Janet Fraser
Chief Regulatory Officer
Phone: 604-623-4046
Fax: 604-623-4407
bchydroregulatorygroup@bchydro.com

February 28, 2014

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

Dear Ms. Hamilton:

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

BC Hydro writes to submit its F2013 Demand Side Management Milestone Evaluation Summary Report (**the Report**), dated February 28, 2014 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 F2013 for the following:

1. Consumer Electronics Program: F2010
2. Residential Lighting Program: F2012
3. Refrigerator Buy-Back Program: F2011 – F2012
4. Residential Behaviour Program: F2011 – F2012
5. Renovation Rebate Program: F2009 – F2011
6. Power Smart Partners – Transmission Program: F2010 – F2011

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

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

Yours sincerely,

Janet Fraser
Chief Regulatory Officer

sh/ma

Enclosure (1)

BC hydro
powersmart

Demand Side Management Milestone Evaluation

Summary Report F2013

February 2014

ABSTRACT

This report provides a summary of Milestone Demand Side Management (**DSM**) Evaluations completed by Power Smart Evaluation during F2013.

ACKNOWLEDGEMENTS

The Power Smart Evaluation team wishes to thank the members of the Evaluation Oversight Committee and the external DSM evaluation advisors for their assistance and support.

Table of Contents

List of Tables

1.0 Introduction

BC Hydro evaluates its 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 undertakes a comprehensive approach to confirm the electricity savings that result from its DSM initiatives. A key aspect of this approach is the evaluation of DSM initiatives. Evaluation activities center on three main categories, which are described below: process evaluations, market evaluations and impact evaluations. The basic objectives of evaluations are to document activities, assess impacts, and identify opportunities for improvement.

The British Columbia Utilities Commission (***BCUC***) Resource Planning Guidelines note: "*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 F05/06 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, evaluations are conducted at major initiative milestones and can include elements of process, market, and impact evaluations. Third, evaluations are reviewed and approved by a BC Hydro cross-functional DSM Evaluation Oversight Committee (**EOC**), chaired by a manager from outside the Power Smart business group. The structure of the EOC follows recommendations from the BCUC in 2004 to diversify the membership to ensure third party DSM evaluation oversight. BC Hydro also has two external senior advisors who provide assistance and support to the Power Smart Evaluation department to ensure that BC Hydro's DSM evaluations align with industry best practice.

[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 DSM evaluation industry.

1.2 DSM Evaluation Principles and Approach

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

1. 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.
2. Leveraging existing program, market, and customer data to minimize evaluation costs.
3. Using multiple lines of evidence to increase the credibility, validity, and reliability of evaluation findings
4. Reviewing and approving completed evaluation studies by the Evaluation Oversight Committee, which represents key stakeholders.

DSM evaluations are often divided into three main categories: process evaluations, market evaluations, and impact evaluations. These three types of studies can be summarized as follows:

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 are the gross impacts of the initiative on energy consumption and peak demand?
- What are the net impacts of the initiative on energy consumption and peak demand?

1.3 Evaluation Studies

Evaluations summarized in this report include the following:

- Consumer Electronics Program: F2010
- Residential Lighting Program: F2012
- Refrigerator Buy-Back Program: F2011 – F2012
- Residential Behaviour Program: F2011 – F2012
- Renovation Rebate Program: F2009 – F2011
- Power Smart Partners – Transmission Program: F2010 – F2011

2.0 Residential Programs

2.1 Consumer Electronics Program: F2010

2.1.1 Introduction

The Consumer Electronics program is a multi-year energy acquisition and market transformation initiative that encourages its customers to purchase energy efficient televisions and recycle unneeded televisions. The program goals are to:

1. Generate energy savings and increase the market penetration of more efficient televisions by partnering with retailers to influence the consumer television buying decision;
2. Generate energy savings by reducing the number of obsolete televisions in the home; and
3. Increase consumer awareness of energy efficiency by calling attention to the electricity use of televisions, both in older televisions in the home and new televisions being purchased.

The purpose of this study is to conduct an evaluation of the Consumer Electronics program for BC Hydro's fiscal year 2010 (**F2010**). The study includes an impact evaluation and elements of a market evaluation.

The target market includes both residential customers and supply chain actors, including manufacturers, retailers, and recyclers. The initial ENERGY STAR® 3.0 (Energy Star) specification for televisions came into force in November 2008, with subsequent standards developed by the Consortium for Energy Efficiency (**CEE**). The Power Smart Consumer Electronics program was launched on April 1, 2009, with an initial mid-stream or retailer incentive of $20.00 per CEE Tier 2 television, with the CEE Tier 2 specification being 15 per cent better than Energy Star 3.0. Given the rapid evolution of the market, there have been frequent revisions of the Consumer Electronics mid-stream retailer offer.

2.1.2 Objectives and Methods

For this study, there were six main objectives:

1. Conduct a program review
2. Undertake a supply-side assessment
3. Undertake a demand-side assessment
4. Produce and analyze television hours of use and load information
5. Estimate energy and peak demand savings
6. Conduct a comparison with comparable programs of other leading utilities

The study approach used multiple lines of evidence, since no single line of evidence provided information on all of the evaluation issues for this study of the television market.

1. **Program Review.** To conduct the program review and develop the program logic model, we reviewed program documents, interviewed BC Hydro program staff, and conducted a literature review focussing on recent studies and reports on televisions. Information from the CEE was particularly useful.

2. **Supply Side Assessment.** To undertake the supply side assessment, we tabulated and examined relevant results of an annual retail store tracking study that covers representative samples of stores. We also conducted a Consumer Electronics trade ally survey.
3. **Demand Side Assessment.** To undertake the demand side assessment, we tabulated and examined relevant results of the Energy Star Awareness Quarterly Tracking Survey and the Television Baseline Survey.
4. **Hours of Use.** To produce and analyze information on hours of use profiles by season, we conducted a one-year Residential Monitoring Study that measured television hours of use.
5. **Energy and Peak Demand Savings.** To estimate peak demand and energy savings, engineering algorithms were populated with the results of items 2 through 4 described above.
6. **Program Comparison.** To compare BC Hydro Power Smart's Consumer Electronics program with those of other leading utilities, a literature review was conducted.

2.1.3 Results

Program Review. At the time of program launch in 2009, market analysis indicated that there were several barriers to increased sales of energy efficient televisions in British Columbia including low awareness of Energy Star and CEE qualified televisions among consumers, relatively low availability of televisions with high energy efficiency levels in retail stores, and relatively high prices for energy efficient televisions.

BC Hydro has employed a phased strategy to transform the television market and acquire energy and peak demand savings. The program has successfully addressed these barriers through four main components: specifications development, information and promotions, financial incentives, and retailer training. The program rationale was examined using a program logic model, which was developed from interviews with program staff, a documents review and a literature review. This review and analysis confirmed that the basic program logic was valid. There were strong linkages among inputs, outputs, purposes and goal statements. Indicators for key components of the logic model were clear, well defined and measurable.

Supply Side Assessment. There was a shift in the distribution of televisions for sale in retail stores in British Columbia towards higher energy efficiency levels between 2009 and 2010. Average price decreased by about 5 per cent, from $1,134 in 2009 to $1,084 in 2010. There is generally an increase in price as the energy efficiency level increases. The average price of a Tier 4 television, the highest efficiency level, was found to be $1,390 compared to the average price of $640 for base television sets that do not meet minimum Energy Star requirements.

Demand Side Assessment. Highlights of the demand side assessment are as follows:

- Number Owned. 97 per cent of the 641 Television Baseline Survey respondents stated that they had at least one television, while the remaining 3 per cent stated that they had none. About two-thirds of respondents owned more than one television.
- Hours of Use. For their four most important televisions ranked by hours of use, respondents to the Television Baseline Survey were asked how many hours per day they used each television. First televisions were reportedly used an average of 4.5 hours per day on weekdays and 5.4 hours per day on weekends.
- Purchase decision factors. Those respondents who had purchased a television in the previous two years were asked to state the most important factor in their decision to choose that

particular television instead of choosing another television. Thirty-five per cent said that factor was the price, 16 per cent said it was picture quality, 13 per cent said it was features, 12 per cent said it was overall quality, 11 per cent said it was size, 6 per cent said it was brand name and 3 per cent said it was energy efficiency.

- Customer Awareness. Respondents to the Energy Star Awareness Quarterly Tracking Survey had high levels of awareness of Energy Star televisions and of television recycling.

Hours of Use. A 12-month Residential Monitoring Study of hours of use was conducted in 48 households. Run time meters were used to collect fifteen minute interval data for the production of load shapes, hourly use by season and annually, and peak coincident television usage. Average measured daily hours of use were 5.6 hours, and the measured share of televisions on during BC Hydro's peak demand period was 49.7 per cent.

Energy and Peak Demand Savings. Net energy savings for new televisions are estimated as the product of participating units, unit kW savings, measured hours of use, electricity cross effects adjustment and net to gross ratio. Net energy savings for recycled televisions are estimated as the product of incremental units, unit kWh savings, electricity cross effects adjustment and a net to gross ratio. Peak demand savings refer to program impact on the load during the peak demand period, which is 4:00 p.m. to 9:00 p.m. during the winter.

To estimate peak demand (kW) and energy (kWh) savings for new televisions, we used the algorithms (1) and (2) shown below.

(1) ΔkWh = Incented units * unit power savings * measured hours of use * electricity cross effects adjustment * net to gross ratio.

(2) ΔkW = Incented units * unit power savings * peak coincidence factor * electricity cross effects adjustment * net to gross ratio.

To estimate peak demand (kW) and energy (kWh) savings for recycled televisions, we used the algorithms (3) and (4) shown below. Evaluated peak demand savings were derived by applying the residential rate class load shape (capacity) factor to the net evaluated energy savings. The factor was developed through internal BC Hydro calculations.

(3) ΔkWh = Recycled units * unit energy savings * electricity cross effects adjustment * net to gross ratio.

(4) ΔkW = Recycled units * unit energy savings * capacity factor * electricity cross effects adjustment * net to gross ratio.

Table 2.1 New Energy Efficient Televisions Energy Savings, F2010

CEE Energy Specification	Incented Units (000)	Unit Power Savings (W)	Annual Hours of Use	Cross Effects Adjustment (1 – electricity cross effects)	Net to Gross Ratio (1 – free riders)	Net Energy Savings (GWh/year)
Tier 2	58	22	2,044	0.92	0.74	1.8
Tier 3	37	45	2,044	0.92	0.74	2.3
Tier 4	15	94	2,044	0.92	0.74	2.0
Total	110					6.1

Table 2.2 New Energy Efficient Televisions Peak Demand Savings, F2010

CEE Energy Specification	Incented Units (000)	Unit Power Savings (W)	Peak Coincidence Factor	Cross Effects Adjustment (1 - electricity cross effects)	Net to Gross Ratio (1 - free riders)	Net Peak Demand Savings (MW)
Tier 2	58	22	0.497	0.92	0.74	0.4
Tier 3	37	45	0.497	0.92	0.74	0.6
Tier 4	15	94	0.497	0.92	0.74	0.5
Total	110					1.5

Table 2.3 Recycled Televisions Energy and Peak Demand Savings, F2010

	Units (000)	Share Plugged In	Unit Energy Use (kWh/year)	Cross Effects Adjustment (1 - electricity cross effects)	Net to Gross ratio	Net Energy Savings (GWh/year)	Peak Coincidence Factor	Net Peak Demand Savings (MW)
Total	153	0.80	79	0.92	0.42	3.7	0.25	0.9

Summary savings estimates are shown in the following table.

Table 2.4 Energy and Peak Demand Savings, F2010

Year	Energy Savings (GWh/year)		Peak Demand Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
F2010	8.6	9.8	2.0	2.4

Program Comparison. It is useful to compare Power Smart's program offering with those of other utilities. Incentives offered by 24 organizations for five consumer electronics technologies were included in comparison, based on CEE data. The key observation is that BC Hydro's offer is comparable to those of other leading utilities in the market for consumer electronics.

2.2 Residential Lighting Program: F2012

2.2.1 Introduction

This report provides an impact evaluation and elements of a market evaluation of the Residential Lighting program, a multi-year energy acquisition and market transformation initiative that encourages its customers to use energy-efficient lighting, with a focus on compact fluorescent lamps (**CFLs**), light emitting diodes (**LEDs**), energy efficient fixtures and LED fixtures. The objectives of the program include:

1. Sustain and increase a greater market share of energy efficient lighting products in advance of regulations for more efficient lighting
2. Promote efficient lighting products not covered by regulations and newer products such as LEDs
3. Promote and increase awareness province wide and drive customers to retailers to purchase efficient products
4. Provide residents province-wide with an accessible and simple lighting program

2.2.2 Objectives and Methods

For this study, there were six main objectives: (1) conduct a program review; (2) undertake a supply side assessment; (3) undertake a demand side assessment; (4) measure hours of use and peak demand; (5) estimate energy and peak demand savings; and (6) conduct a program comparison.

1. **Program Review.** To conduct the program review and develop the program logic model, we conducted staff interviews and reviewed program documents.
2. **Supply Side Assessment.** To undertake the supply side assessment, we conducted trend analysis using data from an annual retail store tracking study that covers representative samples of stores (about 40 establishments per year) and a trade ally survey.
3. **Demand Side Assessment.** To undertake the demand side assessment, we conducted customer surveys in British Columbia (n = 601) and the comparison group of North and South Dakota (n = 601) and undertook z-tests for differences.
4. **Hours of Use and Peak Coincidence.** To measure hours of use and peak coincidence, we used load monitoring data (n =377 measurement points) with each lamp monitored for at least 12 months.
5. **Energy and Peak Demand Savings.** To estimate energy and demand savings, we used engineering algorithms based on the information just cited as well as sales data.
6. **Program Comparison.** To conduct the program comparison, we undertook a detailed literature review.

2.2.3 Results

Program Review. From a program logic perspective, there were three main program activities: retailer education, product rebates and consumer education.

1. Power Smart has provided retailer education for the residential lighting market since the inception of the program. Retailer education is a key component of the current Residential Lighting program, with retailer education conducted both in-store and on-line.

2. Product rebates are aimed at creating customer interest in energy efficient lighting and reducing first costs. The Lighting Campaign in Spring 2011 included in-store instant discounts on selected lighting products from March 1 to April 30, 2011, while the Lighting Campaign in Fall 2011 included in-store instant discounts on selected lighting products from October 1 to November 30, 2011.
3. Consumer education is aimed at creating customer awareness, knowledge and purchase intent for energy efficient lighting products, and the lighting campaigns included radio, print, television and point of purchase materials.

The program rationale was examined using a program logic model, which was developed from interviews with program staff, a documents review and a literature review. This review and analysis confirmed that the basic program logic was valid. There were strong linkages among inputs, outputs, purposes and goal statements. Indicators for key components of the logic model were clear, well defined and measurable.

Supply Side Assessment. The purpose of the supply side analysis was to examine product shelf space share, product prices, and product wattages.

1. For the three years for which we have data, the shelf stock shares by lamp type are constant, with the combined share of CFL and LED lamps at 28 per cent
2. From F2010 to F2012, incandescent lamps have fallen in price, and most types of CFLs have increased in price. Reasons for the increases in CFL prices are not known
3. Average wattage for incandescent lamps declined significantly from F2011 to F2012, which is what one might expect given the Provincial lamp regulation, which effectively eliminated standard A-line shape 75 watt and 100 watt lamps. Average wattage for CFLs and LEDs did not change significantly from F2011 to F2012.
4. The trade ally survey focussed on marketing executives and managers responsible for consumer lighting with major retail chains and examined retailer views on several program dimensions. Surveys were completed with nine retailers. Almost all of the trade allies surveyed responded that: the lighting program marketing materials were very or somewhat effective in promoting sales of Energy Star lighting; the program incentives were very effective in encouraging them to purchase and stock Energy Star lighting products; and, current program activities were effective in encouraging the retailer to sell more Energy Star lighting products. All of the respondents responded that they were very or somewhat satisfied with Power Smart's current Residential Lighting Program.

Demand Side Assessment. The purpose of the demand side analysis was to examine customer product awareness, lamp purchase behaviour and program attribution of energy savings for six product categories - four lamp categories and two fixture categories - using information from North and South Dakota for comparisons.

1. British Columbia (**B.C.**) survey respondents show a higher level of product awareness than Dakota survey respondents for all four lamp categories, and these differences are statistically significant for three lamp product categories, but not for incandescent lamps
2. BC survey respondents show a higher level of purchase than Dakota survey respondents for incandescent lamps, LED lamps, halogen lamps and fixtures, but a lower rate of purchase for basic CFLs and specialty CFLs
3. Customer satisfaction for specialty CFL and LED lamps was very similar in the two jurisdictions

4. Survey respondents were asked how influential program activity was in their decision to purchase energy efficient lighting products, and free rider rates were calculated by weighting the responses and finding a weighted average, with a free rider rate of 19 per cent for specialty CFLs and 27 per cent for Energy Star fixtures
5. Sales data was used to develop a free rider rate of 11 per cent for LED lamps and 16 per cent for LED fixtures
6. Spillover was estimated by comparing the purchase rates between B.C. and North and South Dakota, and found to be zero for CFLs and 293 per cent for LEDs

Hours of Use and Peak Coincidence. Estimates for daily hours of use and peak coincidence were based on an in home monitoring study. Daily hours of use is an annual average based on twelve months of monitoring, and peak coincidence is the share of lamps which were on during the typical winter peak period. Information on location of lamps and fixtures by room was used to weight the monitored hours of use by room to calculate daily hours of use and peak coincidence for lamps and for fixtures, with the results shown.

Table 2.5 Hours of Use and Peak Demand

	Daily Hours of Use	Peak Coincidence (Share of products on during peak)
Lamps	2.56	31.1%
Fixtures	3.18	39.4%

Energy and Peak Demand Savings. Key variables in the calculation of energy and peak demand savings algorithms are unit energy savings, unit peak demand savings, the installation rate net of replacements, the free rider rate, the spillover rate, the electricity cross effects (**CE**) adjustment, and the number of rebated units in millions. The delta watts estimates were provided from program information based on BC Hydro internal analysis, and the annual hours and peak coincidence estimates came from the Residential Load Monitoring Study. Installation rates were derived from participant surveys. Free rider rates are explained above, while the estimate of one minus cross effects comes from a recent internal BC Hydro study. For energy savings, the basic algorithm is:

$$\Delta GWh = \Delta W * Hours * Install * (1 - FR + SO) * (1 - CE) * Units.$$

For peak savings, the basic algorithm is:

$$\Delta MW = \Delta W * Coincidence * Install * (1 – FR + SO) * (1 – CE) * Units.$$

Table 2.6 Net Unit Savings

Product	Unit energy savings (kWh/year)	Unit peak demand savings (W)	Install rate	1 - free rider rate	1 - electricity cross effects	Net unit energy savings (kWh/year)	Net unit peak demand savings (W)
CFL	49.5	16.4	0.94	0.81	0.95	35.8	11.9
LED	41.1	13.6	0.82	0.89	0.94	28.2	9.3
LED fixtures	61.5	20.7	1.00	0.84	0.94	48.6	16.3
CFL fixtures	127.7	42.9	1.00	0.73	0.98	91.4	30.7

Table 2.7 Net Energy and Demand Savings

Product	Net unit Energy Savings (kWh/year)	Net unit peak demand Savings (W)	Program Incented Units	Energy Savings without Spillover (GWh/year)	Peak Demand Savings without Spillover (MW)	Energy Savings with Spillover (GWh/year)	Peak Demand savings with Spillover (MW)
CFL	35.8	11.9	236,532	8.5	2.8	8.5	2.8
LED	28.2	9.3	140,402	4.0	1.3	15.6	5.1
LED fixtures	48.6	16.3	12,322	0.6	0.2	0.6	0.2
ES fixtures	91.4	30.7	40,567	3.7	1.2	3.7	1.2
			Total	**16.7**	**5.6**	**28.4**	**9.3**

Evaluated energy savings were 28.4 GWh compared to reported energy savings of 15.5 GWh, while evaluated peak savings were 9.3 MW compared to reported peak savings of 5.5 MW.

Table 2.8 Energy and Peak Demand Savings

Year	Energy Savings (GWh/y)		Peak Demand Savings(MW)	
	Reported	Evaluated	Reported	Evaluated
F2012	15.5	28.4	5.5	9.3

Program Comparison. The purpose of the program comparison was to compare Power Smart's residential lighting offering with those of other leading utilities, including the budget, forecast savings, and the scope of the offer. BC Hydro's offer is comparable to those of other leading utilities in the market for energy efficient lighting.

2.3 Refrigerator Buy-Back Program: F2011 and F2012

2.3.1 Introduction

This report provides an impact evaluation and elements of a market evaluation of the Refrigerator Buy-Back program for BC Hydro's fiscal years 2011 and 2012 (F2011-F2012). The Refrigerator Buy-Back program is a multi-year energy acquisition and market transformation initiative that encourages its customers to turn in unused or little used refrigerators for recycling in an environmentally friendly manner. The program offer has three main features:

1. Free refrigerator pick-up from customers' homes
2. Free disposal of the refrigerator in an environmentally friendly manner
3. $30 incentive for each refrigerator collected with a maximum of two refrigerators per household. The program also offered limited freezer pick up

The Refrigerator Buy-Back program objectives are to:

1. Generate energy savings for BC Hydro by reducing the number of inefficient spare refrigerators in the market and by removing inefficient refrigerators from the resale market
2. Provide a specific opportunity for customers to reduce their electricity bills
3. Increase consumer awareness of energy efficiency and home energy management by educating customers about the high electricity consumption associated with spare refrigerators

2.3.2 Objectives and Methods

For this study, there were six main objectives: (1) conduct a program review; (2) undertake a supply side assessment; (3) undertake a demand side assessment; (4) produce and analyze hours of use and load information data; (5) estimate energy and peak demand savings; and (5) examine the extent of market transformation.

1. **Program Review.** To conduct the program review and develop the program logic model, we reviewed program documents, interviewed BC Hydro program staff, and conducted a literature review focussing on recent studies and reports on appliance recycling programs.
2. **Supply Side Assessment.** To conduct the supply side assessment we tabulated and examined relevant results of an annual retail store tracking study that covers representative samples of stores (about 40 appliance retailers per year).
3. **Demand Side Assessment.** To conduct the demand side assessment we tabulated and examined relevant results of the participant and non-participant surveys. Each of these surveys included 401 respondents and provides accuracy of plus or minus 5 per cent, 19 times out of 20.
4. **Metering Study.** To analyze refrigerator power consumption, we conducted energy consumption testing at BC Hydro's Powertech Labs facility.
5. **Energy and Peak Demand Savings.** To estimate peak demand (kW) and energy (kWh) savings for recycled refrigerators and freezers, we used engineering algorithms.
6. **Market Transformation.** To estimate the extent of market transformation, we estimated times-series models of the saturation rate for second refrigerators.

2.3.3 Results

Program Review. The program had three main activities: marketing, refrigerator pick-up and recycling. The rationale for the Refrigerator Buy-Back program was examined using this program logic model, which was developed from interviews with staff, a documents review and a literature review. This review and analysis confirmed that the basic program logic was valid. There were strong linkages among inputs, outputs, purposes and goal statements. Indicators for key components of the logic model were clear, well defined and measurable.

Supply Side Assessment. The assessment of the supply side of the market for refrigerators was based on the four most recent annual retail store tracking studies, conducted in about 40 appliance retail stores each year. Key supply trends were as follows:

- **Capacity.** For all refrigerator types, average capacity was 20.3 cubic feet in each of 2009, 2010 and 2011 and increased slightly to 20.9 cubic feet in 2012.
- **Energy Consumption of New Refrigerators.** Average energy consumption has not changed significantly over the period 2009-2012, and for all refrigerator types, average energy consumption was 488 kWh per year in 2009, 471 kWh per year in 2010, 469 kWh per year in 2011 and 470 kWh per year in 2012.
- **Price.** The average price of a refrigerator was $1,613 in 2012, an increase of $85 from 2011. The lowest priced refrigerator was $290 and the highest priced refrigerator was $14,350.

Demand Side Assessment. The assessment of the demand side of the market was based on a quasi-experimental design using a survey of 401 program participants and 401 non-participants. Highlights of the demand side assessment are as follows:

- **Refrigeration Saturation.** Non-participants owned an average of 2.37 refrigerators compared to 1.48 refrigerators for participants, and the difference was statistically significant.
- **Operational Rate.** Participants were more likely to have disposed of a refrigerator that was operational at the time of disposal (91 per cent) than were non-participants (74 per cent), and the difference was statistically significant.
- **Capacity of Refrigerator.** There is no significant difference in refrigerator capacity between refrigerators recycled by program participants and non-participants.
- **Age of Refrigerator.** Participants recycled refrigerators which were significantly older than those recycled by non-participants, with an average age of 18.0 years for participants compared to 13.5 years for non-participants.
- **Program Influence.** Participants were more likely to be influenced by the program in their decision to recycle the refrigerator than non-participants, and the difference was statistically significant.
- **Participant Satisfaction.** Participants had high levels of satisfaction with the initial call to arrange a refrigerator pick-up, arranging a pick-uptime, and overall satisfaction with the program.
- **Program Awareness.** Seventy one per cent of non-participant respondents had heard of the program before the survey was administered.

Metering Study. BC Hydro pick-up contractors delivered 400 refrigerators to the BC Hydro Powertech Labs testing facility. Of the 400 units, only 337 refrigerators were operative and tested. The 63 units not included in the final database did not operate for various reasons or developed problems soon after they were plugged in at the testing facility. Units are moved multiple times before reaching the Powertech Labs, resulting in damage to some units rendering them inoperable. The refrigerators operating between 1°C and 5°C consumed an average of 69.3 kWh per month, while the average for all the refrigerators that provided acceptable test data was 75.4 kWh per month or 905 kWh per year.

Energy and Peak Demand Savings. Gross unit refrigerator energy consumption was calculated based on the results of the metering study, while gross unit freezer energy consumption was calculated based on an industry standard refrigerator to freezer energy consumption ratio.

Free ridership was calculated using the destination approach with participant survey data as inputs. The destination approach is a standard framework for the evaluation of appliance recycling programs and is used to assess the probability that a fridge would stay connected to the BC Hydro grid in the absence of the program recycling it. Non-participant spillover was calculated based on the outcome of the non-participant survey and market data. Free ridership and non-participant spillover were combined to generate a net to gross ratio.

An adjustment for electricity cross effects was applied to account for the space heating penalty and cooling system benefit associated with increased energy efficiency. A deduction was also applied to account for the operational rate, the proportion of refrigerators that were not operational.

The program is not assumed to induce the purchase of new refrigerators and therefore no deduction is made for the energy consumption of new refrigerators. This assumption is supported by the program design and evaluation industry standard practice for appliance recycling programs, as well as evidence from the Supply Side Assessment, Demand Side Assessment, and Metering Study.

To estimate net peak demand (kW) and energy (kWh) savings for recycled refrigerators and freezers, we used engineering algorithms.

(1) ΔkWh = Program incented units * unit energy savings * operational rate * electricity cross effects adjustment * net to gross ratio.

(2) ΔkW = Program incented units * unit demand savings * operational rate * electricity cross effects adjustment * net to gross ratio.

The following table provides the net unit energy and peak demand savings for refrigerators and freezers.

Table 2.9 Net Unit Energy and Peak Demand Savings

	Gross Unit Energy Savings (kWh/y)	Gross Unit Demand Savings (W)	Net to Gross Ratio	Electricity Cross Effects Adjustment	Operational Rate	Net Unit Energy Savings (kWh/y)	Net Unit Demand Savings (W)
Refrigerator	905	109	0.74	0.94	0.85	535	63
Freezer	812	97	0.74	0.98	0.85	501	60

Net total energy savings are the product of net unit energy savings and the number of units picked up by the program. Net total peak demand savings are the product of net unit peak demand savings and the number of units picked up by the program.

Table 2.10 Net Total Energy and Demand Savings

Year	Appliance	Net Unit Energy Savings (kWh/year)	Net Unit Demand Savings (W)	Units	Net Energy Savings (GWh/year)	Net Demand Savings (MW)
F2011	Refrigerator	535	63	33,573	18.0	2.1
	Freezer[2]	501	60	625	0.3	0.0
				Total	**18.3**	**2.2**
F2012	Refrigerator	535	63	31,493	16.8	2.0
	Freezer[2]	501	60	633	0.3	0.0
				Total	**17.2**	**2.0**

Reported and evaluated energy and peak demand savings for the Refrigerator Buy-Back Program in F2011 and F2012 are compared in the following table.

Table 2.11 Reported and Evaluated Energy and Peak Demand Savings

Year	Energy Savings (GWh/year)		Peak Demand Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
F2011	21.2	18.3	2.4	2.2
F2012	17.9	17.2	2.0	2.0

Market Transformation. The key findings are that:

- Presence of the program reduces the overall saturation rate of second refrigerators by about 1.4 per cent per year
- Presence of the program reduces the single family dwelling saturation rate of second refrigerators by about 2.2 per cent per year
- Presence of the program reduces the duplex and row house saturation rate of second refrigerators by about 1.2 per cent per year

[2] Freezers were included in the program for a brief period on a trial, promotional basis.

2.4 Residential Behaviour Program F2011 – F2012

2.4.1 Introduction

BC Hydro launched the Residential Behaviour Program in October 2008 under the Team Power Smart advertising campaign as a multi-year behavioural change and energy acquisition program. It resides alongside the Residential Inclining Block (**RIB**) rate and Smart Metering Infrastructure (**SMI**) as one of three complementary Demand Side Management initiatives that aim to capture cost-effective behavioural energy savings by encouraging customers to improve energy efficiency and to adopt more energy conscious behaviours in their homes.

Energy reduction challenges form the core of the Behaviour Program. Participating households have the opportunity to engage in a 1-year challenge to reduce their home electricity consumption by 10 per cent during that time and, for those that are successful, they can earn a $75 reward in addition to the bill savings that will have incurred. The Behaviour Program had 61,905 participant households in F2011 (fiscal year ending March 31, 2011) and 78,955 households in F2012 (fiscal year ending March 31, 2012).

This report provides an impact evaluation and elements of a process evaluation of the Residential Behaviour Program for F2011 and F2012.

2.4.2 Objectives and Methods

The objectives of this study are to:

1. Profile the population of Behaviour Program participants in terms of their status in the program, their demographic and housing composition, as well as their motivations and attitudes towards energy conservation
2. Estimate the electricity savings attributable to the Program for F2011 and F2012
3. Identify the groups of participants and their associated conservation behaviours that produced the majority of the electricity savings
4. Profile participants in terms of their behaviours, attitudes and experience as related to program achievement

Overview

The program's electricity savings in F2011 and F2012 were estimated using a quasi-experimental design that compared electricity consumption before and after each fiscal year among participant households and a group of pair-matched comparison households. This difference-of-differences method drew on four parameters:

1. Pre-program consumption values among comparison households
2. In-program consumption values among comparison households
3. Pre-program consumption values among participant households
4. In-program consumption values among participant households

The final measure of interest then became the difference of (1) and (2) minus the difference of (3) and (4).

Participant profiling and program insights have been based on survey samples among participants and non-participants. Note that the non-participant survey sample was drawn from BC Hydro's billing system independently of the exercise that pair-matches comparison households.

Approach for Matching

From the total population of program participants, 46,119 participant households in F2011 and 57,703 participant households in F2012 were successfully pair-matched with comparison households based on nearest neighbour matching of annual consumption during their respective pre-program periods (the year before). To address and control for observable parameters, the pool of comparison households eligible to be matched to a given participant was first restricted to those that shared the same region, dwelling type, main space heating fuel and rate group as recorded in BC Hydro's customer billing system. This matching methodology strengthened the internal validity of the quasi-experimental design because the participant and comparison households were pair-matched on critical characteristics. Although matching was based on annual consumption in each pre-program year, post-hoc analysis proved that the two groups were also virtually identical in their monthly consumption values within the pre-program year.

Participant households that went unmatched – 15,786 in F2011 and 21,252 in F2012 – were excluded from average annual household savings calculations, but were later credited when the savings estimates were extrapolated to the entire population of participants.

Approach for Program Impacts

For each fiscal year evaluated, annual savings estimates were computed for nine separate sub-groups of program participants (six 'In-Challenge' groups, one 'Past Challengers' group, and two 'Never Challenged' groups) based on the aggregation of their monthly savings estimates.

Average annual savings per household in a participant sub-group was an equally weighted sum of the 12 average monthly savings estimates in the in-program year. These average annual savings estimates for the participant sub-group were then extrapolated to the entire population of households in that sub-group, including those households that were deemed ineligible for the pair matching.

Total program impacts for the fiscal year of interest were computed by summing the annual savings estimates from all nine participant sub-groups. Evaluated peak demand savings were derived by applying the residential rate class load shape factor to the net evaluated energy savings. The factor was developed through internal BC Hydro calculations.

2.4.3 Results

Population Profiling

The table on the following page summarizes the status of participating households in each of F2011 and F2012 and their estimated electricity savings. One key finding is that the number of participant households engaged in a 1-year energy reduction challenge nearly doubled from 9,646 in F2011 to 19,905 in F2012. This is an important observation because the majority of program savings were expected to come from households engaged in a challenge – be it their first 1-year challenge, their second 1-year challenge, etc. – rather than from households that were idle.

Table 2.12 Net Program Electricity Savings by Participant Sub-Group

Participant Sub-Group	F2011					F2012				
	Total Count		Average Savings per Household (kWh/year)		Total Annual Savings (GWh/year)	Total Count		Average Savings per Household (kWh/year)		Total Annual Savings (GWh/year)
	⇓		⇓		⇓	⇓		⇓		⇓
In Challenge 1 (1st 1-year challenge)	6,145	x	453.0	=	2.8	12,065	x	491.8	=	5.9
In Challenge 2 (2nd 1-year challenge)	2,394	x	189.5	=	0.5	4,481	x	313.3	=	1.4
In Challenge 3 (3rd 1-year challenge)	894	x	50.0	=	<0.1	2,303	x	244.4	=	0.6
In Challenge 4 (4th 1-year challenge)	212	x	50.0	=	<0.1	911	x	46.5	=	<0.1
In Challenge 5 (5th 1-year challenge)	1	x	50.0	=	<0.1	143	x	46.5	=	<0.1
In Challenge 6 (6th 1-year challenge)	0	x	-	=	0.0	2	x	46.5	=	<0.1
Total In Challenge	9,646		341.4	=	3.3	19,905		399.4	=	7.9
Past Challenger: in hiatus	19,389	x	(24.9)	=	(0.5)	17,935	x	(36.1)	=	(0.6)
Never Challenged: sufficient baseline	25,353	x	18.6	=	0.5	30,212	x	31.9	=	1.0
Never Challenged: insufficient baseline	7,517	x	18.6	=	0.1	10,903	x	31.9	=	0.3
Total	**61,905**		**55.3** [1]		**3.4**	**78,955**		**109.1** [1]		**8.6**
Total Peak Savings (MW)					**0.65** [2]					**1.63** [2]

[1] Total average annual electricity savings are weighted by participant sub-group.

[2] Based on BC Hydro's peak coincidence factor 0.19 for residential behaviour capacity savings.

Electricity Savings by Participant Sub-Group

Another key insight gleaned from the table is the finding that annual savings per household measured highest among Challenge 1 households, stepped down through the challenge numbers, and measured lowest among Never Challenged households. Although the savings estimates for these Never Challenged households were fairly nominal, the finding supports the hypothesis that these households could incur some energy savings due to having been exposed to program messaging and collateral such as brochures or other marketing materials.

Past Challengers were the only participant sub-group to incur greater consumption of electricity relative to their comparison group over the course of F2011 and F2012. This finding may point to both the rationalization and effectiveness of an energy reduction challenge in that by not being in one, Past Challengers may be comparably less engaged than others in their conservation efforts as they go without a formalized, structured goal and without milestone dates to work towards. Their increased consumption may simply reflect some slight fatigue – a relaxation in effort – after completing a yearlong challenge.

All of these findings support program theory that households enrolled in a behavioural program with enabling tools, communications and feedback mechanisms will be more apt to reduce their home electricity consumption. Further along these lines, households engaged in a structured energy reduction challenge are most successful in their efforts.

Free Ridership and Spillover

The estimation of free ridership and spillover was not pursued due to the complexity of a behavioural change program coupled with a quasi-experimental approach to its evaluation. There was no consistent or persuasive evidence to suggest that there was a significant level of free ridership unaccounted for in the gross savings estimates, yet there was reason to believe that there was some unestimated spillover. The energy savings estimates that have been presented are unadjusted for free ridership and spillover, but are considered to be net of these.

Total F2011 and F2012 Net Program Savings

As detailed in Table 2.13 below, total net energy savings attributable to the Power Smart Residential Behaviour Program measured 3.4 GWh/year for F2011 and 8.6 GWh/year for F2012, with associated peak demand savings of 0.6 MW and 1.6 MW, respectively.

Table 2.13 Reported and Evaluated Energy and Peak Demand Savings

Year	Energy Savings (GWh/year)		Peak Demand Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
F2011	3.8	3.4	-	0.6
F2012	5.2	8.6	-	1.6

The substantial increase in energy savings from F2011 to F2012 can be attributed to both a higher number of households engaged in a challenge, particularly a first one when the savings opportunities are the greatest, and higher average annual savings for most of the participant sub-groups in F2012.

Participant and Program Insights

Findings strongly suggest that participants likely incurred savings due to enhanced efforts on four main fronts – space heating, space cooling, laundry and dishwashing behaviours. To a lesser extent, in-home behaviours relating to lighting, smaller plug-load items and water use also measured more favourably among participants than among non-participants.

Participants rated the program's analysis tools, information and feedback mechanisms favourably in terms of supporting their conservation efforts. Multiple lines of evidence uncovered in this study strongly suggest that the program's value is assisting households operationalize and transform their intention and effort around conservation to a successful outcome in the form of better habits and behaviours.

A total of 62 per cent of participants rated their experience to date with the Behaviour Program favourably, rating it as having been either 'excellent' (11 per cent) or 'good' (51 per cent). All of these findings support program theory that households enrolled in a behavioural program with enabling tools, communications and feedback mechanisms will be more apt to reduce their home electricity consumption.

2.5 Renovation Rebate F2009 – F2011

2.5.1 Introduction

The *LiveSmart BC Efficiency Incentive Program* (**LiveSmart**) is a partnership between the British Columbia Ministry of Energy, Mines and Natural Gas (**MEMNG**) and the major provincial utilities: Fortis BC Gas (formerly Terasen Gas), Fortis BC Electric, and BC Hydro. LiveSmart consists of education and financial incentives for homeowners to make their homes more energy efficient. Following a comprehensive home energy assessment by a certified energy advisor, homeowners were provided with a report that includes a list of recommended energy-efficient upgrades to their home. Based on the advisor's recommendations, homeowners choose to complete one or more retrofits to improve their home's energy efficiency. LiveSmart participants received an average of approximately $1,250 in incentives through the program.

The overall goals of the LiveSmart program are to:

- Reduce GHG emissions
- Provide a specific opportunity for residential customers to reduce their energy and water bills
- Generate energy savings for utility program partners by improving the level of energy efficiency of B.C.'s housing stock
- Increase customer awareness of energy efficiency and home energy management by educating customers about the high consumption associated with inefficient homes
- Build industry delivery capacity to advance the whole home energy retrofit market in B.C. and enable future implementation of mandatory building labeling

The Renovation Rebate Program is BC Hydro's internal name for its role within LiveSmart to support whole home energy efficiency retrofits that lead to electricity savings. All Renovation Rebate program incentives are distributed through LiveSmart.

This report provides an impact evaluation and elements of a process evaluation of the Renovation Rebate program for F2009 through F2011.

2.5.2 Objectives and Methods

There were two main objectives considered for this study:

1. Estimate gross and net energy and GHG savings attributed to the Renovation Rebate program between April 2008 and March 2011 (fiscal years F2009 - F2011)
2. Investigate customer satisfaction with the program and the influence of other factors determining program participation, including demographics, household characteristics and behaviors surrounding in-home energy use

Customer surveys were used to collect information on participant experience and satisfaction, and participant and non-participant decision-making to inform free rider and spillover estimates. Monthly billing data from April 2005 through December 2011 was collected for a sample of program participants and non-participants.

The majority of the retrofit activities expected to result in electricity savings for BC Hydro fell into three main categories:

1. Air-source heat pump installations for electrically heated homes
2. Building envelope measures (insulation, windows, doors, draftproofing) for electrically heated homes
3. Variable speed motors (**VSM**) in furnace and heat pump installations

Evaluated Gross Savings Method: The primary methodology for the gross savings analysis was a regression analysis using a quasi-experimental design comparing annual household consumption of participants and non-participant groups, using pre and post-retrofit weather-adjusted consumption data. Participants were defined as all customers in the analysis sample with electrically-heated homes receiving a BC Hydro-funded rebate, and non-participants were electrically-heated homes without rebates. This was used to calculate the average annual electricity savings per participant. This figure was multiplied by the total number of program participants with the same characteristics.

Estimating savings in homes without electric heat was more challenging. BC Hydro incentives in these homes were primarily for variable speed furnace motors, which included households installing a VSM on the blower in conjunction with furnaces and air-source heat pumps (**ASHP**). Estimating energy savings for households installing a VSM with a natural gas furnace used a comparison of pre and post retrofit consumption of participants for households where only a new furnace with VSM was installed.

To estimate electricity savings due to BC Hydro funding for a VSM in households in homes (formerly) without electric heat with a heat pump, a method was required to factor out changes in electricity consumption due to ASHPs, since BC Hydro did not contribute toward ASHP incentives. It was difficult to use regressions to estimate savings for homes installing heat pumps due to any savings effect from the VSM being overwhelmed by the additional electricity consumption requirements of the ASHP. For the purpose of this evaluation, the average electricity savings from a VSM installed with a natural gas furnace obtained above was used for the unit energy savings for a VSM installed with a furnace or a heat pump, and multiplied by the total number of participants installing either.

Net Savings Method: To arrive at net savings estimates, a net-to-gross ratio was developed based on results of the participant and non-participant surveys where respondents were asked a series of questions about their prior plans to complete home upgrades and what they would have done in the absence of the program. Evaluated peak demand savings were derived by applying the residential rate class load shape factor to the net evaluated energy savings. The factor was developed through internal BC Hydro calculations.

2.5.3 Results

Customer Awareness of and Satisfaction with LiveSmart: Fifty-eight per cent of all program eligible households in British Columbia knew of LiveSmart and/or the federal *ecoENERGY Retrofit Homes* program by name, including an understanding that the programs provide financial assistance in the form of rebates to encourage homeowners to make energy efficiency upgrades. Based on LiveSmart program eligibility criteria, the total potential home energy efficiency upgrade market in British Columbia was comprised of approximately 1.2 million households. It is estimated that over 600,000 households completed some type of energy efficiency upgrades between F2009 and F2011.

When asked about the primary reason why they participated in LiveSmart, participants most frequently selected: *to save on home energy costs* (48 per cent); and *to take advantage of the incentives/rebates* (34 per cent).

Non-participants selected three main reasons for why they chose not to participate in the program. Nearly one-half (48 per cent) of these households felt it was *too expensive to hire a Certified Energy Advisor to conduct the initial energy assessment* while 32 per cent felt that the *incentive amounts were too small to make the effort worthwhile* and 27 per cent felt the *steps necessary to participate in the program were too complicated*.

Participants were asked a variety of questions about their experience with various aspects of the program, including their perceptions of the information provided, interaction with the Certified Energy Advisor and their contractor, rebate amount and satisfaction with the program overall. Ninety one per cent of participants reported being satisfied with the program overall including 55 per cent being 'very satisfied'. Most participants agree that the *LiveSmart upgrades have led to a more comfortable home* (89 per cent) while somewhat fewer agree that the *upgrades have led to lower household energy bills* (77 per cent), and that the *upgrades have led to a higher resale value of their home* (67 per cent). Participants also *feel more proud of their home since participating in the LiveSmart program* (72 per cent) and believe the *value of the program far outweighs the cost of the energy assessments and upgrades* (70 per cent). LiveSmart received its strongest endorsement in the finding that nearly all participants would recommend the program to other households thinking about beginning home renovation activities (92 per cent).

Energy and Peak Demand Savings:

Overall, BC Hydro contributions to LiveSmart resulted in estimated gross electricity savings of 4.1 GWh/year in F2009, 8.3 GWh/year in F2010 and 9.2 GWh/year in F2011, across BC Hydro's service territory.

Table 2.14 Gross Electricity Savings for Renovation Rebate: F2009-F2011

Fiscal Year	Pre-Retrofit Heating Fuel	Average Annual Electricity Savings per Participant (kWh/year)	Total Participants[3]	Subtotal (GWh/year)	Gross Electricity Savings (GWh/year)
F2009	Electricity	2,853	770	2.2	4.1
	Natural Gas & Other	414	4,511	1.9	
F2010	Electricity	2,853	1,797	5.1	8.3
	Natural Gas & Other	414	7,635	3.2	
F2011	Electricity	2,853	1,926	5.5	9.2
	Natural Gas & Other	414	9,036	3.7	

Gross electricity savings in each year were estimated using a three-year estimate of average savings per participant. To the extent that the mix of products or measures differed year to year, actual savings in each year will vary from these estimates.

Electrically heated homes that received BC Hydro incentives saved an average of 2,853 kWh per year in electricity during the 3 year time period assessed. This represents a savings of 17.3 per cent[4] of total average annual consumption.

[3] Total number of participants based on data provided by BC Hydro based on total number of invoices from the MEMNG.

[4] Average electricity consumption across LiveSmart eligible households with electric heat in 2010 was 16,483 kWh.

The average electricity savings per household as a result of BC Hydro's incentives in natural gas heated homes was assumed to be equivalent to the standalone estimate of electricity savings for furnace installations – which is primarily attributed to the installation of the variable speed motor on the furnace blower. As outlined in the methodology section, it was not practical or possible to directly estimate the electricity savings for this group due to the proportion of households installing air-source heat pumps.

Determination of net savings attempted to separate out the program impacts that were a result of other influences, such as consumer self-motivation. The evaluated average free-ridership and participant spillover was 44 and 12 per cent respectively. The evaluation also estimated the program influenced a significant amount of non-participant spillover - equivalent to 84 per cent of the total program gross savings.[5] Together, these adjustments amount to an overall net-to-gross ratio of 1.5 for the entire LiveSmart program. The same net-to-gross ratio was applied to the Renovation Rebate program gross savings to arrive at net savings estimates.

The following table summarizes the estimates of evaluated gross and net savings. LiveSmart's electric efficiency measures funded by contributions by BC Hydro saved saved 6.2 GWh/year in F2009, 12.5 GWh/year in F2010, and 13.9 GWh/year in F2011 on a net basis.

Table 2.15 Gross and Net Energy and Peak Demand Savings

Year	Gross Electricity Savings (GWh/year)	Gross Peak Demand Savings (MW)	Free Ridership Rate	Participant Spillover Rate	Non-Participant Spillover Rate	Net to Gross Ratio	Net Electricity Savings (GWh/year)	Net Peak Demand Savings (MW)
F2009	4.1	1.1	0.44	0.12	0.84	1.51	6.2	1.7
F2010	8.3	2.3					12.5	3.5
F2011	9.2	2.6					13.9	3.9

Note: Totals may not add due to rounding.

Reported and evaluated energy and peak demand savings for the Renovation Rebate Program are compared in the following table.

Table 2.16 Reported and Evaluated Energy and Peak Demand Savings

Year	Energy Savings (GWh/year)		Peak Demand Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
F2009	3.0	6.2	-	1.7
F2010	7.6	12.5	-	3.5
F2011	7.2	13.9	-	3.9

[5] For a small proportion of non-participants, their early experience with the program appeared to have some influence on their decisions to install retrofits. Many of these respondents reportedly looked into or even began the process of participating in the program – some as far as having hired a Certified Energy Advisor to conduct an initial energy assessment. A large proportion of the total non-participant spillover savings can be attributed to these particular households, as their mean spillover scores were much higher than other non-participants.

3.0 Industrial Programs

3.1 Power Smart Partners – Transmission Program: F2010-F2011

3.1.1 Introduction

BC Hydro's Power Smart Partners – Transmission (**PSP-T**) program is a multi-year energy acquisition and market transformation initiative. This program encourages BC Hydro's large industrial transmission service customers to undertake energy-efficient investments while supporting their response to the conservation price signals of the Transmission Service Rate.

This report presents an impact evaluation and elements of a process evaluation of the program for BC Hydro's fiscal years 2010 and 2011 (F2010 and F2011). This evaluation covers the gross and net program savings achieved through two approaches: program enabled and incentive. Program enabled savings are electricity savings that resulted from technical and business enablers funded by the program. Program enabled savings projects did not receive direct project funding from BC Hydro. Instead they benefited from the transmission service conservation rate structure. Incentive savings are electricity savings funded by the program with a direct incentive. Outside the scope of this evaluation are industrial self-generation projects and the impact of the Transmission Service Rate.

3.1.2 Objectives and Methods

This evaluation had one objective: to estimate energy and peak demand savings. The following methods were employed:

Evaluated Gross Savings: Evaluated gross savings provide an estimate of actual energy savings produced by the projects that participated in the program. Evaluated gross savings were derived by segmenting the projects into four categories:

1. For projects with completed measurement and verification (**M&V**) results, evaluated gross savings are determined on the basis of M&V results. M&V involves electrical and hours of use metering. Project specific, and end use average, realization rates were calculated as the ratio of M&V'd savings to reported savings. Projects with M&V accounted for approximately half of the program's reported savings over the two-year period.
2. For large projects without M&V, evaluated gross savings are based on reported savings adjusted for evaluation review. Evaluation review includes file review, visual inspection of the project, and customer interviews. Project specific, and end use average, realization rates were calculated as the ratio of evaluation review savings to reported savings. Projects without M&V that underwent evaluation review accounted for approximately 25 per cent of the program's reported savings.
3. For projects without M&V or evaluation review, and where a closely matched realization rate was available, evaluated gross savings are based on reported savings adjusted with a matched realization rate. The realization rate was derived by considering the results of steps 1 and 2 above as well as the industrial sectors and energy end uses of the projects. Projects without M&V or evaluation review that were adjusted with a closely matched realization rate accounted for approximately 15 per cent of the program's reported savings.
4. For projects without M&V, evaluation review, or a closely matched realization rate, average realization rates by energy end use were applied to reported savings to calculate gross savings.

The average realization rates were calculated using the results of steps 1 and 2. These projects were generally small and unique. These projects made up approximately 10 per cent of the program's reported savings.

Evaluated gross savings (kWh/year) = Savings from projects with M&V results + Savings from projects from evaluation review + Savings from remaining projects

Net to Gross Ratio: The net to gross ratio provides an estimate of the proportion of evaluated gross savings that are attributable to the PSP-T Program. The net to gross ratio adjusts for free riders and spillover. Free riders are program participants who would have implemented the energy saving project reported by the program even in the absence of program activities. Spillover refers to program participants and non-participants whose energy savings projects occur through actions that were not reported by the program but which were influenced by the program.

The net to gross ratio was derived through an online survey of PSP-T participants and non-participants. The surveys included a number of detailed questions to provide an understanding of customers' decision making criteria and also presented specific information on projects reported by the program in cases where the survey respondent was a program participant. Survey results were checked for consistency and for sample representativeness and then input to a decision tree in order to calculate the net to gross ratio.

Evaluated Net Energy Savings: Evaluated net energy saving were calculated as the product of evaluated gross energy saving and the net to gross ratio.

Evaluated net energy savings (kWh/year) = Evaluated gross energy savings * Net to gross ratio

Evaluated Peak Demand Savings: Evaluated peak demand savings were derived by applying the transmission rate class load shape factor to the net evaluated energy savings. The factor was developed through internal BC Hydro calculations.

Evaluated net peak demand savings (kW) = Evaluated net energy savings * Load factor.

3.1.3 Results

Evaluated Gross Savings: Evaluated gross savings and the overall realization rate are presented below by funding approach and fiscal year. Evaluated gross savings were 83 per cent and 97 per cent of reported savings in F2010 and F2011, respectively. Reported savings in this instance refer to savings expected by the program, less the impact of any M&V already completed on individual projects and less the impact of any program level adjustments such as a deemed net to gross ratio.

Table 3.1 F2010 Evaluated Gross Savings and Realization Rate by Funding Approach

Funding Approach	Reported Energy Savings (GWh/year)	Realization Rate	Evaluated Gross Energy Savings (GWh/year)
Program Enabled	37.1	82%	30.5
Incentive	4.2	93%	3.9
Totals	**41.3**	**83%**	**34.4**

Table 3.2 F2011 Evaluated Gross Savings and Realization Rate by Funding Approach

	Reported Energy Savings (GWh/year)	Realization Rate	Evaluated Gross Energy Savings (GWh/year)
Program Enabled	52.6	96%	50.3
Incentive	11.8	104%	12.3
Totals	**64.4**	**97%**	**62.6**

Incentive savings achieved higher realization rates than did program enabled savings. This trend is partly explained by the prevalence of operational and procedural projects in the program enabled savings category, which have lower savings certainty than the equipment upgrades more common in the incentive category. It is further explained by the higher proportion of incentive savings that undergo M&V relative to program enabled savings. The increase in the realization rate between F2010 and F2011 is due to an increase in M&V activity across both funding approaches.

Net to Gross Ratio: Presented below are the results of the net to gross ratio analysis. The net to gross ratio was estimated to be 81 per cent, comprising 45 per cent free ridership offset by 26 per cent spillover. Free ridership of 45 per cent was in turn the average of 65 per cent free ridership among program enabled savings and 7 per cent free ridership among incented savings.

Table 3.3 Free Ridership, Spillover and Net to Gross Ratio Results

Adjustment	Incentive	Program Enabled	Overall Mean
Free Ridership	7%	65%	45%
Participant Spillover	N/A	N/A	22%
Non-Participant Spillover	N/A	N/A	4%
Net to Gross Ratio			**81%**

The survey asked free ridership questions on each project reported by the program. This allowed free ridership to be assessed separately for incented and program enabled savings. Spillover was also calculated using the survey method. Spillover could not be assessed by funding approach, because by definition spillover projects are those projects that were influenced by the program but did not make use of either funding approach offered by the program. Due to the relatively small number of eligible program participants, a distinct net to gross ratio cannot be calculated for each fiscal year.

Reported and Evaluated Savings: The tables below show evaluated net savings by fiscal year.

Table 3.4 F2010 Reported and Evaluated Net Savings

Funding Approach	Energy Savings (GWh/year)		Peak Demand Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
Program Enabled	37.1	24.7	4.3	2.9
Incentive	4.2	3.2	0.5	0.4
Totals	**41.3**	**27.9**	**4.8**	**3.2**

Table 3.5 F2011 Reported and Evaluated Net Savings

Funding Approach	Energy Savings (GWh/year)		Peak Demand Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
Program Enabled	52.6	40.7	6.1	4.7
Financial Incentive	11.8	10.0	1.4	1.2
Totals	**64.4**	**50.7**	**7.5**	**5.9**

Glossary

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

Certified Energy Advisor (CEA) **–** Independent experts in application of energy-related systems, assemblies and components for improved residential energy efficiency. CEAs are affiliated with Natural Resources Canada to deliver the EnerGuide rating service. Before being certified, each EnerGuide rating service energy advisor must complete training in a number of fields related to residential energy efficiency and also conduct several home evaluations under the guidance of an instructor.

Challenge n households **–** Households in engaged in their n^{th} energy reduction challenge as of the cut-date in the fiscal year of interest.

Comparison Group **–** Households included in the matching analysis and the difference-of-differences impact equation that have not joined the Behaviour Program.

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

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

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

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

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

Reported Savings **-** Estimate of savings based on customer initially reported savings, engineering review and site inspection. These estimates represent the unverified savings.

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.

Free ridership (FR) **-** Energy use of a program participant who would have implemented the program measure or practice in the absence of the program. *In the Power Smart Partner - Transmission report, the free ridership is expressed as a fraction of the reduction of energy savings due to the free ridership to the gross energy savings of the program participant.*

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

Ministry of Energy, Mines and Natural Gas (MEMNG) – Provincial Government of BC Ministry of Energy, Mines and Natural Gas and Responsible for Housing.

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

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

Never Challenged Households: Sufficient Baseline Consumption – participant households that have never commenced an energy reduction challenge, though they are able to do so.

Never Challenged Households: Insufficient Baseline Consumption – participant households that have never commenced an energy reduction challenge because they do not have the required 12 months of baseline consumption at their current residence.

Past Challenge(r) Households – participant households that have completed at least one energy reduction challenge, but are currently not engaged in one.

Quasi-experiment - In a quasi-experimental design, there is no random assignment to a treatment or control group. Treatment and comparison group members are matched post-hoc on relevant characteristic(s).

Realization Rate - The ratio of initial estimates of savings to savings adjusted for data errors and measurement and verification results. Does not reflect program attribution or influence on the savings achieved.

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

Variable Speed Motor (VSM) – In the context of the LiveSmart report, VSMs are installed on the blower in furnaces and heat pump air-handling units to distribute air throughout the home's duct system. VSMs operate at lower speeds most of the time, and higher only when necessary.

Acronyms and Abbreviations

CFL – Compact Fluorescent Lamp

DSM – Demand Side Management

EOC – Evaluation Oversight Committee

LED – Light Emitting Diode

M&V – Measurement and Verification

PSP – Power Smart Partners