh to peak kWh from internal calculations, based on a rate class load shape. For the purpose of this evaluation, the ratio was 0.130 MW/GWh for the Rebate offer and 0.125 MW/GWh for the Direct Install offer.

3.1.3 Results

Objective 1: Customer and Trade Ally Feedback

Satisfaction among program participants and trade allies with a number of important program components was high. The highest rated program components for Rebate offer participants were: the service provided by the [trade allies]; the length of time for the project to be completed; and the overall application procedure. The highest rated program components for the Direct Install offer were: the application procedure; service provided by their [trade ally]; and the products installed. The highest rated program components for trade allies were: the content of program communication; the range of products offered; and the overall program.

Some program components received relatively low ratings (< 51 per cent) by program participants. Rebate offer participants gave their lowest ratings on: the usability of the online application; the variety of products funded; and direct mail information. Trade ally respondents provided their lowest ratings on BC Hydro training about the program.

Objective 2: Determinants of Investment Decisions

Rebate offer participants and non-participants were asked how influential various considerations were as a driver of energy-efficient investment. For both participants and non-participants, the top factors emerged to include operating costs, electricity prices and the environment. For participants, participation in PIP was also a top factor.

Direct Install participants and non-participants were asked whether or not various considerations were a "major factor", a "minor factor" or "not a factor at all" as a driver of energy-efficient investment. For participants and non-participants, the top three major factors were operating costs, the environment, and the overall level of electricity prices.

Objective 3: Market Analysis

Over the five years ending in F2013, a total of 2,394,700 products were incented through PIP. Most (2,051,000) were incented through the Rebate offer. Lighting products made up 96 per cent of all products installed.

To gauge the state of market transformation, trade allies who indicated that they were very knowledgeable or somewhat knowledgeable about the broader energy efficiency market place were asked additional questions about recent price trends and forecast sales for six main types of products.

The most commonly cited price increase trends were for standard T8 lamps and energy saving T8 lamps. The most commonly cited price stability trends were for occupancy sensors and high bay luminaires. The most commonly cited price decrease trends were for LED screw in lamps and high wattage LED luminaires.

The most commonly cited sales increase forecasts were for LED screw in lamps and high wattage LED luminaires. Few respondents indicated a sales decrease forecast. The most commonly cited stable sales forecast were for standard T8 lamps and energy saving T8 lamps.

Rebate offer participants who installed LEDs through the program were asked about the baseline lighting technologies in place prior to their energy efficient retrofit. Eighty-five per cent reported that the baseline lighting technology was incandescent or halogen, while 15 per cent reported that it was compact or linear fluorescent.

Objective 4: Free Ridership and Spillover

Free ridership and spillover estimates were based on multiple-question, self-report survey information. The free ridership rate was 17 per cent and 18 per cent for the Rebate and Direct Install offers, respectively. The participant spillover rate for the Direct Install offer was 11 per cent; non-participant spillover was not estimated. For the Rebate offer the combined spillover rate was 19 per cent, made up of 15 per cent participant spillover and 4 per cent non-participant spillover.

Objective 5: Energy and Associated Peak Demand Savings

Energy and associated peak demand estimates are shown below. Energy savings are incremental annual net run rate savings achieved for each fiscal year. Results are presented by offer and for the whole program overall in the tables that follow. The primary driver for the differences between reported and evaluated savings is the inclusion of the cross effects adjustment factor.

Table 3.1.3 Rebate Offer Comparison of Incremental Reported and Evaluated Net Impacts

Fiscal Year	Energy Savings (GWh/year)		Associated Peak Demand Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
F2011	59.1	55.1	7.7	7.2
F2012	89.7	82.5	11.7	10.7
F2013	33.8	30.6	4.4	4.0

Table 3.1.4 Direct Install Comparison of Incremental Reported and Evaluated Net Impacts

Fiscal Year	Energy Savings (GWh/year)		Associated Peak Demand Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
F2011	14.1	10.3	1.8	1.3
F2012	12.0	10.7	1.5	1.3
F2013	2.8	2.3	0.4	0.3

Table 3.1.5 Total Program Comparison of Incremental Reported and Evaluated Net Impacts

Fiscal Year	Energy Savings (GWh/year)		Associated Peak Demand Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
F2011	73.2	65.4	9.4	8.5
F2012	101.7	93.2	13.2	12.0
F2013	36.6	32.9	4.8	4.3

3.1.4 Findings and Recommendations

Findings

1. Satisfaction among program participants and trade allies with a number of important program components is high. Over 60 per cent of participants across both offers gave favorable ratings to service provided by the trade allies, and the overall application procedures to receive funding. Among trade allies at least three-quarters rated the content of program communications, the range of products offered, the frequency of program communications, and the overall program as excellent or good.
2. Some program components received relatively low ratings (< 51 per cent) from survey respondents. Rebate offer participants provided the lowest ratings on the usability of the online application, variety of products funded, and direct mail information. Trade ally respondents provided their lowest ratings on BC Hydro training on the program.
3. The Rebate offer had high levels of non-participant awareness, with 63 per cent of non-participants aware of the offer. Only 15 per cent of non-participants reported being aware of the Direct Install offer.
4. Power Smart Alliance members play an important role in promoting the program. Twenty-five per cent of Rebate offer participants reported being contacted by an Alliance member.
5. Eighty-five per cent of participants who installed LED lighting technologies through the program reported baseline conditions that matched program assumptions regarding energy efficiency.
6. Metered hours of use were very close to the deemed hours of use for both offers. Consequently, the realization rates for gross energy and peak savings rates were very close to one.
7. For the Direct Install offer, free ridership was estimated to be 18 per cent for all program years evaluated. This was partially offset by an estimated spillover rate of 11 per cent, resulting in a net-to-gross ratio of 0.93.
8. For the Rebate offer, free ridership was estimated at 17 per cent for all program years evaluated but this was completely offset by an estimated participant spillover of 4 per cent and non-participant spillover of 15 per cent, resulting in a net-to-gross ratio of 1.02.

Total program savings for both offers were 65.4 GWh/year in F2011, 93.2 GWh/year in F2012, and 32.9 GWh/year in F2013.

Recommendations

Listed below are recommendations resulting from this study, starting with recommendations for program management (1, 2 and 3) followed by recommendations that could serve both program evaluation and program management purposes (4 and 5), and recommendations for future evaluation (6 and 7).

1. Consider expanding the variety of products offered by the program, given feedback from participants.
2. Investigate ways to improve the online application process.
3. Further explore the reasons for low satisfaction ratings from trade allies on training from BC Hydro, to determine if investment in additional training is warranted.
4. Consider increasing the frequency of surveying of participants and non-participants. This could inform updates to program baseline assumptions, and facilitate the estimate of free ridership and spillover for individual program years in a multi-year evaluation period.
5. Survey customers and trade allies on their awareness, understanding, and satisfaction at the overall program level and at the individual program component (i.e., offer) level. Understanding customer perceptions at both levels will facilitate continuous improvement to the program design and components.
6. Use stratified sampling techniques for the selection of sites that undergo measurement of hours of use. This approach to sample design would allow for the estimation of precision, which would help clarify the strength (or limitation) of the evaluation results.
7. Investigate whether hours of use are changing over time as a result of technology changes such as widespread adoption of building energy management systems. This investigation could be completed by adding relevant questions to periodic surveys of trade allies.

3.1.5 Conclusions

PIP has achieved its objective of generating energy savings. Participant and trade ally satisfaction with the program is generally high.

3.2 WCA Initiative: F2011 - F2012

3.2.1 Introduction

BC Hydro offers the WCA initiative to its large commercial customers (in both public and private sectors) as part of its Power Smart Partner (**PSP**) program. WCA encourages workplace activities that promote sustained energy reduction through behavior changes related to energy use.

After beginning in 2007 as a pilot offer with ten customers, in 2010 the initiative expanded to 30 large commercial customers. These customers represent approximately 300 sites in six sectors: advanced education, K-12 schools, healthcare, municipalities, property management (office buildings), and retail/hospitality.

In June 2011, BC Hydro commissioned a consultant (The Cadmus Group, Inc.) to conduct an impact and process evaluation of the WCA initiative to assess its energy savings and to understand its influence on energy-efficiency behaviors in the workplace.

The evaluation period covers F2011 through F2012.

3.2.2 Approach

The study objectives were to estimate the gross electricity impacts and net electricity savings of the WCA initiative, and to evaluate the effectiveness of the WCA initiative delivery, as summarized below.

Table 3.2.1 Summary of Evaluation Objectives and Research Questions

Evaluation Objective	Research Questions
1. Estimate gross electricity impacts for WCA initiative participants	What factors influence electricity consumption at WCA initiative participant sites? What is the year-over-year change in electricity consumption at WCA initiative participant sites, after controlling for known variables?
2. Estimate net electricity savings of the WCA initiative	Can valid comparison sites be identified for WCA initiative participants? What are the net energy savings from the WCA initiative? Is the hypothesis that net savings equaled 5 per cent of total site consumption valid? How can the reliability and accuracy of behavioral energy savings estimates for the commercial sector initiatives be improved?
3. Evaluate the effectiveness of the WCA initiative delivery	What were the perspectives of BC Hydro staff and consultants regarding WCA participation? What were BC Hydro staff and WCA consultants' perceptions of customer needs and marketplace trends? How effective were the initiative's social marketing strategies? What were the barriers to participation that can be addressed by initiative design and implementation? What were the key opportunities and obstacles in the WCA initiative compared with similar behavior programs at other utilities?

The following table summarizes the data sources and methods employed in this study for each evaluation objective.

Table 3.2.2 Summary of Evaluation Objectives, Data Sources and Methodology

Evaluation Objective	Main Data Sources	Methods
1. Estimate gross electricity impacts	WCA initiative data for participants, including WCA enrollment status and activity start date BC Hydro monthly billing data for WCA initiative participants, from April 2006 to March 2012, including site consumption, demand, region, business sector BC Hydro records of expected savings and savings effective dates from non-WCA initiatives BC Hydro records of heating and cooling degree days by region from April 2006 to March 2012 BC Hydro tariff change dates	Econometric models - linear regression using Ordinary Least Squares.
2. Estimate net electricity savings	BC Stats demographic and economic data BC Hydro monthly billing data from April 2006 to March 2012 for comparison group sites, including site consumption, demand, region, business sector BC Hydro records for comparison group sites, of expected savings and savings effective dates from non-WCA initiatives. BC Hydro records of heating and cooling degree days by region from April 2006 to March 2012 BC Hydro tariff change dates Results from Objective 1	Econometric models – linear regression using Ordinary Least Squares Quasi-experimental design using Difference-in-Differences
3. Evaluate the effectiveness of the WCA initiative delivery	WCA participant quarterly reports, pre-post surveys and recorded event data BC Hydro staff interviews (n = 12) WCA consultant interviews (n = 8) Energy Champion interviews (n = 30)	File review Qualitative analysis

Objective 1: Estimate Gross Electricity Impacts

Regression analysis was used to estimate gross electricity impacts for each participating sector. The regression model included terms for certain non-initiative factors that typically affect energy usage patterns. These non-initiative factors included heating degree days, cooling degree days, engineering estimates of energy savings due to other BC Hydro energy-efficiency programs, and BC Hydro's implementation of conservation rate structures.

While this method controls for a number of factors, it does not produce an estimate of electricity savings attributable to the WCA initiative. The method does not account for other factors that were potentially correlated with WCA activity, such as naturally occurring energy efficiency trends, trends in occupancy, or patterns of business activity. These other factors are accounted for in the estimation of net electricity savings in Objective 2.

Objective 2: Estimate Net Electricity Savings

Quasi-experimental design using difference-in-differences was used to estimate net electricity savings. Difference-in-differences adjusts the gross energy impacts by the difference in energy consumption observed at comparable non-participants over the same time period. This method controls for factors that were potentially correlated with WCA activity, such as naturally occurring energy efficiency, trends in occupancy, or patterns of business activity. If both participants and non-participants groups are reasonably similar, then any remaining differences in consumption between groups are attributed to be a result of the initiative.

Successful application of the D-in-D model with the benefit of a well matched comparison group should produce results that are net of natural conservation, participant spillover and electricity cross effects (natural gas cross effects were not evaluated). If the comparison group can be matched to participants on a wide range of factors such as corporate culture and demographics then results may also be net of free ridership.

Net associated demand savings were estimated using an energy-to-peak coincidence factor calculated from a class average load shape.

Objective 3: Initiative Delivery

Interviews were used to evaluate the effectiveness of the WCA initiative's delivery. Information from the WCA participant's quarterly reports, pre- and post-participation surveys, and recorded event data was also collected and analyzed. These sources were useful for assessing the building occupants' awareness and attitudes and identifying key activities contributing to the outcomes of the WCA initiative.

1. Interviews were conducted with 12 WCA program staff and BC Hydro key account managers (**KAMs**) and with eight WCA consultants. In addition, interviews were conducted with 30 energy champions – individuals who played key roles leading "Green Teams" and coordinating and reporting on WCA activities at participating sites – within 22 of the 30 organizations that participated. During these stakeholder and energy champion interviews, the evaluators gathered perspectives about the initiative's planning, implementation, and reporting. In addition, respondent insights were gathered about initiative effects, satisfaction, motivations and barriers, and opportunities to improve initiative design, marketing, and implementation.

3.2.3 Results

Objective 1: Gross Electricity Impacts

The Retail/Hospitality sector was divided into three groups according to the nature of the business (e.g., restaurant, hotel, etc).

Statistically significant estimates[8] of gross electricity impacts could not be found for the following sectors/subsectors: Municipalities (other buildings), Government, Advanced Education or Healthcare.

8 20 per cent or lower probability that the true impacts are zero

Statistically significant gross energy impact results were found for the remaining six sectors, although in some cases not for each year of program participation. These results are summarized below.

Table 3.2.3 Gross Electricity Impacts

Participant Group	Gross Electricity Impacts (% Change in Consumption)	
	First Year of Participation (%)	Second Year of Participation (%)
K-12 Schools	-5.7	-4.7
Property Management	-3.1	N/A
Municipalities (Libraries/Administration)	N/A	-5.5
Retail/Hospitality Group 1	N/A	-4.2
Retail/Hospitality Group 2	+3.4	N/A
Retail/Hospitality Group 3	+6.2	+17.4

Note: Negative values represent electricity savings, positive values represent relative increases in consumption. N/A indicates no measurement possible or not statistically significant.

As shown in Table 2.1.3, gross electricity impacts were found to be negative for some sectors (indicating that a reduction in consumption occurred, after controlling for the factors described in the Approach section), and positive for others (indicating a consumption increase). Consumption increases are likely due, at least in part, to factors not included in the model, such as patterns of business activity.

Objective 2: Net Electricity Savings

Valid comparison groups could only be identified for the following three sectors: K-12 schools, Property Management, and Municipalities. Comparison groups could not be identified for the remaining sectors, because of a lack of similar non-participant sites.

Statistically significant net energy savings were found only for the K-12 School sector and only for the second year of WCA initiative participation. Net savings as a per cent of consumption for this sector in the second year of participation year were 3 per cent. This equates to evaluated net savings for the K-12 school sector of 0.4 GWh/year in F2012, compared to reported savings of 0.8 GWh for K-12 schools in F2012.

Statistically significant net energy savings were not found for Property Management or Municipalities, in either year of participation, or for K-12 schools in the first year of participation. Because of the wide error bounds on the estimates, an overall estimate of evaluated net savings could not be produced.

Table 3.2.4 Comparison of Incremental Reported and Evaluated Net Impacts

Fiscal Year	Energy Savings (GWh/year)		Associated Demand Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
F2011	18.5	N/A	2.2	N/A
F2012	12.7	N/A	1.5	N/A

Note: N/A indicates no statistically significant estimate available.

Objective 3: Effectiveness of the Initiative Delivery.

Interviews with the various WCA stakeholders (BC Hydro staff, KAMs, and outside consultants) and energy champions explored experiences, successes and challenges with the initiative. These are summarized below.

- Energy Champions were excited about reducing energy and promoting energy conservation through behavior change in the workplace. They reported that the behavior change initiative enhances many environmental initiatives at their organizations. They also said that they believe WCA produces energy savings beyond energy-efficiency retrofits installed through BC Hydro's Power Smart Partner Program.
- Energy champions emphasized that visible senior management support for WCA was necessary to ensure sustained WCA involvement from their green team members (those who help deploy specific initiative activities) and building occupants. They said senior management support could be demonstrated through sustainability policies or direct engagement in the WCA initiative launch or activities.
- Energy champions who had real-time data collection methods, and who were able to report energy savings from the initiative's activities to building occupants and senior management, reported that such feedback generated excitement, additional support, and initiative visibility throughout the year.

The following challenges were identified:

- WCA energy champions reported they had limited funding, time, and staff resources to keep up with the demands of launching, implementing, and reporting the initiative activities. Many champions said the WCA incentive was important, but that funding was not enough to cover the costs of additional materials needed to enhance the marketing toolkit provided by BC Hydro.
- While most energy champions were positive about the consulting assistance they received, some champions said they expected more communication and support from the WCA consultants.
- Some KAMs and WCA consultants said they would like to have greater feedback from participating organizations regarding initiative successes and lessons learned.
- Energy champions and stakeholders said that the lack of marketing materials or outreach support reduced the ability of their green teams to maintain visibility of the initiative. KAMs and consultants specifically suggested that BC Hydro develop a targeted brochure for WCA that would more effectively enlist senior management support.
- Energy champions reported they had limited ability to track energy savings resulting from initiative activities. Many stated that they would like to track the targeted behaviors and events, but lacked a consistent method, sub-metering resources, or sufficient staff support.

Despite developing success indicators (e.g., involving senior management) and rating participating organizations according to those indicators, the evaluation was not able to find consistent correspondence between the ratings and the savings estimates. This is likely due to imprecision in the savings estimates and incomplete data about participant activities

3.2.4 Findings and Recommendations

Findings

Objectives 1 and 2: Estimate Gross Impacts and Net Electricity Savings

1. A number of factors made it difficult to use statistical and econometric methods to detect WCA savings. Savings for most sectors were not able to be precisely estimated for a number of reasons, including:
    - ***WCA savings represented a small percentage of total site consumption***. When savings are a small share of consumption, the signal-to-noise ratio is typically large, and it can be hard to detect the savings even after controlling for energy-use drivers, such as weather.
    - ***Building occupancy and business activity data was not available for most buildings.***[9] Information about major contributors to energy use, such as building occupancy and business or economic activity, was unavailable for most sites and years. The lack of these data increased the amount of unexplained variation in the consumption data and decreased the ability to detect savings from WCA-supported activities.
    - ***The initiative study enrolled a relatively small number of sites in each sector***. The small number of sites increased the savings uncertainty due to variability in sampling.
    - ***Initiative activity leading to savings was only roughly tracked***. Each initiative site had a WCA activity start date, but little variability in these dates appeared between sites, and it was unclear if the dates corresponded to the start of WCA activity in particular buildings or the start of activity in the sectors.
2. It was difficult to establish a causal relationship between the WCA initiative and estimated reductions in consumption because of the non-experimental research design for the evaluation. To estimate net savings, the evaluation employed a quasi-experimental research design that involved developing a comparison group through attempts to match consumption and other characteristics of participants to nonparticipants. However, a comparison group could not be identified for all of the sectors, limiting this more robust type of analysis.

Objective 3: Assess the Effectiveness of the Initiative Delivery

The following were identified by BC Hydro staff, consultants and energy champions as barriers that interfered with achieving WCA initiative goals: Budget constraints, difficulty obtaining senior manager support, lack of staff support in participating organizations, inability to provide timely feedback to employees about the effects of energy savings activities, and keeping employees engaged over time.

Recommendations

A list of recommendations is identified below, organized into areas of consideration for program implementation and future evaluations of similar programs.

[9] WCA initiative consultants attempted to collect occupancy and business activity data for a sample of approximately 60 participant buildings (ten in each of the six sectors) during the initiative period. While this data would likely help explain more variation in consumption, the consultants and participants indicated that the data collection is time-consuming and tedious. Many experienced difficulties understanding what data to collect and how to collect it accurately.

Program Implementation

1. Consider increasing the WCA initiative incentives, and require that participants propose how they will use the funding source to meet the requirements of the initiative. Additional incentives may enable participants to assign more staff resources, develop more customized promotional materials and activities, and ensure that the program continues to engage employees and maintain visibility throughout the year.
2. Provide additional communication and guidance that clarifies what participants should receive from consultants throughout the duration of the WCA campaign. Communicate with consultants more regularly about their initiative roles and responsibilities.
3. Consider additional communication strategies to share lessons learned among the initiative participating organizations and stakeholders. Some examples are monthly or quarterly newsletters and regularly scheduled participant events that will foster networking and allow BC Hydro to compile and circulate tips, successes, and dos and don'ts for succeeding with WCA.
4. Consider developing a WCA initiative brochure that provides information at a glance to upper-level management decision makers.
5. Investigate a more targeted and quantifiable approach to collecting WCA insights and savings results through consistent yearly surveys of employees and a modified reporting template. Provide additional guidance on approaches to collect results data, such as a checklist to record the numbers of lights turned off or monitors shut down in a month.
6. Consider investigating different feedback mechanisms. BC Hydro's program management staff suggested that there may be opportunities to help participating organizations track and report WCA event savings by leveraging Smart Meter data, dashboards, sub-metering, or online portals currently under development, or by providing them with customized energy-savings reports.

Future Evaluations

7. Collect additional site and WCA activity data to determine reasons for the variations in site energy use. This should include passenger traffic, occupancy rates and business activity data for participant and nonparticipant sites for at least the 12 months before and all months during WCA participation. Detailed information about WCA activity might include dates when significant activity occurred. BC Hydro should collect this information uniformly and systematically across sites.
8. Collect higher frequency (hourly, daily, or weekly) site energy-use data to increase the chances of detecting WCA savings. The variance of the savings estimates will decrease as the number of energy-use observations increases. Also, with higher frequency data, observable variables such as weather may be able to explain more of the variation in energy use, increasing the precision of the savings estimates.
9. Consider sub-metering particular end uses. With more detailed information about the timing of specific energy-saving activities, it may be possible to estimate savings at the end-use level. These actions will also help BC Hydro provide timely feedback to participants about their success in reducing energy use.
10. Incorporate more experimental research design elements in future evaluations, when feasible. This would increase confidence in the attribution of savings to the initiative. For example, for sectors with large numbers of relatively homogeneous sites, BC Hydro should consider randomly

assigning some sites to the initiative and others to a control group, recognizing that there is potential for contamination of control sites in organizations that also have treatment sites.

11. Prior to program participation, perform a statistical power analysis to estimate the probability of detecting the WCA savings. This analysis will allow BC Hydro to determine whether it can expect to estimate savings and whether additional sites, data collection (such as end-use metering), or a longer intervention period is needed. BC Hydro could use data on baseline energy use and the results of this evaluation to develop assumptions for the analysis.

3.2.5 Conclusions

Overall, energy champions were excited about reducing energy and promoting energy conservation through behavior change in the workplace. They reported that the behavior change initiative enhances many environmental initiatives at their organizations. They also said that they believe WCA produces energy savings beyond energy-efficiency retrofits installed through BC Hydro's Power Smart Partner Program.

The impact evaluation suggests that the WCA initiative saved energy in F2011 and F2012, as noted below. The estimated savings were positive in most years and for most sectors. However, wide error bounds also meant it was often not possible to reject the hypothesis of zero savings. Despite best efforts, savings could not be estimated precisely because: (1) the savings were small relative to consumption; (2) information about site occupancy and business conditions was not available for all participants; and (3) the initiative enrolled a relatively small number of sites in each sector. Because of this uncertainty, the savings estimates should be interpreted with caution.

Precise estimation of net energy savings cannot be achieved without either increasing site level data collection well beyond current practice, or significantly changing the participant recruitment approach such that new participants are matched to control sites.

Glossary

***Baseline* -** Energy consumption based on the existing or pre-implementation stage of the process. This level of consumption can be established by the measurements and or engineering calculations and is based on a specific level of production or operation.

***Cross Effects (CE)* -** Change in energy consumption of one process due to change of energy consumption of another process (usually in heating ventilation and air conditioning, HVAC, systems due to change in lighting).

Difference-of-Differences Method (Double Difference) – Compares a treatment and a comparison group before and after an intervention. This method can be applied in both experimental and quasi-experimental designs and requires baseline and follow-up data from the same treatment and control group.

***End Use* -** The final level of electrical energy use considered for an industrial application.

***Energy* -** Energy refers to the amount of electricity consumed (or produced) over a certain time period, measured in watt-hours. Energy savings are the reduction in the amount of electricity consumed over a certain time period.

***Experiment* -** In an experimental design, participants are randomly assigned to a treatment group or to a control group.

***Free Ridership* -** Free-riders are those participants who would have made similar energy efficiency improvements in the absence of the program.

***Gross Savings* -** The change in energy consumption and/or associated demand that results directly from program-related action taken by the participants in the DSM program irrespective of why they participated.

***Net savings* -** The change in energy consumption and/or associated demand that is attributable to the utility DSM program. The change in consumption or associated demand may include the effects of free riders and spillover.

***Net to Gross Ratio* -** The combination of free rider and spillover estimates which are then applied to the gross savings to provide an estimate of net savings attributable to the program. Reflects program influence, does not reflect project performance in terms of energy savings estimated or measured.

***Peak Demand* -** Demand refers to the amount of electricity that is consumed at any instant in time, measured in multiples of watts. Peak demand savings are the reduction in amount of electricity that is consumed at system peak demand, which for BC Hydro occurs on a winter weekday between approximately 5 p.m. and 7 p.m.

***Price Elasticity* -** The most commonly used measure in the electricity industry when analyzing consumption changes due to rate adjustments. It provides a straightforward and easy-to-compare means to measure the price impacts on electricity consumption and the magnitude of customers' price sensitivity. It is defined as the percentage change in quantity demanded divided by the percentage change in price. For example, a price elasticity assumption of -0.10 means that for each one per cent increase in real price, electricity usage declines by 0.10 per cent.

***Realization Rate* -** The ratio of initial estimates of gross savings to gross savings adjusted for evaluation, measurement and verification results. The realization rate does not reflect program attribution or influence on the (net) savings achieved.

***Reported Savings* –** Initial estimate of net savings based on engineering calculations, review and site inspection, adjusted by program assumptions for free-ridership, spillover and market effects. These estimates represent the unevaluated savings.

***Spillover* -** Spillover occurs when individuals are influenced or impacted by the program (either directly as program participants or indirectly as non-participants) to make additional energy efficiency improvements without additional assistance from the program.