BC hydro
FOR GENERATIONS

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December 23, 2010

Ms. Erica M. 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)
British Columbia Hydro and Power Authority (BC Hydro)
F2006/F2006 Revenue Requirements Application
BCUC Decison: Order No. G-96-04 October 29, 2004, Directive 66 (page 197)

BC Hydro is writing to submit its F2010 Demand Side Management Milestone Evaluation Summary Report (**the Report**), dated December 2010 in compliance with Directive 66 (page 197) of the BCUC 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 milestone evaluations completed during F2010 for the following:

1. Residential Inclining Block Rate F2009;
2. Transmission Service Rate F2007, F2008 and F2009;
3. Power Smart Windows F2008 and F2009;
4. Commercial Power Smart Partners F2008 and F2009;
5. Product Incentive Program F2008;
6. Product Incentive Program F2009;
7. Residential Lighting Program: CFL Component F2009;
8. Residential Lighting Program: Energy Star Fixtures Component F2009;
9. Residential Lighting Program: Seasonal LED Component F2009; and
10. Refrigerator Buy-Back Program F2007, F2008 and F2009.

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 e-mail at bchydroregulatorygroup@bchydro.com

Yours sincerely,

Joanna Sofield
Chief Regulatory Officer

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Enclosure (1)

F2010 Demand Side Management Milestone Evaluation Summary Report

December 2010

ABSTRACT

This report provides a summary of Milestone Demand Side Management (**DSM**) Impact Evaluations completed by Power Smart Evaluation and Research during F2010.

ACKNOWLEDGEMENTS

The Power Smart Evaluation and Research team wishes to thank the members of the Evaluation Oversight Committee and the Evaluation Oversight Committee Expert Advisors for their assistance and support.

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Glossary

Auto-correlation - Auto-correlation refers to a situation where the error terms are correlated over time, rather than being uncorrelated as is typically assumed for a least squares regression.

Adjusted R-squared - The adjusted R-squared is the proportion of the variance explained by the model in a least squares regression.

CDD - Each degree of mean temperature above 18 degrees Celsius is considered to be a "cooling degree-day" (**CDD**), with monthly cooling degree-days the sum of the daily cooling degree-days.

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 consumed at system peak demand, which for BC Hydro occurs on a winter weekday between approximately 5 p.m. and 7 p.m.

Demand Side Management – The definition of Demand Side Management is the same as the definition of "demand-side measures" set out in section 1 of the *Clean Energy Act*, which is "a rate, measure, action or program undertaken; (a) to conserve energy or promote energy efficiency, (b) to reduce the energy demand a public utility must serve, or (c) to shift the use of energy to periods of lower demand, but does not include (d) a rate, measure, action or program the main purpose of which is to encourage a switch from the use of one kind of energy to another such that the switch would increase greenhouse gas emissions in British Columbia, or (e) any rate, measure, action or program prescribed.

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

Evaluation Design - An evaluation design describes the nature of the treatment group and the control/comparison group.

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

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

HDD - Each degree of mean temperature below 18 degrees Celsius is considered to be a "heating degree-day" (**HDD**), with monthly heating degree-days the sum of the daily heating degree-days.

Least Squares Regression - In a least squares regression, the parameter values are selected based on the minimization of the sum of squares of the error terms.

Maximum Likelihood Regression - In a maximum likelihood regression, the parameter values are selected based on the maximum of the likelihood function.

Price Elasticity of Demand - The price elasticity of demand measures the responsiveness of demand to a change in price and it is defined as the percentage change in quantity divided by the percentage change in price.

Quasi-experiment - In a quasi-experimental design, there is no random assignment, but treatment and comparison group members are matched on some relevant characteristic(s) and selected on a probabilistic basis.

Run Rate - The rate at which a DSM program is saving electricity at any point in time and is usually expressed as GWh per year at the end of a specific fiscal or calendar year.

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

1 Introduction

BC Hydro evaluates its Demand-Side Management (**DSM**) initiatives to document their activities and impacts, to validate energy and peak savings and to improve the design and operation of initiatives. The objective of BC Hydro's DSM evaluation function is to provide timely, credible, actionable and cost-effective evaluation studies. BC Hydro uses the California Evaluation Framework[1] as a guide to undertaking DSM evaluations and related activities.

1.1 Background

BC Hydro resumed DSM activity in 2002 and, since the resumption of DSM, undertaking evaluations of DSM initiatives has been a core activity. Program evaluation activities center on four main types of studies which are described below: baseline studies, process evaluations, market evaluations and impact studies. The basic objectives of program evaluations are to document program activities, assess program impacts and identify opportunities for program improvement.

The British Columbia Utilities Commission (**BCUC**) Resource Planning Guidelines note that: "Because of measurement difficulties and uncertainty about consumer behaviour, DSM programs should be evaluated before and after implementation to determine their full impacts." Further in Directive 69 of its decision on BC Hydro's F2005/2006 Revenue Requirements Application, the BCUC directed BC Hydro to file "executive summaries of its milestone evaluation reports and full final evaluation reports for each program".

BC Hydro determines the impact of its DSM initiatives in the following manner. First, a complete evaluation plan is prepared covering the scope, issues, timing and expected costs of the evaluation study(s). Second, process, market and impact evaluations are conducted at major milestones or at program completion. Third, evaluations are reviewed and approved by a BC Hydro cross-functional DSM Evaluation Oversight Committee (**EOC**) chaired by a Senior Manager from BC Hydro's Engineering Services Business Unit. The EOC membership also has two external senior advisors from Lawrence Berkeley National Laboratory, and Pacific Gas and Electric Company.

1.2 DSM Evaluation Principles and Approach

BC Hydro's approach to DSM evaluation emphasizes four main principles:

- Undertaking baseline studies and periodic data collection to understand the nature and size of the pre-program market and changes in the market over time;
- Leveraging existing program, market and customer data to minimize evaluation costs;
- Using multiple lines of evidence to increase the credibility, validity and reliability of evaluation findings; and
- Reviewing and approving completed evaluation studies by the EOC, which represents key stakeholders.

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[1] The California Evaluation Framework provides a consistent, systemized, cyclic approach for planning and conducting evaluations of energy efficiency programs. The framework is widely used in the industry.

DSM evaluations are often divided into four main categories: baseline studies; process evaluations; market evaluations; and impact evaluations. These four types of studies are summarized as follows:

Baseline Studies. In baseline studies, the researcher describes the nature of the market, the roles of market actors and the market shares of more efficient and less efficient technologies. Key issues for baseline studies include the following:

- What are the sources of market data and how timely and reliable are they?
- What is the size of the market?
- What are the sales and market shares of more efficient and less efficient product?
- What are the prices of more efficient and less efficient product?
- Who are the key market actors?
- What are their roles?
- How can specific barriers to adoption of the technology be incorporated in program design?

Process Evaluations. In process evaluations, the researcher identifies and describes the program model or program logic, start-up procedures, implementation procedures and anticipated outcomes. Key issues for process evaluations may include the following:

- Are program goals clear, well defined, measurable and achievable?
- Are the goals clearly communicated through the organization?
- Is responsibility clearly defined?
- How efficient and effective are program processes?
- How can program processes be improved?
- What is the extent of stakeholder awareness of and participation in the program?
- How satisfied are the stakeholders with the program and its components?

Market Evaluations. In market evaluations, the researcher attempts to understand the impact of the program on the demand-side and the supply-side of the market. Key issues for market evaluations include the following:

- What is the size of the market?
- How much of the market has been captured?
- What is the remaining market potential?
- What are the barriers to market transformation?
- How successfully are the market barriers being addressed?

- What are the sales of more efficient and less efficient products?
- What are the prices of more efficient and less efficient products?

Impact Evaluations. In impact evaluations, the researcher evaluates the goals and objectives of the DSM initiative with respect to the outcomes, whether intended or unintended. Key issues for impact evaluations include the following:

- What are the short-term impacts on clients or stakeholders?
- What are the long-term impacts on stakeholders?
- What the gross impacts of the initiative on energy and peak demand?
- What are the net impacts of the initiative on energy and peak demand?

1.3 Evaluation Studies

Evaluations summarized in this report include the following:

1. Residential Inclining Block Rate F2009;
2. Transmission Service Rate F2007, F2008 and F2009;
3. Power Smart Windows F2008 and F2009;
4. Commercial Power Smart Partners F2008 and F2009;
5. Product Incentive Program F2008;
6. Product Incentive Program F2009;
7. Residential Lighting Program: CFL Component F2009;
8. Residential Lighting Program: Energy Star Fixtures Component F2009;
9. Residential Lighting Program: Seasonal LED Component F2009; and
10. Refrigerator Buy-Back Program F2007, F2008 and F2009.

2 Residential Inclining Block Rate F2009

2.1 Introduction

BC Hydro introduced the Residential Inclining Block (**RIB**) rate on October 1, 2008 after receiving BCUC approval in August 2008. The rate involved: (1) a basic charge of 12.38 cents per day; (2) a Step 1 rate of 5.98 cents per kWh; and (3) a Step 2 rate of 7.21 cents per kWh.

The purpose of this study is to provide a process and impact evaluation of the Residential Inclining Block rate based on its first six months of operation.

2.2 Approach

For this study there are five main issues addressed by the process evaluation and the impact evaluation:

- **Rate Structure Review.** Characterize BC Hydro's RIB rate and include a description of the program logic for the rate;
- **Customer Awareness.** Assess residential customer awareness of the new rate structure;
- **Customer Satisfaction.** Determine levels and changes in residential customer satisfaction with the RIB rate;
- **Behavioural Change.** Determine levels and changes in residential customer behaviour associated with the RIB rate; and
- **Energy and Peak Savings.** Evaluate energy and peak savings due to the RIB rate for F2009.

Table 2.1 summarizes evaluation issues, main data sources and methods for this study.

Table 2.1 Evaluation Issues, Data Sources and Methods

Issues	Main Data Sources	Methods
Rate structure review	Program interviews Participant survey Non-participant survey	z-tests
Customer awareness	Participant survey Non-participant survey	Cross tabulations
Customer satisfaction	Participant survey Non-participant survey	z-tests
Behavioural change	Participant survey Non-participant survey	Cross tabulations
Energy and peak savings	Participant survey Non-participant	Engineering algorithms, Multiple regression analysis

The impact evaluation uses engineering algorithms informed by price elasticities estimated using econometric models. Price elasticities for Step 1 and Step 2 consumption are estimated using equation (1) and equation (2), where the subscripts refer to region and billing period.

(1) $\textit{Step 1 Consumption}_{it} = \alpha + \beta_1 \textit{Lower Mainland}_{it} + \beta_2 \textit{Northern Region}_{it} + \beta_3 \textit{Southern Interior}_{it} + \beta_4 \textit{Apartment}_{it} + \beta_5 \textit{Mobile Home}_{it} + \beta_6 \textit{Other Dwelling}_{it} + \beta_7 \textit{Row House}_{it} + \beta_8 \textit{Electric Heat}_{it} + \beta_9 \textit{Log Step 1 price}_{it} + \textit{Log Heating Degree Days}_{it} + \textit{Log Unemployment Rate}_{it} + \textit{Interactions} + \varepsilon_{it}$.

(2) $\textit{Step 2 Consumption}_{it} = \alpha + \beta_1 \textit{Lower Mainland}_{it} + \beta_2 \textit{Northern Region}_{it} + \beta_3 \textit{Southern Interior}_{it} + \beta_4 \textit{Apartment}_{it} + \beta_5 \textit{Mobile Home}_{it} + \beta_6 \textit{Other Dwelling}_{it} + \beta_7 \textit{Row House}_{it} + \beta_8 \textit{Electric Heat}_{it} + \beta_9 \textit{Log Step 2 price}_{it} + \textit{Log Heating Degree Days}_{it} + \textit{Log Unemployment Rate}_{it} + \textit{Interactions} + \varepsilon_{it}$.

The definition of a price elasticity ε is given by equation (3) where q refers to quantity and p refers to price:

(3) $\varepsilon = (\Delta q/q) / (\Delta p/p)$

Solving for the change in quantity yields equation (4):

(4) $\Delta q = \varepsilon * q */ (\Delta p/p)$

Algorithms (5) to (7) below are used to estimate the consumption impact due to changes in price. The changes in prices (Δ Step 1 and Δ Step 2) are each measured from a flat rate equivalent of $0.0655 per kilowatt-hour.

Elasticities are the regression coefficients of price from Equations (1) and (2) and account totals are those of March 31, 2009.

(5) Δ Step 1 kWh = Step 1 elasticity per cent Δ Step 1 price*No. Step 1 accounts*Average Step 1 kWh*

(6) Δ Step 2 kWh = Step 2 elasticity per cent Δ Step 2 price*No. Step 2 accounts*Average Step 2 kWh*

(7) Δ kWh = Δ Step 1 kWh + Δ Step 2 kWh

2.3 Results

1. Rate Structure Review. Reviewed rate structure documentation and held discussions with program staff to understand the intent, design and key features of the RIB rate and to build a program logic model. Review of this logic model indicates that the rate structure is appropriate for the following reasons. First, program linkages have face validity and are plausible. Second, assumptions are reasonable and likely to be met. Third, there are objectively verifiable indicators that track key components of the program logic, so progress against objectives can be measured.

2. Customer Awareness. To determine levels and changes in residential customer awareness of the RIB rate the following question was asked with a slight modification for the baseline period before the rate was in place: "Last October, BC Hydro implemented a two-step or two-tiered conservation rate structure for its residential customers. In any given billing period, households pay one rate in the first block of their electricity consumption and a higher rate for any additional electricity consumption that occurs in the second block. Were you previously aware of this new type of rate?" Customer awareness of the RIB rate was 32 per cent in September 2008 and 39 per cent in March 2009, for an increase of 7 per cent. This difference has a z-value of 2.53 and it is significant at the 1 per cent level of significance. Although the level of awareness of the RIB rate has increased significantly, less than one-half of residential customers are aware of the RIB rate.

3. Customer Satisfaction. To determine levels and changes in residential customer satisfaction with the RIB rate the following question was asked of those respondents who were aware of the RIB rate: "Would you say you generally support this two-step conservation rate, oppose it, or are you indifferent to it?" The share of customers supporting the RIB rate was 40 per cent in September 2008 and 51 per cent in March 2009, for an increase of 11 per cent. This difference has a z-value of 2.15 and it is significant at the 2 per cent level of significance. The share of customers opposing the RIB rate was 38 per cent in September 2008 and 24 per cent in March 2009, for a decrease of 14 per cent. This difference has a z-value of -2.98 and it is significant at the 1 per cent level of significance. The share of customers indifferent to the RIB rate was 11 per cent in September 2008 and 21 per cent in March 2009, for an increase of 10 per cent. This difference has a z-value of 2.15 and it is significant at the 2 per cent level of significance. These results indicate a significant strengthening of residential customer support for the RIB rate.

4. Behavioural Change. To understand changes in the frequency of energy conservation behaviours on the part of residential customers, surveyed customers were asked how frequently they undertook a set of ten energy conservation behaviours using a four-point labelled scale. For two behaviours, there was no change in frequency of the behaviour between the two surveys (September 2008 and March 2009). For two behaviours, there was a reduction in the frequency of the behaviour between the two surveys. For three behaviours, there was an increase in the frequency of the behaviour between the two surveys, but the change was not statistically significant. For three behaviours, there was an increase in the frequency of the behaviour between the two surveys and the change was statistically significant at the 10 per cent level. Net energy savings associated with these behavioural changes were not estimated for this evaluation, although such estimates may be available in future RIB rate impact evaluations.

5. Energy and Peak Savings. The changes in prices (Δ Step 1 and Δ Step 2) are each measured from a flat rate equivalent of $0.0655 per kilowatt-hour as shown in Table 2.2.

Table 2.2 Change in Relative Price

	Rate	Flat Rate Equivalent	ΔPrice	ΔPrice/Price
Step 1	0.0598	0.0655	-0.0057	0.087
Step 2	0.0721	0.0655	0.0066	0.101

Econometric models were used to estimate the price elasticities, which in turn were used to calculate energy savings. Table 2.3 on the next page provides the results of the ordinary least square (**OLS**) regression models used for this analysis. Sample sizes, t-values (in parentheses), regression parameters and F statistics are shown in each column. Three asterisks indicate a statistical significance less than 1 per cent, two asterisks a level between 1 and 5 per cent and one asterisk a level of 10 per cent.

Column 2 presents the results for the Step 1 consumption model. All of the regression coefficients are statistically significant at the five per cent level or better and the explanatory power of the model is excellent with an adjusted R-squared of 0.914. The estimated Tier 1 price elasticity is -0.092.

Column 3 presents the results for the Step 2 consumption model. All of the regression coefficients are statistically significant at the five per cent level or better and the explanatory power of the model is excellent with an adjusted R-squared of 0.935. The estimated Tier 1 price elasticity is -0.247.

Table 2.3 Regression Models (Bimonthly Data for F1995 – F2009)

Variable	Tier 1 Consumption	Tier 2 Consumption
Intercept	6.326*** (61.005)	4.497*** (16.116)
Lower Mainland	0.182*** (8.143)	0.823*** (14.013)
Northern Region	-0.090*** (-3.497)	-0.159** (-2.329)
Southern Interior	0.280*** (13.659)	1.178*** (21.652)
Apartment	-0.663*** (-80.961)	-0.594*** (-27.225)
Mobile Home	-0.047*** (-5.678)	-0.272*** (-12.487)
Other Dwelling	-0.359*** (-43.837)	0.983*** (45.075)
Row House	-0.157*** (-19.107)	-0.507*** (-23.251)
Electric Heat[2]	-0.055*** (4.014)	-0.364*** (9.909)
Log of Heating Degree Days	0.102*** (30.339)	0.384*** (42.986)
Log of Unemployment Rate	-0.021*** (-4.577)	-0.053*** (-4.569)
Log of Tier 1 Price	-0.092** (-2.705)	-
Log of Tier 2 Price	-	-0.247** (-2.698)
Adjusted R^2	0.914	0.935
F	1210.422 (0.000)	1624.057 (0.000)
Sample size	3,520	3,520

Note One, two or three asterisks indicate that the coefficient is statistically significant at the 10 per cent, 5 per cent, or 1 per cent level respectively. The t-statistics and probability for the F-test are shown in parentheses.

Table 2.4 provides the estimated energy savings for F2009. Step 1 customers increased their consumption by an estimated 41.3 GWh per year and Step 2 customers reduced their consumption by an estimated 133.3 GWh per year. The net effect is a reduction in estimated consumption of 92 GWh per year.

[2] The negative sign on these parameters is caused by the inclusion of two significant interactions with Electric Heat (choice of heating fuel). When the effect of this variable is considered in tandem with the interactions Dwelling Type x Electric Heat and Heating Type x Log of Heating Degree Days, the presence of electric heating is associated with a positive increase in usage per account – as expected.

Table 2.4 Estimated Change in Energy Consumption by Tier

Tier	Price Elasticity	% Change in Rate	Number of Accounts	kWh per Account[3]	GWh/year Change
Step 1	-0.092	-0.087	1,593,202	3,240	41.3
Step 2	-0.247	0.101	948,392	5,634	-133.3
Total			1,593,202	6,603	-92.0

Table 2.5 summarizes the estimated energy and peak impacts of the RIB Rate for F2009 and compares evaluated energy savings with the rate structure estimate. For F2009, evaluated estimated energy savings are 92 GWh per year compared to the rate structure estimate of 94 GWh per year and estimated peak savings are 20 MW.

Table 2.5 Rate Structure Energy Savings and Peak Savings

	Period	Energy Savings (GWh/year)		Peak Savings (MW)	
		Reported	Evaluated	Reported	Evaluated
RIB Rate	F2009	94.0	92.0	-	20.0

6. Study Limitations. This evaluation study has five limitations, which BC Hydro intends to minimize in the next impact evaluation. First, although the sample used for the regression modelling uses a relatively large panel of 3,520 observations, the treatment period included is only six months. The next impact evaluation will use a longer treatment period, which will add credibility and robustness to the study. Second, since the treatment period covered by this evaluation is relatively short, those customers who have responded to the rate have likely done so through behavioural change measures rather than though retrofit measures. The next impact evaluation will attempt to assess the relative importance of behavioural measures and retrofit measures. Third, residential electricity consumption is affected by several factors which are not included in the model. These factors include increased proliferations of certain end uses such as electronic products, increased energy efficiency of certain end uses such as refrigeration and the impact of DSM activities. The collective impact of these factors on the residential load is not known, but they could have an impact on the estimates of elasticities. Fourth, the demand modelling assumes that customers react symmetrically to price increase and price decreases. As additional months of experience with the RIB rate is gained, this assumption will be examined and tested. Finally, it is important to note that, because of differences in the methodologies used, the elasticity estimates generated in this study are not comparable to those in the RIB rate applications. However, the differences in methodologies do not affect the comparability of the energy consumption values shown in Table 2.4.

2.4 Conclusions and Recommendations

Customer Awareness. Customer awareness was analyzed using the results for the September 2008 and March 2009 Power Smart Tracker waves. Customer unaided awareness of the RIB rate was at 32 per cent in September 2008 but increased to 39 per cent in March 2009. It is recommended that increased efforts be made to increase residential customer awareness of and understanding of the RIB rate.

3 These values pertain to the October 1, 2008 to March 31, 2009 period; tiered pricing was not in effect prior to this time.

Customer Conservation Behaviour. Customer performance of ten key behavioural conservation measures was examined using the results for the September 2008 and March 2009 Power Smart Tracker surveys. For three of ten behaviours, frequencies increased between the two surveys with 90 per cent statistical significance. The remaining seven showed either deteriorating performance or improvements, which were not statistically significant. It is recommended that increased efforts be undertaken to enhance customer performance of energy conservation behaviours.

Energy and Peak Savings. Engineering algorithms using econometric estimates of Step 1 and Step 2 price elasticities were used to estimate energy savings attributed to the RIB Rate. For F2009, estimated energy savings are 92 GWh per year and estimated peak savings are 20 MW. It is recommended that these estimates be used in reporting energy and peak savings.

3 Transmission Service Rate F2007, F2008 and F2009

3.1 Introduction

BC Hydro introduced the Transmission Service Rate (**TSR**) in April 2006 after receiving BCUC approval. The rate involves three main components with an additional program support component outside of the TSR: (1) stepped rate; (2) time of use rate; (3) retail access; and (4) enabling activities. Each of these components is briefly discussed in turn.

The stepped rate RS 1823 replaced the RS 1821 transmission rate, which was a flat rate, with an energy cost of 2.735 cents per kWh. The stepped rate is an inverted block rate where the first 90 per cent of the Customer Baseline Load purchased by a customer is at a lower rate and the balance consumed is at a higher rate. For the introduction of the rate, the price for Tier 2 energy was set at 5.4 cents per kWh and the price for Tier 1 energy was 2.428 cents per kWh.

Time of use rate RS 1825 is an optional rate, which allows customers to reduce their energy bills by changing when they consume electricity. The time of use rate is designed to encourage customers to shift load from peak periods to off-peak periods. The time of use rate also has the same Tier 1 and Tier 2 split, but pricing varies by time of day and season of the year. There are no customers on Time of Use rates at the present time.

Retail access allows customers to purchase some or all of their electricity from suppliers other than BC Hydro. This has the objectives of encouraging the development of independent power producers as well as a more competitive market for bulk electricity in British Columbia (**B.C.**). No customers have chosen the Retail Access option to date.

Program enabling activities are designed to help customers with the identification, appraisal and implementation of projects to reduce energy consumption. Program enabling activities were not included in the terms of reference for this evaluation.

The purpose of this study is to provide an impact evaluation of the TSR, based on the first three years of its implementation.

3.2 Approach

This study uses a multiple lines of evidence approach. The main data sources or lines of evidence included in this study include: program staff interviews; file and documents reviews; billing data; DSM impacts; industrial output; industrial employment; and pre-implementation and post-implementation executive interviews.

A major source of information for this study was a set of detailed interviews with 25 BC Hydro staff and 40 executives from 34 of the largest transmission voltage customers, with the executive interviews conducted in two rounds in October 2008 and March 2009, respectively. The interviews were based on a detailed discussion guide, but they were conversational and open-ended, so that customers were able to talk about the issues that were important to them.

The study used econometric modelling to estimate the impact of the rate on purchased energy consumption. The key point is to estimate the price elasticity of demand, which is defined as a percentage change in purchased electricity consumption divided by the percentage change in price. Because TSR customers are subjected to two prices – the Tier 1 price and the Tier 2 price – both prices need to be included in the model. Two indicators of economic activity are used; shipments of durable goods and industrial sector employment. Finally, because purchased electricity consumption is affected by Power Smart activity, adjusted purchased electricity consumption is used, which is defined as the sum of actual purchases plus estimated Power Smart savings.

The model is estimated using 83 months of data from April 2002 through February 2009. Actual consumption is the sum of monthly consumption aggregated across TSR customers. Power Smart savings are amortized estimates of savings adjusted for persistence and aggregated across TSR customers. Tier 1 price and Tier 2 price are from BC Hydro data. Durable shipments and industrial employment are from B.C. Statistics.

The basic method for the impact analysis uses time-series regression modeling in log linear form. Log linear models have the advantage of having coefficients that are interpretable as elasticities. It is assumed that the log of consumption is a linear function of a constant, the log of Tier 1 price, the log of Tier 2 price, the log of durables output, the log of industrial sector employment and an error term as shown in Equation (1). The impact of stepped rates is then given by the Tier 2 price elasticity γ times the relative change in the Tier 2 price from the base year times Tier 2 consumption lagged one year as given by Equation (2).

$$(1)\ logGWh_t = \alpha + \beta\ logP1_t + \gamma\ logP2_t + \delta\ logdur_t + \zeta\ logemploy_t + error_t$$

$$(2)\ \Delta GWh_t = \gamma * \Delta rate_t * Tier2\_consumption_{t-1}$$

3.3 Results

Energy Savings. The impact of the stepped rate was examined in two ways: first, an examination of trends in energy consumption for BC Hydro’s main customer classes with a view to comparing transmission voltage customer consumption trends with consumption trends for other rate classes and, second, an estimate of the impact of the TSR on energy consumption using an econometric model. On the first point, from F2006 to F2009, residential sales increased at an average annual rate of 3.3 per cent, light industrial and commercial sales increased at an average annual rate 0.7 per cent, other sales increased at an average annual rate 4.4 per cent and total sales were essentially flat, but large industrial sales fell at an average annual rate 4.3 per cent. This is significant support for the hypotheses that the TSR has reduced electricity sales and increased electricity savings. On the second point, the estimated impact of the TSR is given by the Tier 2 price elasticity γ times the relative change in the Tier 2 price from the base year times Tier 2 consumption lagged one year. The estimated impact of the TSR is a run rate reduction in purchased electricity of 236 GWh per year for F2007, 126 GWh per year for F2008 and 113 GWh per year for F2009 for a total of 474.4 GWh per year over three years. The run rate refers to the estimated savings if the response to the rate were in place for a year. It should be noted that the reduction in Tier 2 energy is also driven by two other factors, the level of economic activity as reflected by the log of durable shipments and the log of employment variables and the impact of DSM program enabling activities.

Table 3.1 Electricity Sold by Customer Class (GWh)

	F2004	F2005	F2006	F04-06 Annual % Change	F2007	F2008	F2009	F06-09 Annual % Change
Residential	15,646	15,814	16,261	2.0	16,651	17,553	17,861	3.3
Light industrial & commercial	17,175	17,459	17,913	2.2	18,268	18,406	18,265	0.7
Large industrial	15,505	16,177	16,428	3.0	15,989	15,380	14,303	-4.3
Other	1,825	1,755	1,838	0.4	2,003	1,961	2,083	4.4
Total domestic	50,151	51,025	52,440	2.3	52,911	52,300	52,512	0.0

The impact of the stepped rate on energy consumption is estimated using an econometric model. Table 3.2 presents the results of three nested econometric models. Model 1 includes only price variables and excludes other economic drivers of the load. The sign of the coefficient on the log of Tier 1 price is negative as expected and it is statistically significant (indicated with ***), but the coefficient on the log of Tier 2 price is not statistically significant. Model 2 includes the price variables as well as durables shipments as drivers. The sign of the coefficient on the log of Tier 1 price is negative as expected and it is statistically significant, but again the coefficient on the log of Tier 2 price is not statistically significant. Model 3 includes the price variables as well as durables shipments and employment as drivers. Now, the sign of the coefficients on the log of both Tier 1 price and Tier 2 price are negative as expected, and they are statistically significant and the coefficients on the log of durable shipments and the log of employment are positive as expected and are statistically significant. The preferred regression is Model 3, which has the greatest explanatory power and signs on the price variables, which meet a priori expectations. The results from Model 3 are therefore used in the subsequent analysis.

Table 3.2 Regression Models (Log Adjusted Sales in GWh)

	Model 1	Model 2	Model 3
Constant	20.5857*** (0.0193)	11.6596*** (1.4848)	6.5693*** (1.8247)
LogP1	-0.1694*** (0.0393)	-0.1914*** (0.0326)	-0.2069*** (0.02990)
LogP2	0.0791 (0.0751)	0.0614 (0.0632)	-0.1627** (0.0789)
Log durable shipment	-	0.6145*** (0.1014)	0.5601*** (0.0931)
Log employment	-	-	0.9250*** (0.2231)
Adjusted R^2	0.71	0.82	0.85
Sample size	83	83	83

Table 3.3 provides the details of the impact analysis. As indicated above, the impact of the TSR is given by the Tier 2 price elasticity γ times the relative change in the Tier 2 price from the base year times Tier 2 consumption lagged one year. The estimated impact of TSR is a run rate reduction in purchased electricity of 236 GWh per year for F2007, 126 GWh per year for F2008, 113 GWh per year for F2009 for a total of 474.4 GWh per year over three years. Reduction in

Tier 2 energy is also driven by two other factors, the level of economic activity as reflected by the log of durable shipments and the log of employment variables and the impact of DSM program enabling activities.

Table 3.3 Impact Analysis

	Tier 2 Price	Δ P2/P2	Tier 2 Energy Lagged	Price Elasticity	Δ GWh/year
F2006	2.735	-	-	-	-
F2007	5.4	0.9744	1,488	-0.1627	235.9
F2008	5.4	0.9744	795	-0.1627	126.0
F2009	7.36	1.6910	410	-0.1627	112.8
F2007-F2009	-	-	-	-	474.7

3.4 Conclusions and Recommendations

1. Process Evaluation. Recommend that a further round of Executive Interviews be conducted in the spring of 2010 to assist with a future evaluation of the TSR. The scope and content of the executive interview information collection protocol should be harmonized with the information needs of rate management.

2. Impact Evaluation. Recommend that the possibility of using customer specific data be explored for the next impact evaluation. This could include estimation of a statistically adjusted engineering model if appropriate drivers of individual customer loads can be obtained.

3. Reporting. Recommend that the evaluated estimates of energy and peak savings be used in future reporting for F2007, F2008 and F2009.

4 Power Smart Windows F2008 and F2009

4.1 Introduction

Windows represent a major area of heat loss in the typical residential dwelling. High performance Energy Star windows can substantially reduce windows-related energy loss. At the time of program launch in 2005, Energy Star windows had very low market shares in both the residential renovation and the residential new construction market. BC Hydro introduced the Power Smart Windows Initiative to increase market penetration of Energy Star Windows as a first step in transforming the windows market in B.C.

To qualify as an Energy Star window, the window must meet the maximum allowable U-value, which varies by climate zone. The U-value refers to the watt loss per degree Celsius per square metre of glazing. Canada is divided into four climate zones where Zone A is the mildest zone and Zone D is the coldest zone and only Zones A, B and C are represented in B.C. The baseline window is a double glazed window with clear glass, vinyl frame and sash, air filled, with a U-value of 2.73. The baseline window watt loss is based on pre-program market research with manufacturers and distributors. To meet the Energy Star requirements, windows need to have some combination of the following features: double or triple glazing with a sealed glass unit; low-emissivity glass; an inert gas such as argon or krypton in the sealed unit, low conductivity of warm edge spacer bars; insulated frame; and good air tightness. Low-emissivity refers to a layer which goes between the glass panes and which slows the transfer of heat between the inside and outside of the window and reflects sunlight reducing heat gain in the summer time.

The Power Smart Windows Initiative was launched in September 2005 as a component of the Renovation Rebate and New Home programs. It offered rebates of $1 per square foot for Energy Star windows installed in electrically heated single family dwellings, duplexes, row houses and apartments. The financial incentives were supported by a number of additional activities including advertising, manufacturer and retailer negotiations, trade ally partnerships, website promotions and windows certification. As of March 1, 2007, BC Hydro’s financial incentive to Energy Star window purchasers was replaced by an exemption from the 7 per cent provincial sales tax. BC Hydro continued with a number of other program activities. For F2008, Power Smart had a negotiated Fall Promotion, where manufacturers offered a windows incentive to BC Hydro customers. BC Hydro supported the Fall Promotion through a print media buy, funding for co-operative advertising and website support. Some 14 manufacturers participated in the Fall Promotion. For F2009, Power Smart had a negotiated Fall Promotion and a negotiated Spring Promotion, where again manufacturers offered a windows incentive to BC Hydro customers, supported by print media, website, co-operative advertising and contest support. Some 12 manufacturers participated in the Fall Promotion, while 17 manufacturers participated in the Spring Promotion. The purpose of this study is to conduct a process, market and impact evaluation of the Power Smart Windows Initiative for F2008 and F009.

4.2 Approach

For this study, there are five main evaluation issues as follows:

- **Program Review.** Conduct a detailed program review, including documenting the history of program activities, summary of program energy and cost metrics and development of a program logic model;

- **Demand-side Assessment.** Undertake a demand-side market assessment, including customer satisfaction, primary reasons for replacing windows, importance of various windows attributes in window choice and non-energy benefits;

- **Supply-side Assessment.** Undertake a supply-side market assessment, including manufacturer satisfaction and sales of glazing by area for new dwellings and retrofits;

- **Sales Impacts.** Evaluate program impacts on incremental sales of Energy Star windows; and

- **Energy and Peak Impacts.** Evaluate program impact on electricity energy consumption, electricity peak consumption, natural gas energy consumption and natural gas peak day consumption.

Table 4.1 summarizes the evaluation issues, data sources and methods of this study.

Table 4.1 Power Smart Windows: Evaluation Issues, Data Sources and Methods

Evaluation Issue	Data Source	Method
Program Review	Program documents Staff interviews	Program logic model
Demand-side analysis	Customer survey (n = 800)	Cross tabulations
Supply-side analysis	Manufacturer survey (n = 18)	Cross tabulations
Sales impacts	Baseline and subsequent surveys	Econometric models of demand and supply
Energy and peak impacts	Baseline surveys Residential End Use Survey Weather data	Whole building energy models

The study applies an interrupted time-series model using regression analysis as well as building energy modelling. The regression analysis is used to estimate the increase in Energy Star qualifying glazing areas due to the program. The building energy modelling is used to estimate the reduction in electricity and natural gas consumption per square foot of incremental Energy Star qualifying glazing. The product of the change in glazing area times the change in energy consumption then gives the change in energy use due to the program. Because of the complexity of this evaluation a multiple lines of evidence approach is used. Multiple lines of evidence are used when no single line of evidence or methodology can provide information on all of the evaluation issues of interest.

Regression modeling is used to estimate the impact of the program on incremental installation of Energy Star qualifying glazing. Equation (1), Equation (2) and Equation (3), respectively, are used to model the program impact on new homes, renovations and the total market and Equation (4) is used to model the supply-side of the model.

Equation (1) indicates that the incremental area of Energy Star glazing in new residential construction measured in thousands of square feet is a linear function of a constant term, the number of new housing starts in thousands of units, the price ratio of Energy Star windows to non-Energy Star windows, a program variable (that takes on the value zero from F1999 to F2007, the value 1 in F2008 and the value 2 in F2009) and an error term.

$$(1)\ NArea_t = \alpha_1 + \beta_1\ Starts_t + \gamma_1\ Priceratio_t + \delta_1\ Program_t + \varepsilon_{1t}$$

Equation (2) indicates that the incremental area of Energy Star glazing in renovations is a linear function of a constant term, the number of new housing starts in thousands of units, the price ratio of Energy Star windows to non-Energy Star windows, a program variable and an error term.

(2) $RArea_t = \alpha_2 + \beta_2\ Starts_t + \gamma_2\ Priceratio_t + \delta_2\ Program_t + \varepsilon_{2t}$

Equation (3) indicates that the total incremental area of Energy Star glazing is a linear function of a constant term, the number of new housing starts in thousands of units, the price ratio of Energy Star windows to non-Energy Star windows, a program variable and an error term. Note, first, that the subscript t refers to year t and, second, that the subscript refers to new residential construction, the subscript 2 refers to renovations and the subscript 3 refers to the total market for windows.

(3) $TArea_t = \alpha_3 + \beta_3\ Starts_t + \gamma_3\ Priceratio_t + \delta_3\ Program_t + \varepsilon_{3t}$

Equation (4) indicates that the price ratio for Energy Star windows is a function of a trend term, the program variable and an error term.

(4) $Priceratio_t = \alpha_4 + \beta_4\ Trend_t + \gamma_4\ Priceratio_t + \varepsilon_{4t}$

4.3 Results

1. Program Review. Before program launch, BC Hydro conducted detailed baseline research to understand the nature of the windows markets for new construction and for retrofits. This research found that the share of Energy Star windows sold in the combined retrofit and new construction market was less than five per cent. This research also identified several barriers to increased sales and market penetration of Energy Star windows. The rationale for the program was to address these barriers through an integrated and coordinated set of program activities. Based on interviews with program staff, a review of program documents and the literature review, four main program activities were identified: (1) window certification support; (2) manufacturer and retailer support; (3) advertising and other promotions; and (4) manufacturer window incentives. For each of the four sets of activities, the summary logic model documents the chain from inputs to outputs to purposes to goals. In other words, the model indicates that at each level of the logic if the assumptions are met, then the next level of the logic will be achieved. The assessment is that each of the logic chains is plausible and realistic. It is therefore, concluded that the program has a valid and realistic program rationale.

2. Demand-side Assessment. The demand-side market assessment is based primarily on a survey of 800 BC Hydro customers who purchased windows as part of a renovation and participated in the Power Smart windows initiative. Customers were asked a variety of questions about their levels of satisfaction with Energy Star windows and the windows initiative. The share of customers who were either satisfied or very satisfied with various attributes is as follows: overall satisfaction with the Energy Star windows initiative (68 per cent); knowledge of the window contractor (79 per cent); choice of windows qualifying for the rebate (70 per cent); information available on the Energy Star windows initiative (66 per cent); information available on Energy Star windows (69 per cent); and satisfaction with Energy Star windows (95 per cent). Customers were asked the relative importance of various attributes in their choice of windows. The share of customers who said the reason was either important or very important is as follows: comfort in your home (93 per cent); energy efficiency (92 per cent); appearance (82 per cent); initial cost of window (66 per cent); noise transmission (68 per cent); and ultraviolet light transmission (59 per cent).

3. Supply-side Assessment. The supply-side assessment is based primarily on a series of surveys of B.C. window manufacturers, in particular, the most recent survey that was conducted in June 2008. The number of window manufacturers producing Energy Star Windows in B.C. increased from five in June 2005 to 19 in September 2006 and to 27 in May 2008. Window manufacturers were asked a variety of questions about their levels of satisfaction with Energy Star windows and the windows initiative. The share of manufacturers who were either satisfied or very satisfied with various attributes is as follows: overall initiative satisfaction (50 per cent); frequency of communications from BC Hydro (50 per cent); display and promotional materials provided by BC Hydro (50 per cent); opportunities for co-operative joint advertising with BC Hydro (39 per cent); processes and procedures to certify windows as Energy Star windows (39 per cent); effectiveness of BC Hydro's education awareness campaign (28 per cent); and BC Hydro's sales training in Energy Star windows (17 per cent).

4. Sales Impacts. A simple demand and supply model is applied in which the price is established to clear the market, that is, the quantity demanded equals the quantity supplied at the market clearing price. The demand equation for the total windows market in F2008 as shown in Table 4.2 has an excellent fit, with an adjusted R-squared value of 0.98 and all of the regression coefficients are statistically significant. The equation indicates that for glazing in new construction and renovations, an increase of 1,000 starts increases Energy Star glazing area by 44,300 square feet, a doubling of the Energy Star to non-Energy Star price ratio reduces Energy Star glazing area by 237,000 square feet and the presence of the Power Smart windows initiative increases the Energy Star glazing area by 2,440,000 square feet in F2008. The demand equation for F2009 indicates that the presence of the Power Smart Windows Initiative increases the Energy Star glazing area by 4,880,000 square feet in F2009.

Table 4.2 Determinants of Energy Star Glazing Area, F2008
(000 Square Feet)

	New Construction (1)	Renovation (2)	Total (3)
Constant	21,296*** (4872)	7385*** (736)	28,680*** (4,819)
Starts (000)	34.3*** (12.0)	10.0*** (3.2)	44.3*** (12.9)
Price ratio	-179*** (40)	-58*** (5.8)	-237*** (40)
Program	1720** (719)	721*** (86)	2,440*** (734)
Adjusted R^2	0.97	0.99	0.98
F	114.6 (0.00)	316.7 (0.00)	182.6 (0.00)
Durbin-Watson	2.43 (-0.21)	2.03 (-0.01)	2.57 (-0.28)

Note One, two or three asterisks means that the coefficient is statistically significant at the 10 per cent, 5 per cent or 1 per cent level respectively.

The supply equation for the total market as shown in Table 4.3 has a good fit, with an adjusted R-squared value of 0.72, with two of the three coefficients statistically significant. In particular, the coefficient on the program variable is not statistically significant which means that the current program has no independent impact on price. The key message from this equation is that the price of Energy Star windows falls by 2.2 per cent per year.

Table 4.3 Determinants of Energy Star Price Ratio (ES Price/non-ES Price)

	Price (1)
Constant	1.26*** (0.039)
Trend	-0.022*** (0.0077)
Program	-0.051 (0.055)
Adjusted R^2	0.72
F	12.7 (0.00)
Durbin-Watson	1.16 (0.42)

Note One, two or three asterisks means that the coefficient is statistically significant at the 10 per cent, 5 per cent or 1 per cent level respectively.

5. Energy and Peak Impacts. Unit energy savings are estimated by developing a series of archetypes for 36 scenarios with and without Energy Star windows. The scenarios were modelled using the Lawrence Berkeley National Laboratory's RESFEN 5.0 windows modelling software. The estimates of energy savings were expressed as weighted averages for the three Energy Star climate zones and for B.C. as a whole. Savings were then normalized on a per square foot basis and multiplied by the relevant incremental window area derived from the sales analysis. Incremental electricity energy savings were 6.6 GWh per year for F2008 and 13.3 GWh per year for F2009. Incremental electricity peak savings were 1.4 MW for F2008 and 2.9 MW for F2009.

Table 4.4 Energy and Peak Savings Estimates

	Period	Evaluated Energy Savings	Evaluated Peak Savings
Electricity		**GWh per year**	**MW**
	F2008	6.6	1.4
	F2009	13.3	2.9

4.4 Conclusions and Recommendations

Energy and Peak Demand. Incremental electricity energy savings were 6.6 GWh per year for F2008 and 13.3 GWh per year for F2009. Incremental electricity peak savings were 1.4 MW for F2008 and 2.9 MW for F2009. It is recommended that these numbers be used in reporting.

5 Commercial Power Smart Partner Program F2008 - F2009

5.1 Introduction

The Commercial Power Smart Partner (**PSP**) program utilizes financial incentives to encourage business and institutional customers to complete a variety of retrofit installations. There is also a wide range of additional supporting activities including energy managers, energy management assessments, education and training, recognition, benchmarking and tools for operational and behavioural savings. The main objective of the Commercial PSP program is to acquire significant electricity savings in the short term while laying the groundwork for additional energy savings in the future through the promotion of an energy conservation business culture. Commercial PSP participants must be BC Hydro Tier 1 customers and this means that they must purchase at least $50,000 in electricity per year from BC Hydro. A customer who commits to becoming a Power Smart Partner gains access to technical assistance for the identification and implementation of energy efficiency projects as well as financial assistance to reduce first costs.

The commercial sector includes commercial, government, institutional and First Nations customers and has been segmented into the following two customer classifications:

(1) Large Commercial Customers or Key Accounts: this represents both Tier 1 and 2 customers providing annual revenues to BC Hydro greater than $50,000. There are approximately 490 Tier 1 customers and 1,000 Tier 2 customers with large strategic customers having a Key Account Manager.

(2) Small and Medium Businesses: this represents customers providing annual revenues to BC Hydro less than $50,000. There are approximately 68,000 customers in this segment and these customers do not have a Key Account Manager assigned to them.

Analysis of the market found that there are six key barriers this target market faces relating to energy efficiency and conservation: (1) Affordability; (2) Availability; (3) Awareness; (4) Acceptance; (5) Adoption; and (6) Advocacy. Program activities are aimed at reducing these barriers.

The purpose of this study is to conduct a process, impact and market evaluation of BC Hydro’s Commercial Power Smart Partners program in F2008 and F2009.

5.2 Approach

For this study, the five main evaluation issues are as follows:

- **Program Rationale:** Assess the rationale for the Commercial PSP program.
- **Review:** Assess the effectiveness and efficiency of key program components.
- **Customer Survey**: Examine participant building characteristics, importance of various factors in the program participation decision and participant customer satisfaction.
- **Gross Impacts:** Estimate gross energy and peak savings due to the Commercial PSP program.

- **Net Impacts:** Estimate net energy and peak savings due to the PSP Commercial and SUCH Program.

Gross and net energy savings were estimated for program activity for F2008 and F2009. The impact evaluation addressed program savings as follows: (1) the program's gross energy savings were estimated by applying an appropriate ratio estimator to detailed monitoring and verification data collected for 123 sites (there were 475 participant sites for the period covered by this study); (2) the program's peak savings were estimated by applying the ratio of peak to energy obtained from Load Research; (3) survey based free rider and spillover rates were used to calculate a net program realization rate; and (4) the net realization rate was applied to program estimates of gross energy and peak savings to obtain net energy and peak savings. Evaluation issues, data sources and methods for this study are summarized in Table 5.1.

Table 5.1 Evaluation Issues, Data Sources and Methods

Evaluation Issues	**Main Data Sources**	**Method**
Program rationale	Documents review, program interviews	Program logic model
Program review	Documents review, program interviews	Tabulations
Customer survey	Surveys (n = 45 for F2009 and n = 12 for F2008)	Tabulations
Gross energy and peak savings	Database review On site M&V (n =123)	Stratified ratio estimates
Net energy and peak savings	Surveys (n = 45 for F2009 and n = 12 for F2008)	Free rider and spillover analysis

The Stratified Ratio Estimation approach first stratifies projects by the expected savings, which generally reduces the coefficient of variation of actual savings in each stratum. The measurement and verification (**M&V**) sample projects will therefore be properly weighed up to estimate total program savings. Stratified Ratio Estimation focuses on the relationship between a variable *y* and a second variable *x*. Let x_i represent the expected energy savings of the *i*th site for an energy saving program. And y_i represent the evaluated energy saving of the corresponding site. Let N denotes the number of sites in the population. Then if b denotes the population ratio of evaluated energy savings over expected energy savings among the N sites in the population, then:

$$b = \frac{\sum_{i=1}^{n} w_i \, y_i}{\sum_{i=1}^{n} w_i \, x_i}$$

This is called the stratified ratio estimator. Here n is the number of sites in the M&V sample and w is the case weight of each sample site. With a stratified sample design, the case weight is the number of units in the population in each stratum divided by the number of sites in the sample in the stratum.

For each sample site, the error is calculated as $e_i = y_i - bx_i$. The standard error of b is calculated as:

$$se(b) = \frac{\sqrt{\sum_{i=1}^{n} w_i (w_i - 1) e_i^2}}{\sum_{i=1}^{n} w_i \, x_i}$$

Confidence intervals for the realization rate and for evaluated total program energy savings can be calculated based using this formula.

The relative precision of ratio B is the error bound (at the given level of confidence) divided by the estimate of B. This is equivalent to the following equation:

$$rp = z \frac{cv}{\sqrt{n}}$$

Here rp denotes the relative precision, z denotes the coefficient of the normal distribution at the specified confidence level, n is the sample size and cv denotes the coefficient of variation.

5.3 Results

1. Program Rationale. Program rationale is concerned with the issue of whether or not it is realistic to assume that the program as implemented can achieve its stated objectives. In conducting this assessment of program rationale, program documents were reviewed, in-person interviews were conducted and a program logic model was built. At the risk of some oversimplification, it was determined that the program includes five main activities: (1) program and project management; (2) energy managers; (3) program enablers; (4) implementation fund; and (5) behavioural and operational activities. For each of these five main activities, the following set of linkages was defined: input > output > purpose > goal. In each case, the linkages were judged to be clear, well defined and plausible. Based on this review, it is concluded that the rationale for the program was sound. Each of the five activities is reviewed in the next section.

2. Program Review.

(a) Program and Project Management. The responsibility for planning and oversight rests with Commercial Marketing. This responsibility includes program design, planning, marketing, promotions and monitoring, but it excludes program delivery and related activities.

(b) Energy Manager. A critical initial step is to secure a dedicated energy manager who can work with a company's senior management resources to create and implement a corporate level energy management program. The Energy Manager utilizes the various program techniques and tools such as the program enablers, the implementation fund and behavioural and operational initiatives to ensure that the company's energy policies and long-term goals are met through energy savings initiatives. The energy manager plays a vital role to integrating the other components of PSP's Integrated Energy Conservation Management Approach.

(c) Program Enablers. Enablers provide Power Smart Partners and Energy Managers with the tools, techniques, support and coaching to identify the most appropriate energy efficiency projects to meet the company's energy efficiency targets.

(d) Implementation Fund. The Implementation Fund provides funding for opportunity assessments and energy studies to help identify projects as well as capital incentives to help address an organization's financial barriers to implementing energy efficient initiatives. The capital incentives are tiered based upon the length of a customer's payback and are open to all technologies.

3. Customer Survey. Program success appears to be due primarily to five main factors: (1) comprehensive approach to energy savings and energy management; (2) effective customer relations management through the Key Account Managers; (3) effectiveness of capital incentives in encouraging identified but dormant projects; (4) greater than expected energy and non-energy benefits for customers; and (5) a relatively low cost of acquired energy for BC Hydro.

4. Gross Impacts. Table 5.2 shows the Stratified Ratio Estimation result of realization rate and total evaluated energy savings conducted by end use level for the PSP program. The realization rates for end use of HVAC, lighting, refrigeration and other are estimated as 0.98, 0.96, 1 and 1 respectively with an overall realization rate of 0.97. Total estimated gross energy savings of PSP program is 76.19 GWh.

Table 5.2 Estimation of Realization Rate and Evaluated Savings for PSP

End-use	Expected Savings (GWh/year)	M&V Sites (number)	Realization Rate	Precision at 90% Confidence Level (%)	Evaluated Gross Savings (GWh/year)
HVAC	29.38	17	0.98	2.14	28.78
Lighting	34.36	98	0.96	5.94	32.92
Refrigeration	2.16	4	1.00	0.10	2.16
Other	12.38	4	1.00	0.28	12.33
Total	78.27	123	0.97	2.69	76.19

5. Net Impacts. Table 5.3 shows the program reported and evaluated net savings. The evaluation determined a net realization rate of 0.929, utilizing participant surveys that developed estimates of free riders and spill over effects. Evaluated net incremental energy savings are 25.6 GWh per year in F2008 and 45.2 GWh per year in F2009. Evaluated net incremental peak savings are 4.1 MW in F2008 and 7.3 MW in F2009.

Table 5.3 Reported and Evaluated Net Energy Savings and Peak Savings

Program	Period	Energy Savings (GWh/year)		Peak Savings (MW)	
		Reported	Evaluated	Reported	Evaluated
Commercial PSP	F2008	36	25.6	-	4.1
Commercial PSP	F2009	37	45.2	-	7.3
Commercial PSP	F2008-09	73	70.8	-	11.4

5.4 Conclusions and Recommendations

1. Program Design and Implementation. Commercial PSP has achieved high levels of customer satisfaction. Recent program redesign emphasized a comprehensive approach to energy management and energy efficiency has helped it meet its goal of reducing barriers to market transformation for commercial and institutional customers. There still appear to be opportunities for further program enhancement including the following: (1) increasing understanding of customer decision-making, motives and barriers; (2) encouraging more effective lighting redesign; (3) increasing emphasis on energy efficient cooling and mechanical systems; and (4) placing greater emphasis on sharing lessons learned with trade allies and customers. It is recommended that additional research be undertaken to better understand how the program can achieve broader and deeper savings.

2. Future Research. During review of this study, two additional issues emerged for future evaluation research. First, there is some evidence that the program may be leading to non-participant spillover and this may be quantitatively significant. Second, participant spillover projects may have average energy savings which are different in magnitude than participant projects. It is recommended that the next evaluation examine these two issues.

3. Energy and Peak Impacts. Evaluated net incremental energy savings are 25.6 GWh per year in F2008 and 45.2 GWh per year in F2009. Evaluated net incremental peak savings are 4.1 MW in F2008 and 7.3 MW in F2009. It is recommended that these numbers be used in reporting.

6 Product Incentive Program F2008

6.1 Introduction

The Power Smart Product Incentive Program (**PIP**) began in November 2003. PIP offers financial incentives to encourage business and institutional customers to install a variety of simple retrofit installations and save energy. A wide variety of products are eligible for PIP, although the bulk of savings to date have come from energy efficient lighting products. The program is administered primarily through an online application site which simplifies application procedures and keeps administrative costs low. A sample of PIP projects are site audited to verify installation of the rebated equipment.

The goals of the program include the following: (1) generate energy savings for BC Hydro by replacing inefficient technologies with more efficient technologies; (2) increase energy efficiency awareness by actively communicating product options; (3) educate customers on the benefits of efficient products; (4) contribute to market transformation for specific technologies; (5) better meet the needs of underserved small and medium business customers; and (6) increase business customer satisfaction.

The purpose of this study is to provide a process, market and impact evaluation of the Product Incentive Program.

6.2 Approach

For this study, the five main evaluation issues are as follows:

- **Program Review.** Characterize BC Hydro's Product Incentive Program, including an analysis of the program logic;
- **End Use Consumption.** Characterize end use consumption for main end uses by building segment;
- **Customer Survey.** Assess customer program participation, satisfaction, product installation, free riders, spillover;
- **Program Analysis.** Examine customer applications by main product group and by main space type; and
- **Energy and Peak Savings.** Evaluate energy and peak savings attributable to the program for F2008.

The evaluation issues, data sources and methods used in the study are summarized in Table 6.1. The main evaluation methods used are engineering algorithms based on end use metering.

Table 6.1 Evaluation Issues, Data Sources and Methods

Evaluation Issues	Main Data Sources	Method
Program review	Program files Program interviews	File review
End use consumption by segment	Site visits (n = 316) Billing data Weather data	DOE 2.1 models
Participation, satisfaction, product installation, free riders, spillover	Customer survey (n = 150) Program interviews	Cross tabulations
Market analysis	Program data base Previous evaluations	Cross tabulations
Energy and peak savings	On-site metering Program data base	Engineering algorithms

Gross and net energy savings were estimated for program activity completed in the period April 1, 2007 through March 31, 2008. Gross savings are the basic estimate of program savings and are usually based on an engineering study and/or technical calculations. Gross savings generally do not account for factors external to the program that could impact energy savings and may therefore include energy savings that are not attributable to the program. In contrast, net savings are estimated by adjusting the initial gross savings estimates by the expected influences of non-Program related factors including free-ridership, and spillover. Gross savings estimates for the PIP program are calculated automatically when the customer enters the project information into the online application and rely on deemed savings algorithms for each technology type.

Gross savings were estimated using the following algorithm, where W_{pre} and W_{post} are the wattages of the original and replacement products, hours refers to hour of use for the relevant space type, area refers to the area of the relevant space type and the summation is over areas:

$$(1) \quad Gross\ kWh_{savings} = \sum (W_{pre} - W_{post}) * hours\ of\ use_{area} / 1000.$$

Since the program applications provided these calculations with assumed hours of use, the major calculation was to correct the assumed hours of use by space-weighted actual hours of use based on metering data. Gross peak demand was estimated by using the ratio of average kWh to peak kWh from a previous evaluation.

Net savings were estimated using the following algorithm, where W_{pre} and W_{post} are the wattages of the original and replacement products, hours refers to hours of use for the relevant space type, area refers to the area of the relevant space type and the summation is over areas:

$$(2) \quad Net\ kWh_{savings} = \sum (W_{pre} - W_{post}) * hours\ of\ use_{area} / 1000 * (1 - free\ rider\ rate + spillover\ rate).$$

Again, net peak demand was estimated by using the ratio of average kWh to peak kWh from a previous evaluation.

6.3 Results

1. Program Review. The PIP has been successful in building a high level of product awareness and purchase behaviour for energy efficient lighting products in the commercial sector and institutional sector. The program has been gaining some momentum, with increased customer applications for efficient lighting products leading to increased annual savings. Program rationale was examined using a program logic model, examining the linkages among inputs, outputs, purpose and goal for each activity. It was found that the program logic model made sense and that the PIP had a strong program rationale.

2. End Use Consumption. DOE 2.1 models for 316 sites, based on detailed on-site audits, were used to examine end use consumption by building type. The analysis found that: (1) total consumption per square foot varies substantially across building segments, from a low of 10.2 kWh per square foot per year for elementary schools to a high of 74 kWh per square foot per year for large grocery stores; (2) for most building segments, interior lighting is the most important end use with refrigeration for large grocery stores and recreation centres, domestic hot water for hotels/motels and equipment for restaurants and miscellaneous establishments among the biggest end uses; and (3) savings opportunities for most segments include interior lighting and HVAC.

Table 6.2 End-use Electricity Consumption (kWh/ft2/year)

Facility type	Cool	Heat	Int. Light	Equip	HVAC Aux	Refrig.	Ext. Light	Elev.	DHW	Cook	Total
Large grocery	2.4	1.9	14.4	4.6	5.6	28.0	3.0	0.3	4.2	9.6	74.0
Hotel/motel	1.1	4.7	6.1	2.7	2.7	1.1	0.8	0.8	10.1	1.1	31.2
Health care	0.5	4.3	5.7	1.9	3.3	0.5	0.4	0.5	1.6	0.7	19.4
High rise office	2.9	3.3	8.0	2.8	4.4	0.1	0.7	0.6	0.8	0.3	23.9
Low rise office	1.9	2.7	7.1	2.5	3.5	0.5	0.8	0.8	0.4	0.4	20.6
Library	1.5	3.7	8.2	1.8	3.1	0.1	0.9	0.8	0.5	0.2	22.2
Recreation centre	1.4	2.6	6.9	2.8	6.8	9.2	0.6	0.5	1.0	0.6	32.4
Large retail	1.8	2.3	9.9	2.3	3.5	0.1	3.1	0.6	0.9	0.5	25.0
Restaurant	3.5	4.0	9.7	17.8	9.2	3.2	4.3	0.2	3.6	10.0	65.5
Elementary school	0.2	2.8	3.5	0.5	1.8	0.1	0.3	0.2	0.2	0.6	10.2
Secondary school	0.3	4.4	4.1	0.8	2.1	0.1	0.3	0.1	1.0	0.2	13.4
Wholesale	1.1	3.9	7.8	5.3	2.4	15.9	0.9	0.2	0.5	2.2	39.2
Miscellaneous	1.9	2.6	7.9	16.1	7.0	1.6	1.5	1.0	1.5	0.3	41.4

3. Customer Survey. A detailed survey was conducted with 150 program participants, covering a range of program aspects. Customers were asked how they became aware of the PIP: the most important sources of customer awareness of the PIP were an electrical distributor or contractor (37 per cent), BC Hydro Account Manager or Customer Care Representative (31 per cent), BC Hydro website (19 per cent) and BC Hydro bill inserts or other promotional literature (14 per cent). Customers were asked about the importance of various factors in their decision to participate in the PIP: the most important factors included reducing energy use to save money (top-two box score of 4 or 5 was 89 per cent) and reducing energy use to save the environment (top-two box score of 4 or 5 was 89 per cent). Customers were asked about their satisfaction with various components of the PIP: areas with particularly high satisfaction levels included service provided by contractors, distributors and BC Hydro personnel, while areas with lower levels of satisfaction included direct mail information about the PIP and the level of incentives offered. Customers were also asked about key characteristics of installed equipment as summarized in Table 6.3.

Table 6.3 Some Characteristics of Installed Equipment (%)

Product Type	Share of Pre-existing Equipment Upgraded (%)	Product Use (hours per day)	Product Share Installed and Functioning (%)
Compact fluorescent lamps	66	15.2	96
Energy saver T8 lamp	68	15.1	99
Standard T8 lamp	59	14.7	95
LED exit signs	76	21.8	97
Halogen infrared lamps	16	13.1	92
High bay fluorescent lamps	33	12.2	90
EE metal halide lamps	43	15.2	97
Pulse start metal halide lamps	43	14.2	100
High pressure sodium lamps	27	13.3	100
Adjustable speed drives	37	13.4	100
Occupancy sensor AC	48	11.4	91
Occupancy sensor lighting	18	12.2	90
Switch plate mounted timers	29	9.7	100
Vending machine sensor	28	13.5	100
Synchronous belt drive	29	10.9	100

4. Program Analysis. The distribution of applications by product type and by facility type was examined. Total product installations under the PIP for F2008 were 276,751. The product shares were: standard T8 (5.1 per cent); energy savings T8 (60 per cent); CFL (17.2 per cent); metal halide (2.3 per cent); halogen infrared (0.9 per cent); other lighting products (11 per cent); and mechanical and other products (3.6 per cent). Program activity is quite concentrated as just two building segments (hotel/motel/strata residences and offices) account for 45 per cent of identified applications.

5. Energy and Peak Impacts. Gross and net energy savings were estimated for program activity in the period April 1, 2007 through March 31, 2008, as shown in Table 6.4. This evaluation addressed gross program savings as follows: (1) the gross savings algorithms and parameter assumptions used in the calculation of program deemed savings were reviewed and modified using BC Hydro light logger data provided by the Measurement and Verification department and reference data used by other similar incentive programs; and (2) net savings were based on gross savings modified by survey based free rider and spillover rates.

Table 6.4 Estimated Energy Impacts

Technology	Gross savings	1 – FR + SO	Net savings
Standard T8	1.786	1.033	1.972
Energy Saver T8	4.524	1.105	5.344
CFL	10.011	1.045	11.183
Metal halide	1.449	1.019	1.578
Halogen infrared	0.332	0.796	0.283
Other lighting	2.358	1.019	2.569
Mechanical	1.874	0.989	1.853
Total	22.334		24.782

Evaluated energy savings are 24.8 GWh per year compared to program reported energy savings of 27.5 GWh per year. Evaluated peak savings are 3.4 MW compared to peak savings based on the program reported energy savings of 3.8 MW, using the energy-peak relationship from the previous PIP evaluation.

Table 6.5 Program Energy Savings and Peak Savings

Program	Period	Energy (GWh/year)		Peak (MW)	
		Reported	Evaluated	Reported	Evaluated
Product Incentive Program	F2008	27.5	24.8	3.8	3.4

6.4 *Conclusions and Recommendations*

1. Program Design and Implementation. Although the PIP has been successful at encouraging energy efficient lighting retrofits, it has had limited success in encouraging energy efficient retrofits for end uses other than lighting. It is recommended that marketing research focus on understanding the energy needs and values of commercial customers in the non-lighting area with a view to identifying additional opportunities for a cost-effective prescriptive commercial program.

2. Effectiveness of Marketing and Incentives. As noted above, when customers were asked about their satisfaction with various components of the PIP, areas with lower levels of satisfaction included direct mail information about the PIP and the level of incentives offered. It is recommended that a comparative review of the level of financial incentives and marketing activities for PIP be undertaken to determine whether program participation and savings can be increased in a cost effective manner.

3. Energy and Peak Savings. Evaluated energy savings are 24.7 GWh per year compared to program reported energy savings of 27.5 GWh per year. Evaluated peak savings are 3.4 MW compared to peak savings based on the program reported energy savings of 3.8 MW. It is recommended that reported energy and peak savings be replaced by these evaluated energy savings and evaluated peak savings numbers.

7 Product Incentive Program F2009

7.1 Introduction

The PIP began in November 2003. The PIP offers financial incentives to encourage business and institutional customers to install a variety of simple retrofit installations and save energy. A wide variety of products are eligible for the PIP, although the bulk of savings to date have come from energy efficient lighting products. The program is administered primarily through an online application site which simplifies application procedures and keeps administrative costs low. A sample of PIP projects are site audited to verify installation of the rebated equipment.

The goals of the program include the following: (1) generate energy savings for BC Hydro by replacing inefficient technologies with more efficient technologies; (2) increase energy efficiency awareness by actively communicating product options; (3) educate customers on the benefits of efficient products; (4) contribute to market transformation for specific technologies; (5) better meet the needs of underserved small and medium business customers; and (6) increase business customer satisfaction.

The purpose of this study is to provide a process, market and impact evaluation of the Product Incentive Program.

7.2 Approach

Evaluation issues in this study were examined in conjunction with internal BC Hydro stakeholders. The four main evaluation issues are as follows:

- **Program Review.** Describe the program and provide an analysis of program logic;
- **Customer Survey.** Assess customer participation and satisfaction with the program; tabulate the number of products installed and calculate free-ridership and spillover rates;
- **Program Analysis.** Examine customer applications by product group and space type; and
- **Energy and Peak Savings**. Evaluate energy and peak savings attributed to the program in Fiscal Year 2009.

The evaluation issues, data sources and methods used in the study are summarized in Table 7.1.

Table 7.1 Evaluation Issues, Data Sources and Methods

Evaluation Issues	Main Data Sources	*Method*
Program review	Program files Program interviews	*File review*
Satisfaction, installation, free riders, spillover	Customer survey (n = 140) Program interviews	*Cross tabulations*
Market analysis	Program data base Previous evaluations	*Cross tabulations*
Energy and peak savings	On-site metering Program data base	*Engineering algorithms*

An updated extract containing information on all projects completed in F2009 was obtained in late September 2009. Customer awareness, satisfaction, program experience, respondent free rider and spillover questions are addressed in a telephone survey of 140 program participants conducted during June and July 2009. Gross and net energy savings were estimated for program activity completed between April 1, 2008 and March 31, 2009. Since gross savings do not account for factors external to the program that might affect savings calculations, net savings adjust initial savings estimates for the influence of non-program related factors. This includes the effects of free-ridership, and spillover. Initial (gross) savings estimates for PIP are calculated automatically when the customer enters project information online and derives from deemed savings algorithms by technology type.

Gross savings estimates apply an algorithm in which W_{pre} *and* W_{post} represent the watt rating of original and replacement products, *hours of use* pertain to the space type and *area* refers to the area of the space type. Results are then summed over space areas as indicated in Equation (1) below:

$$(1) \quad Gross\ kWh_{savings} = \sum (W_{pre} - W_{post}) * hours\ of\ use_{area} / 1000.$$

Assumed hours of use from applications are adjusted according to actual space-weighted hours obtained from on-site metering. Gross peak demand is then estimated by using the ratio of average kWh to peak kWh from the most previous evaluation.

Net savings apply a modified form of the algorithm shown in Equation (1) in which W_{pre} and W_{post} are wattages of original and replacement products, hours of use pertain to space type, area refers to space type. A free-rider rate is added to account for customers who would have purchased the new technology without incentives; a spillover rate is included to account for additional energy efficient purchases collateral to (but influenced by) the program. Results are then summed over space areas as indicated in Equation (2) below:

$$(2)\ Net\ kWh_{savings} = \sum (W_{pre} - W_{post}) * hours\ of\ use_{area} / 1000 * (1 - free\ rider\ rate + spillover\ rate).$$

Net peak demand is estimated by using the ratio of average kWh to peak kWh from a previous evaluation.

7.3 Results

1. Program Review. The PIP has built a high level of product awareness and increased consumption of energy efficient lighting products in both the commercial and institutional sectors and has gained momentum as more customers apply for incentives. Program rationale was examined using a program logic model, examining the linkages among inputs, outputs, purpose and goal for each activity. The logic model is consistent and reflects a strong program rationale.

2. Customer Survey. A detailed survey was conducted with 140 program participants, covering range of program aspects. When customers were asked how they became aware of PIP, the most important sources of customer awareness were electrical distributors or contractors (36 per cent), BC Hydro Account Manager or Customer Care Representative (19 per cent), BC Hydro website (11 per cent) and BC Hydro bill inserts or other promotional literature (9 per cent). When asked about the importance of various factors in their decision to participate, customers reported the most important factors as (1) reducing energy use to save money (top-two box score of 4 or 5 was 96 per cent) and (2) reducing energy use to save the environment (top-two box score of 4 or 5 was 88 per cent). Customer satisfaction with various program components was particularly high with the service provided by contractors, distributors and BC Hydro personnel. Other areas with lower levels of satisfaction included direct mail program information as well as the level of incentive offered.

3. Program Analysis. Total product installations under the PIP for F2009 were 230,738. The product shares were: standard T8 (8.5 per cent); energy savings T8 (21.9 per cent); CFL (18.7 per cent); metal halide (0.5 per cent); halogen infrared (2.8 per cent); other lighting products (23.7 per cent); computer-related installations (23.5 per cent); and mechanical and other products (0.5 per cent).

4. Energy and Peak Savings. Gross and net energy savings were estimated for program activity in the period April 1, 2008 through March 31, 2009. This evaluation addressed gross program savings as follows: (1) the gross savings algorithms and parameter assumptions used in the calculation of program deemed savings were reviewed and modified using BC Hydro light logger data provided by the Measurement and Verification department and reference data used by other similar incentive programs; and (2) net savings were based on gross savings modified by survey based free rider and spillover rates. Table 7.2 summarizes evaluated energy savings and peak savings for the Product Incentive Program for F2009. Evaluated energy savings are 65.80 GWh per year compared to program reported energy savings of 61.38 GWh per year. Evaluated peak savings are 9 MW compared to peak savings based on the program reported energy savings of 8.4 MW, using the energy-peak relationship from the previous PIP evaluation.

Table 7.2 Program Energy Net Savings and Peak Savings

Program	**Period**	**Energy (GWh/year)**		***Peak (MW)***	
		Reported	Evaluated	Reported	*Evaluated*
Product Incentive Program	*F2009*	*61.4*	*65.8*	*8.4*	*9.0*

7.4 Conclusions and Recommendations

Energy and Peak Impacts. Gross and net energy savings were estimated for program activity in the period April 1, 2008 through March 31, 2009. This evaluation addressed gross program savings as follows: (1) the gross savings algorithms and parameter assumptions used in the calculation of program deemed savings were reviewed and modified using BC Hydro light logger data provided by the Measurement and Verification department and reference data used by other similar incentive programs; and (2) net savings were based on gross savings modified by survey based free rider and spillover rates. (Net) evaluated energy savings are 65.8 GWh per year compared to program reported energy savings of 61.4 GWh per year. Evaluated peak savings are 9 MW compared to peak savings based on the program reported energy savings of 8.4 MW, using the energy-peak relationship from the previous PIP evaluation.

8 Residential Lighting Program: CFL Component F2009

8.1 Introduction

Compact fluorescent lamps (**CFLs**) offer an opportunity to reduce lighting costs significantly because they can be used to replace incandescent bulbs in most types of fixtures. BC Hydro's current residential lighting program is a multi-year energy acquisition and market transformation program. The program's CFL component is aimed at motivating residential customers to obtain the best long-term value from their choice of household lighting and to shift customer behaviour and the lighting market so that efficient usage becomes a way of life. When the program was initiated in 2001, CFLs were purchased in bulk by BC Hydro and given free to customers through redeemable vouchers at partnering retail outlets. The program has evolved and mail-in and point-of-sale rebates coupons were also used to promote the purchase of CFLs. The current program relies on instant in-store discounts. The purpose of this study is to provide a process, market and impact evaluation of the CFL component of the Residential Lighting Program.

8.2 Approach

For this study, the five main evaluation issues are as follows:

- **Program Review.** Characterize BC Hydro's CFL component;
- **Supply-side Analysis.** Characterize the supply-side of the residential CFL market in B.C.;
- **Demand-side Analysis.** Characterize the demand-side of the residential CFL market in B.C.;
- **Market Model.** Examine the determinants of CFL purchases; and
- **Energy and Peak Savings.** Evaluate energy and peak savings attributable to the program for F2009.

The basic evaluation approach is a quasi-experimental design using residential customers in North and South Dakota as a comparison group. The evaluation issues, data sources and methods used in the study are summarized in Table 8.1.

Table 8.1 Evaluation Issues, Data Sources and Methods

Evaluation Issues	**Main Data Sources**	**Method**
Program review	Program documents Staff interviews	Documents review
Supply-side analysis	Retail shelf space study	Cross tabulations
Demand-side analysis	Consumer surveys	Cross tabulations
Market model	Consumer surveys	Poisson regression model
Energy and peak saving for F2009	Participant, non-participant and consumer surveys On-site hours of use monitoring	Engineering algorithms

8.3 Results

1. Program Review. The Residential Lighting Program is an electricity acquisition and market transformation program aimed at motivating residential customers to obtain the best long-term value from their choice of household lighting. From March 2002 to August 2004, Residential Power Smart commenced the first phase of its residential lighting program - a free CFL giveaway campaign at retail locations designed to introduce customers to CFLs and educate them on the benefits of this relatively new technology. From October to December 2004 and again from September to December 2005 BC Hydro launched a second phase of its lighting program – a two-tier lighting rebate campaign that featured seasonal LED lights (**SLEDs**), compact fluorescent torchieres (**CFTs**) and CFLs. Mail-in rebate coupons were made available to B.C. residents at shelf level and through BC Hydro's Internet site. From October 2006 to April 2007 BC Hydro launched a third phase of its residential lighting program – a two-tier retail (silver and gold) campaign that featured Energy Star fixtures and CFLs. From October 2007 to Present: BC Hydro increased its focus on Energy Star Fixtures and a transition of the CFL activities starting in spring 2008 to focus on Specialty CFLs (A-line, 3-way, candelabra, reflectors, globes and dimmable) and away from standard spirals. By spring 2008, couponing had been removed from the program, incentives were provided by instant in-store discounts and manufacturers' buy downs. The program has been successful in building a high level of product awareness and purchase behaviour for energy efficient lighting products in the residential sector.

The program rationale was examined using a program logic model, examining the linkages among inputs, outputs, purpose and goal for each activity. The logic model is consistent and reflects a strong program rationale.

2. Supply-side Analysis. Supply-side characteristics were primarily assessed through a shelf space study of 38 major retailers of CFLs, which collected information on CFL market share, range of product choice, price and affordability. Some key supply-side findings included the following:

- Total shelf space allocated to CFLs by regions increased significantly to 25 per cent in November 2008 from 14 per cent in November 2007. CFLs accounted for 6.1 per cent of shelf space in the 2002 baseline survey;

- Spiral CFLs still dominated the market, accounting for 70.8 per cent of all CFLs on store shelves in 2008. They were typically packaged in multiples of two or more and offered the best value on a per-CFL bulb basis. The total share of specialty CFLs increased to 29.2 per cent in F2009 from 27.9 per cent in F2008;

- CFLs rated at 13 to 15 watts accounted for the largest share (54 per cent) of CFL product in F2009, an increase of 10 per cent points from F2008. Home improvement and hardware stores offered the greatest selection of CFLs in terms of wattages, brands and models. Department stores offered the least selection;

- In F2009 40 per cent of CFLs had an average rated lifespan of 10,000 hours; CFLs rated at 8,000 hours (34 per cent) and 6,000 hours (23 per cent) rounded out a second tier that accounted for the remainder of the market; and

- In F2009, the average price of spiral CFLs fell 30 per cent from F2008 to $3.90 per bulb. The average price of A-shape bulbs also decreased by about 17 per cent.

3. Demand-side Analysis. Demand-side characteristics were determined mainly through comparison of customer survey results of 605 BC Hydro customers with 600 households in

North and South Dakota. The Dakotas were selected for the comparison group because they are demographically similar to B.C. but have had no substantive CFL programming. In this quasi-experiment study, participants were asked to recall their awareness of CFL, purchasing and replacing behaviours of CFLs and key features of their household in F2009. Key findings from the survey included:

- About 96 per cent of surveyed BC Hydro residential customers were aware of CFLs in November 2008, which had increased slightly from 95 per cent in January 2008 and perhaps reflecting government announcements that sale of the most common types of incandescent lamps would end in 2012;

- Recall of information, advertising, or promotions from BC Hydro Power Smart regarding CFLs slightly increased to 69 per cent from 64 per cent in F2008. It was 68 per cent in January 2007 and 73 per cent in January 2006;

- Eighty-four per cent of BC Hydro residential customers had at least one CFL in use as of November 2008, compared with 85 per cent in January 2008, but significantly up from 23 per cent in the baseline year of 2002. On average, households purchased 8.7 CFLs in the previous year in November 2008, which was slightly up from 8 in January 2008. Also the net installation rate decreased from 69 per cent in January 2008 to 64 per cent in November 2008;

- Customers were asked their reasons for using CFLs rather than using incandescent lamps. The most frequently mentioned reasons were to conserve electricity and to save money;

- About 78 per cent of BC Hydro's surveyed households indicated they still had incandescent lights in use either indoors or outdoors. The most frequently mentioned reasons why CFLs were not used in these fixtures included: waiting for incandescent bulb to burn out before replacing with CFL; unsuitable fixture; and CFL light was not bright enough; and

- About 11 per cent of surveyed BC Hydro residential customers indicated that they were first time CFLs users in November 2008.

4. Market Model. A Poisson regression was developed to determine the primary drivers of the number of CFLs purchased. This Poisson regression model was aimed at predicting the number of CFLs purchased from demographic information of residential customers, as well as discovering target consumer groups for increasing the penetration of CFLs in the future. Key drivers of CFL purchases included region (B.C. versus Dakotas), building type, ownership, income level and the number of children under age twelve.

5. Energy and Peak Impacts. Total incremental sales of CFLs were based on the BC Hydro and Dakotas customer survey data, which was used to estimate total net sales. Net demand savings were based on net incremental sales, unit kW savings per CFL, the net install rate, the peak coincidence factor and the cross effects using the following algorithm:

(1) $\Delta kW = \Delta Sales * Unit\ kW\ sav * Netintl\ rate * Coincidence\ factor * (1 - cross\ effects)$

where ΔkW denoted net demand savings, ΔSales denoted net incremental sales of CFLs, "unit kW sav" denoted demand saving per CFL bulb and "Netintl rate" denoted the net installation rate, which was the installation rate minus the replacement rate.

Net energy savings were based on net incremental sales, unit kW savings per CFL, the net install rate, annual hours of use and the cross effects correction, using the following algorithm:

(2) ΔkWh = ΔSales *Unit kW sav*NetInstall rate*Annual hours *(1-cross effects)

Where ΔkWh denoted net energy savings, ΔSales denoted net incremental sales of CFLs, unit kW sav denoted demand saving per CFL bulb and "Netintl rate" denoted the net installation rate, which is installation rate minus replacement rate. Cross effects were defined as energy saving lost due to interactive effects of lighting saving and electric heating loss.

Net energy and peak savings were estimated for program activity for the period April 1, 2008 through March 31, 2009, as shown in Table 8.2.

Table 8.2 Program Energy Savings and Peak Savings

Program	Period	Energy (GWh/year)		Peak (MW)	
		Reported	Evaluated	Reported	Evaluated
Residential CFL	F2009	-	52.4	-	16.1

Note The Residential Lighting program reports savings at the amalgamated program level rather than at the individual technology level.

8.4 Conclusions and Recommendations

Program Design and Implementation. Power Smart's residential CFL initiative has been successful in building a high level of product awareness and purchase behaviour for energy efficient lighting products in the residential sector. The residential CFL initiative has successfully made the transition from a give-away and incentive initiative to a market transformation initiative. Given the high level of residential use, it will be major challenge for the program to sustain momentum and further increase the residential saturation and penetration of CFLs.

Energy and Peak Impacts. A quasi-experimental approach was used to determine program impact on net purchases of CFLs by residential customers in B.C. This information was combined with metered hours of use data to estimate energy and peak savings. Energy savings were 52.4 GWh per year and peak savings were 16.1 MW.

9 Residential Lighting Program: Energy Star Fixtures Component F2009

9.1 Introduction

BC Hydro's Residential Lighting Program is a multi-year energy acquisition and market transformation program. The objectives of the Energy Star fixture component are to: (1) transform the market for lighting fixtures; (2) reduce energy consumption; and (3) reduce peak consumption. At the time the Energy Star fixtures initiative was launched, there was low awareness of energy efficient fixtures among consumers and retailers, limited availability of product, and prices were substantially higher than non-Energy Star qualifying lighting fixtures. BC Hydro's market transformation program is aimed at addressing five key market barriers. A mixture of financial incentives, advertising and promotions and special events are used to address these barriers. The purpose of this study is to conduct a process and impact evaluation of the Energy Star fixtures component of the Residential Lighting Program.

9.2 Approach

The basic evaluation methodology is a post-only, quasi-experimental design. The post-only, quasi-experimental design uses a treatment group and a comparison group. The treatment group is 606 randomly selected residential customers in BC Hydro's service territory and the comparison group is 600 randomly selected residential customers in North and South Dakota. North and South Dakota are chosen as the comparison group because they are demographically similar to B.C., but have had no substantive Energy Star fixtures programming.

For this study, the five main evaluation issues are as follows:

- **Program Review.** Characterize BC Hydro's Energy Star fixtures component;
- **Supply-side Analysis.** Characterize the supply-side of the residential lighting fixtures market in B.C.;
- **Demand-side Analysis.** Characterize the demand-side of the residential lighting fixtures market in B.C.;
- **Hours of Use and peak Demand.** Evaluate hours of use and peak demand for residential lighting; and
- **Energy and Peak Savings.** Evaluate energy and peak savings attributable to the program for F2009.

The basic evaluation approach is a quasi-experimental design using residential customers in North and South Dakota as a comparison group. The evaluation issues, data sources and methods used in the study are summarized in Table 9.1.

Table 9.1 Evaluation Issues, Data Sources and Methods

Evaluation Issues	Main Data Sources	Method
Program review	Program files Program interviews	File review
Supply-side assessment	Retail shelf space study (n = 38) Literature review	Cross tabulations
Demand-side assessment	BC Hydro survey (n = 606) Dakota's survey (n = 600)	Descriptive statistics
Hours of use and peak demand for lighting	In home metering (n = 77)	Load shape analysis
Energy and peak savings	BC Hydro survey (n = 606) Dakotas survey (n = 600)	Engineering algorithms

9.3 Results

1. Program Review. BC Hydro has employed a phased strategy to transform the lighting fixtures market and acquire energy and peak savings. At the time of program launch in 2004, there was low awareness of Energy Star fixtures among consumers and retailers, there was limited availability of the energy efficient product on store shelves and prices for Energy Star qualifying products were higher than for conventional lighting fixtures.

The program rationale was examined using a program logic model, examining the linkages among inputs, outputs, purpose and goal for each activity. The logic model is consistent and reflects a strong program rationale.

2. Supply-side Analysis. The supply-side assessment is based on the 2008 shelf space study, which included visits to 38 retail establishments. The retail outlets were selected to be representative of the total province by region – Lower Mainland, Vancouver Island, North and South and store type – drugstore, grocery store, general merchandise and home improvement stores. Energy Star light fixtures accounted for 8.9 per cent of all shelf space allocated to lighting fixtures in the December 2008 study, compared to 3.4 per cent in December 2007. Two manufacturers – Globe (25 per cent) and Heath/Zenith (24 per cent) accounted for 49 per cent of all Energy Star fixtures on the shelf. Energy Star light fixtures, manufactured or branded by Globe accounted for the largest proportion (42 per cent) of Energy Star table lamps. Energy Star outdoor fixtures on store shelves are predominantly manufactured or branded by Heath/Zenith (65 per cent of SKUs).

Light fixture displays can vary greatly depending on the retail banner and location ranging from four linear feet to 1053 linear feet. On average, home improvement stores have the largest light fixture displays, followed by general merchandise stores, grocery stores and pharmacies. Table lamps accounted for the largest share of total shelf space dedicated to fixtures (21 per cent), followed by ceiling fixtures (20 per cent) and wall fixtures (17 per cent). These three fixture types accounted for 58 per cent of all shelf space allocated to household lighting fixtures. Torchieres using either incandescent or compact fluorescent lamps accounted for 2 per cent of shelf space, but Energy Star torchieres account for 40 per cent of all shelf space allocated to torchieres. Home improvement stores carry the largest variety of Energy Star light fixtures (118 models), followed by general merchandise stores (74 models). On a regional basis, there is considerable variance in the market share for several fixture types. Regions outside the Lower Mainland are influenced by differences in retail banner composition and overall sample size.

3. Demand-side Analysis. The demand-side assessment is based on customer surveys with 606 treatment group customers and 600 Dakota comparison group customers. Awareness of the Energy Star label in B.C. continues to be higher (67 per cent) than the Dakota's comparison group (57 per cent) and continues to increase in both markets (61 per cent in B.C. and 50 per cent in Dakotas last year). The awareness of Energy Star in the Dakota's comparison region is at least partially due to promotions by the US Federal Government. Generally, however, as similar informational programs are delivered by the Federal Government in Canada this effect should be neutral (effects of both more or less cancel each other out). However, recall of BC Hydro promotional efforts about Energy Star fixtures has dropped off somewhat to 46 per cent from 54 per cent, compared to the previous year. Recall of Energy Star fixtures promotions in the Dakotas has remained consistent at 31 per cent since last year.

Although awareness of the Energy Star label is higher in B.C., the gap in the purchase rate of Energy Star fixtures between B.C. and the Dakotas has been narrowing in the past few years from 5 per cent in F2007 to 3 per cent in F2008 to just 0.5 per cent this year. The narrowed difference is due to the decrease in B.C. fixture purchases over the past year from 8 per cent to 4.8 per cent and the increase in Dakotas purchases from 2 per cent to 4.3 per cent since 2007. The increase in the Dakota's fixtures purchases may be due to an increase in conservation activities sponsored by the local power distributors. It appears from the low incremental purchase rate of 0.48 per cent that the Dakotas market has caught up to B.C. indicating that there are no longer any measurable market effects or savings attributable to program efforts. Therefore for this evaluation report, the focus will be solely on the direct effects or the energy savings resulting directly from the sale of energy efficient fixtures promoted by BC Hydro via manufacturer buy-downs.

4. Hours of Use. BC Hydro has conducted a detailed residential lighting study to determine annual hours of use by space type and the coincidence of residential lighting use with winter system peak demand. Comprehensive data was collected for 77 lighting points, across seven space types. The mean hours of use was 2.2 hours, with 95 per cent upper and lower confidence levels of 1.7 hours per day and 2.8 hours per day respectively. The mean use coincidence factor was 0.24 hours, with 95 per cent upper and lower confidence levels of 0.17 and 0.30 respectively. There is considerable variability in peak factors by space type, with a low of 0.15 for hallways/laundry/garage/workshop and a high of 0.53 for living rooms.

5. Energy and Peak Impacts. Treatment and comparison group surveys were used to estimate the incremental number of Energy Star qualifying fixtures installed due to the program. However, this year there were no measurable differences between B.C. and the Dakota's comparison groups. Thus, only direct effects are calculated for F2009. Energy Star Fixtures are still relatively new to the B.C. market but are gaining a foothold in the market, indicated by recent shelving stock data. The shelf stock study was used to estimate the net demand savings for each class of Energy Star fixtures. On-site logging was used to estimate hours of use and peak coincidence factors. Finally, all of this information was combined in engineering algorithms to estimate total energy and peak coincident demand impacts.

Total program sales of Energy Star fixtures were derived from BC Hydro retail sales data and were used to estimate total net sales. Net energy savings were based on program sales, free rider rate, annual kWh savings per fixture and the installation rate, using the following algorithm, where the summation is over fixture types:

$\Delta kW_i = \Sigma$ *Program Sales*$_i$ **(1-Free Rider Rate)*Annual kWh energy savings*$_i$** Installation rate*$_{i*}$*(1 – cross effects).*

Net demand savings were based on program sales, free rider rate, average unit kW savings per fixture, the installation rate, the peak coincidence factor and the cross effects correction, using the following algorithm, where the summation is over fixture types:

*$\Delta kWh = \Sigma$ Program Sales$_i$ *(1-Free Rider Rate) *Unit kWh sav$_i$*Installation rate$_i$* Peak Coincidence Factor *(1-cross effects).*

The evaluated energy and peak impacts for F2009 are 5.2 GWh per year and 1.7 MW respectively.

Table 9.2 Program Energy Savings and Peak Savings

Program	Period	Energy (GWh/year)		Peak (MW)	
		Reported	Evaluated	Reported	Evaluated
Energy Star Fixtures	F2009	-	5.2	-	1.7

Note The Residential Lighting program reports savings at the amalgamated program level rather than at the individual technology level.

9.4 Conclusions and Recommendations

Program Design and Implementation. The program has had some success in building product awareness, purchase intent and purchase behaviour for Energy Star qualifying lighting fixtures in B.C. Energy Star fixtures are starting to gain a foothold in the market indicated by an increase in Energy Star fixtures retail shelving stock. The B.C. market and the Dakota comparison market are exhibiting similar Energy Star fixture purchase rates. BC Hydro is not aware of state-induced demand-side management in the Dakotas, but there are federal Energy Star programs and some municipal utilities are promoting energy-efficient residential lighting. Given the recent increasing differences in the demographic characteristics, coupled with the decreasing differences in Energy Star trends, for future studies, a different comparison market is being considered. BC Hydro will be looking to use information regarding multiple comparison jurisdictions in cooperation with other North American utilities, in the future. This will replace the present North and South Dakota comparison market that is starting to present as a market that may not be entirely comparable to B.C.

Energy and Peak Impacts. Energy and peak impacts were estimated using comparison group surveys, the shelf stock study and lighting metering. The energy and peak impacts for F2009 were evaluated at 5.2 GWh/year and 1.7 MW respectively.

Monitoring and Evaluation. Monitoring of the Energy Star fixtures program has included in-store shelf stock surveys to understand the supply-side of the market and surveys of treatment group respondents in B.C. and comparison group customers in North and South Dakota to understand the demand-side of the market.

10 Residential Lighting Program: Seasonal LED Component F2009

10.1 Introduction

A seasonal LED (**SLED**) light string is similar to a conventional incandescent seasonal light string, but it uses a different type of light source called an LED (light-emitting diode). An LED is a semiconductor device that uses solid-state electronics to produce coloured light. SLEDs do not create light through the production of heat; they are illuminated solely by the movement of electrons in a semiconductor material. Also, SLEDs create coloured light directly, while seasonal incandescent bulbs produce white light so filters are needed to deliver the colour required. SLEDs can be installed either indoors or outdoors.

BC Hydro's Residential Lighting Program is a multi-year energy acquisition and market transformation initiative. The program's SLED component is aimed at motivating residential customers to adopt SLED lamps and to adopt the concept of light energy efficiency. The objectives of the program include: (1) transform the market for seasonal lamps; (2) reduce residential energy consumption; and (3) reduce residential peak demand.

As a BC Hydro market transformation program, the SLED program is aimed at addressing five key market barriers including: availability, awareness, accessibility, affordability and acceptance. When the SLED program was launched in 2002, there was low awareness of SLEDs among consumers and retailers, limited availability of SLEDs and prices were substantially higher than traditional seasonal lighting. A mixture of financial incentives, advertising and promotions and special events were used to overcome these market barriers.

This study evaluates the SLED component of BC Hydro's Residential Lighting Program for F2009.

10.2 Approach

The basic evaluation methodology is a post-only, quasi-experimental design. The post-only, quasi-experimental design uses a treatment group and a comparison group. The treatment group is 606 randomly selected residential customers in BC Hydro's service territory and the comparison group is 600 randomly selected residential customers in North and South Dakota. North and South Dakota are chosen as the comparison group because they are demographically similar to B.C., but have had no substantive SLED programming.

Supply-side characteristics were primarily assessed through a shelf space study of 38 major retailers of SLEDs across BC Hydro's four service regions (Lower Mainland, Vancouver Island, Southern Interior and Northern Region) in November 2008. The shelf space survey collected information on SLED market share of seasonal lighting, range of product choice, price and affordability. Specific information included the overall shelf space devoted to lighting products, CFL share of the space, bulb styles, rated life, wattages and prices were collected.

Demand-side characteristics were determined mainly through comparison of customer survey results of 606 randomly selected BC Hydro customers with 600 randomly selected electric utility customers in North and South Dakota. In this quasi-experimental design study, participants were asked to recall their awareness of SLEDs, purchasing and replacing behaviours of SLEDs and key features of their household in F2009.

Evaluation issues, data sources and methods for this study are summarized in Table 10.1.

Table 10.1 Evaluation Issues, Data Sources and Methods

Evaluation Issues	Main Data Sources	Method
Program review	Program documents Staff interviews	Documents review
Supply-side assessment	Retail shelf space study (n = 38)	Cross tabulations
Demand-side assessment	BC Hydro customer survey (n = 606) Comparison group survey (n = 600)	Cross tabulations
Market model	BC Hydro customer survey (n = 606) Comparison group survey (n = 600)	Poisson regression model
Energy and peak savings	Participant, non-participant and consumer surveys On-site monitoring	Engineering algorithms

Total incremental sales of SLEDs are based on BC Hydro and Dakotas customer survey data, which is used to estimate total net sales. Net demand savings are based on net incremental sales, unit kW savings per SLED, the net install rate and the peak coincidence factor, using the following algorithm:

*(1) ΔkW = Σ ΔSales *Unit kW savings*Install rate*Coincidence factor*(1 – cross effects).*

where ΔkW denotes the net demand savings and ΔSales denotes the incremental sales of SLEDs. Net energy savings are based on net incremental sales, unit kW savings per SLED, the install rate, annual hours of use and the cross effects correction. The annual hours of use (**HOU**) was estimated as 171 hours. Net energy saving is estimated using the following algorithm:

*(2) ΔkWh = Σ ΔSales *Unit kW savings*Install rate*Annual hours*Diversity factor*(1-cross effects).*

10.3 Results

1. Program Review. The SLED and related residential lighting initiatives are an electricity acquisition and market transformation program aimed at motivating residential customers to obtain the best long-term value from their choice of efficient household lighting.

The first phase (F2003) of the strategy involved introducing seasonal LEDs to the B.C. market in 2002. At this time 20,000 strings were distributed through 48 Business Improvement Districts and six hotels, with the program supported by extensive media placements but there was no paid advertising. This first phase was successful in building initial awareness, placement and experience with seasonal LEDs.

The second phase (F2004 – F2006) introduced financial incentives, generated enhanced trade ally support and included paid advertising. This second phase was critical in building a critical mass of awareness, interest, stocking and sales.

The third phase (F2007 – present) has involved the withdrawal of direct BC Hydro financial incentives, but with continued promotional and educational support. For example, F2009 programming includes newspaper insertions, billboards, transit shelter ads, outreach event and other education and awareness activities.

The program rationale was examined using a program logic model, examining the linkages among inputs, outputs, purpose and goal for each activity. The logic model is consistent and reflects a strong program rationale.

2. Supply-side Assessment. The supply-side developments with respect to the availability, accessibility and affordability of SLEDs were accessed by shelf space survey of 38 major retailers operating in BC Hydro's service territory. Some key supply-side findings include the following:

- SLEDs accounted for 56 per cent of linear shelf space allocated to seasonal lights in F2009, up from 50 per cent in F2008. SLEDs have taken substantial market share away from traditional mini-light strings and variations;
- The quantity and variety of SLEDs continued to improve in F2009. A major innovation in the previous year was the introduction of two warmer tones of white LEDs, overcoming the aversion of some consumers to the relatively harsh bluish tone of the original white LEDs;
- The range of SLEDs continued to increase, with more designs including LED, mini-bulbs, C9, fibre optic, C7 and bubble lights. LED and mini-bulbs dominated the market, accounting for 60.8 per cent and 20 per cent of all SLEDs on store shelves correspondingly in F2009; and
- Prices for SLEDs varied by string length and LED colour, In F2009, average costs per SKU for 25 LED strings and 70 LED strings were $14.18 and $16.72, up 9.8 per cent and 8.4 per cent correspondingly from $12.92 and $15.43 in F2008. However, average cost per SKU for 35 LED strings was $10.67, which decreased slightly (0.7 per cent) from $10.74 in F2007.

3. Demand-side Assessment. The demand-side assessment is based on a series of customer surveys conducted in B.C. and North and South Dakota from F2003 to F2009. The F2009 customer surveys, which were conducted in November 2008, track customer awareness and purchase information pertaining to F2009. Key demand-side findings include the following:

- In the November 2008 survey, 87 per cent of BC Hydro's residential customers were aware of SLEDs and this is essentially unchanged from the 88 per cent reporting awareness of SLEDs in the January 2008 survey;
- In F2009 39 per cent of BC Hydro's residential customers purchased SLEDs, while 37 per cent of comparison group customers bought SLEDs in F2009;
- SLEDs now make up about 55 per cent of all seasonal lighting strings used by BC Hydro customers as of November 2008 and this share is significantly up from 40 per cent in F2008;

- About 69 per cent of surveyed SLED purchasers in B.C. obtained SLEDs in F2009 to replace existing seasonal lighting product, which is slightly down from 71 per cent in F2008; and

- Customer satisfaction with SLEDs remained high, with 97 per cent of users being either very or somewhat satisfied with the product, up from 91 per cent in F2008.

4. Market Model. A Poisson regression was developed to determine the primary drivers of the number of SLEDs purchased. This Poisson regression model was aimed at identifying existence of primary drivers of SLED purchases. Only the variables for region (B.C./Dakota), home ownership, education level and the total number of occupants are associated with the purchase of SLEDs.

5. Energy and Peak Savings. The gap in the purchase rate of SLEDs between B.C. and the Dakotas has been narrowed in the past few years. This narrowed difference in SLED purchase rates is due to the slight decrease in B.C. and increase in Dakotas over the past year. This likely indicates that the SLED component made little influence on promoting energy efficient SLEDs in the past year. The purchasing of SLEDs has become a natural behaviour to homes in B.C. and changes to market make a relatively small impact on customers' decision-making when it comes to seasonal lighting purchase. As shown in Table 10.2, evaluated energy savings are 0.37 GWh per year and evaluated demand savings are 0.99 MW for F2009.

Table 10.2 Program Energy and Demand Savings Assessment

Seasonal LED	Period	Energy Savings (GWh/year)		Peak Savings (MW)	
		Reported	Evaluated	Reported	Evaluated
	F2009	-	0.37	-	0.99

Note The Residential Lighting Program reports savings at the amalgamated program level rather than at the individual technology level.

10.4 Conclusions and Recommendations

Program Design and Implementation. Power Smart's residential SLED program has been successful in building a high level of product awareness and purchase behaviour for energy efficient lighting products in the residential sector.

Program Implementation. BC Hydro has successfully used SLED give-away programs, lamp exchanges, extensive media placements, financial incentives and paid advertising to build trade ally support, customer awareness, product interest, stocking and sales. The market is now viewed as being substantially transformed.

Energy and Peak Impacts. For F2009, evaluated net energy savings are about 0.4 GWh per year and evaluated peak savings are under 1 MW.

11 Refrigerator Buy-Back Program F2007, F2008 and F2009

11.1 Introduction

The Refrigerator Buy-Back (**RBB**) Program, initiated by BC Hydro Power Smart as a component of the residential DSM portfolio, aims at promoting energy conservation and improving end-use efficiency in BC Hydro's residential market. The program was one of BC Hydro's first residential DSM initiatives in the early 1990s. Supported by financial incentives and a free refrigerator pick-up service, the program encourages, facilitates and accelerates the recycling of old and energy inefficient refrigerators. Qualifying refrigerators must be between 10 and 24 cubic feet and be operational at the time of pick up. The re-launch of the RBB Program in 2002 is a direct response to BC Hydro's long-term conservation strategy to slow the growth of secondary refrigerator ownership and upgrade households to more energy efficient refrigerators. The program provides BC Hydro with a cost-effective way of energy acquisition and helps to foster a conservation culture in B.C.

Since the re-launch in 2002, the program has gone through several phases. First, the Province-Wide Part I program was launched in September 2003 and over the following two years, a total of 70,000 refrigerators were collected and recycled with the emphasis on secondary refrigerator collections. Second, Part II of the program was started in November 2006 to include both primary and secondary refrigerators with the goal to improving overall energy efficiency of refrigerator use in B.C. residential households. Third, Part III of the program was started in January 2007 and continued through the end of 2009 covering periods of F2007 to F2010. During the latter part of F2008, the program increased marketing investments to increase customer awareness and program promotions.

This evaluation study includes a process evaluation (including the review of the program logic model, evaluation of program response and customer satisfaction), a market evaluation and an impact evaluation for F2007, F2008 and F2009.

11.2 Approach

The data sources for the RBB program evaluation include program participant and non-participant surveys and energy metering of recycled refrigerators. Gross and net energy savings were evaluated for F2007 through F2009. Gross savings for manual defrost refrigerators were based on the product of manual defrost refrigerators picked up by the program times the unit savings from metering. Gross savings for automatic defrost refrigerators were based on the product of automatic defrost refrigerators picked up by the program times the unit savings from metering. Adjustments were made for cross effects that resulted from the heat loss due to the removal of refrigerators and extra load required for electric heating homes during the heating period. Net savings were estimated by adjusting the initial gross savings estimates by the expected influences of free-ridership and spillover, based on customer surveys.

The following table summarizes the major evaluation issues, methodology and data resources employed in this report.

Table 11.1 Evaluation Issues, Data Sources and Methods

Evaluation Issues	Main Data Sources	Method
Program review	Program files review, Program staff interviews, Visits to recycling facilities, Literature review	Logic framework
Customer survey	Participant surveys (n = 501 in 2007, and n = 550 in 2008), Non-participant surveys (n = 400 in 2007 and n = 400 in 2008)	Cross tabulations
Program participation and awareness, free ridership, spillover rate	Same as above	Same as above
Customer satisfaction	Same as above	Same as above
Market analysis	Program data base NR Canada statistics Previous evaluations	Same as above
Impaction evaluation - energy and peak savings	Refrigerator metering (n = 295) Program data base	Engineering algorithms

11.3 Results

1. Program Review. Since its inception in the early 1990s, the program has removed approximately 383,000 refrigerators across the province - more than the total number of secondary refrigerators maintained in B.C. households, which is currently estimated at 360,000 units. As a result, by removing aged and inefficient units, the program helps maintain a low growth rate of secondary refrigerator in the province and improve the overall energy efficiency of refrigerators in B.C. households.

By providing a free refrigerator pick-up and recycling service and a $30 incentive, the RBB program encourages BC Hydro's residential customers to recycle their old and energy inefficient refrigerator. To enrol in the program, the customer calls the RBB toll-free number to schedule a pick-up date. A local contractor picks up the customer's operating refrigerator and delivers it to the recycling facility. At the dismantling facility, the refrigerant is recovered and the components and the metal hulk are recycled. Once the process is completed, the customer is mailed the incentive check. A central clearinghouse handles customer calls and scheduling of the pick-up date. The program has been promoted through a combination of radio and newspaper advertising, outreach activities and awareness campaigns as well as being supplemented by bill inserts.

The review of the program logic model indicates that the program rationale is valid for the following reasons. First, the program linkages have face validity and are plausible. Second, the key assumptions are reasonable and are likely to be met. Third, there are objectively verifiable indicators that track performance for the key components for the program logic, so program progress can be measured against program objectives and lastly, the recycling program has lasting impacts on energy use as the recycled units are permanently removed from the grid.

2. Customer Survey. Detailed surveys were conducted with program participants and program non-participants, covering a range of issues related to the program and refrigerator being recycled. Key findings from the participant surveys included the following:

- For the F2009 survey, program participants continue to rank “Free Pick-up”, “Good for the Environment” and “Convenience” as the most important RBB program attributes, followed by “Promotes Energy Efficiency/Saves Energy”;

- Similar to the F2007 and F2008 results, a majority of program participants surveyed for F2009 had one working non-bar refrigerator in the household as of the interview date (December 2008), while a minority (37 per cent) had two such refrigerators;

- Also similar to the F2008 and F2007 surveys, nine out of ten participants gave one refrigerator to the RBB program in the last year and only 7 per cent of respondents turned in two refrigerators; and

- The non-participant survey targeted customers having more than one refrigerator in their home. Key findings from the non-participant surveys included the following:

    - For F2009, 94 per cent of the non-participants report having two working refrigerators in the home as of the interview date, while 6 per cent had 3 or more – both findings were similar to F2008. Almost all of these secondary refrigerators were in use in the last year;

    - A significant proportion of the non-participants appear to value having a second refrigerator; and

    - Knowing the true costs of refrigerator disposal, but not knowing about the BC Hydro Refrigerator Buy-Back Program, more non-participants Definitely/Probably would not (53 per cent versus 44 per cent in F2008) dispose of their second refrigerator.

3. Program Awareness and Participation. Awareness of BC Hydro’s RBB program throughout the evaluation period remained roughly at the same level. The 2007 and 2008 non-participant surveys indicate that approximately one third of non-participants were aware of the RBB program, which is about the same as in the 2006 survey. The majority of non-program participants chose not to participate for the reason that they still needed their secondary refrigerator for cold storage. The average age of their refrigerators is about ten years. Meanwhile, among those non-participants previously unaware of the RBB program, once they were informed of the RBB program, half of them said they would “definitely” or “probably” participate.

4. Customer Satisfaction. The RBB program was rated favourably as the survey shows that 93 per cent of the program participants were very satisfied with the program. Participants rate the importance of various aspects of the RBB program in the following order: convenience; free pick-up service; financial incentive; energy savings associated with the program; environmental impact; and impact on behavioural change.

5. Market Analysis. To understand the market impacts of the RBB program, trends in the saturation rate of second refrigerators in B.C. and in Canada were examined, as shown in Table 11.2. Since the inception of the original program in the early 1990s, the RBB program has removed approximately 383,000 refrigerators across the province, which is more than the number of secondary refrigerators maintained in B.C. households (about 360,000 units). As a result, the RBB program helps to maintain the low growth rate of secondary refrigerator in the province and improve the overall energy efficiency of refrigerators in B.C. households by removing aged and inefficient units.

Table 11.2 Household Penetration of Secondary Refrigerator, B.C. versus Canada

	1997 (%)	2003 (%)	2005 (%)	2006 (%)
Canada (per centage of households)	33	36	30	33
B.C. (per centage of households)	30	29	21	21

Source: *Surveys of Household Energy Use conducted by Natural Resources Canada and BC Hydro's Residential End-Use Survey (2008).*

5. Energy and Peak Impacts. Net energy savings attributable to the RBB program for F2007, F2008 and F2009 is evaluated at 27.5 GWh per year, 26.5 GWh per year and 28.3 GWh per year, respectively. Peak demand savings for F2007, F2008 and F2009 are 3 MW, 3 MW and 3.4 MW, respectively. Among all the refrigerators collected during these periods, the gross average consumption rate of the collected refrigerators is 902 kWh per year, compared to the gross average consumption of 488 kWh per year for new refrigerators. The annual results of the program impact on energy savings and demand savings are listed in the table below.

Table 11.3 Program Impact—Net Energy Savings and Peak Demand Savings

	F2007	F2008	F2009
Number of Refrigerators Collected through the RBB Program	32,588	33,159	37,846
Gross Energy Savings Run Rate (GWh/year)	35.3	34.0	36.5
Net Energy Savings Run Rate(GWh/year)	27.5	26.5	28.3
Reported Savings (GWh/year)	27.2	27.8	19.2
Demand Savings (MW)	3.5	3.6	4.1
Coincidence Peak Demand Savings less Cross–Effects (MW)	3.0	3.0	3.4
Annual Net Energy Savings per Unit (kWh/year)	845	798	747
Measure Lifetime (years)	7	7	7

11.4 Conclusions and Recommendations

Program Rationale. The RBB program has been successful in building a high level of program awareness on the benefits of participating in the program, either to eliminate a second refrigerator or to replace a less efficient primary refrigerator. The rationale for the program was examined using a program logic model, and examining the linkages among inputs, outputs, purpose and goal for each activity. It was found that the program logic model made sense and had a strong program rationale.

Customer Survey. For the F2009 survey, program participants continue to rank Free Pick-up, Good for the Environment and Convenience as the most important RBB program attributes, followed by Promotes Energy Efficiency/Saves Energy.

Market Analysis. To understand the market impacts of the RBB program, trends in the saturation of second refrigerators in B.C. and in Canada were examined. In 2006, the saturation rate of second refrigerators in B.C. was 21 per cent compared to 33 per cent for Canada as a whole. Since the inception of the original program in the early 1990s, the RBB program has removed 383,000 units of refrigerators across the province, which is more than the number of current secondary refrigerators maintained in B.C.

Energy and Peak Impacts. Evaluated net energy savings are 27.5 GWh per year for F2007, 26.5 GWh per year for F2008 and 28.3 GWh per year for F2009, while evaluated net peak savings are 3 MW for F2007, 3 MW for F2008 and 3.4 MW for F2009.