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January 15, 2018

Mr. Patrick Wruck
Commission Secretary and Manager
Regulatory Support
British Columbia Utilities Commission
Suite 410, 900 Howe Street
Vancouver, BC V6Z 2N3

Dear Mr. Wruck:

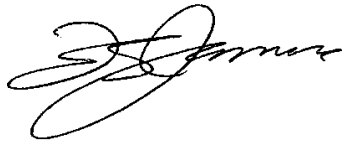
RE: British Columbia Utilities Commission (BCUC or Commission)
British Columbia Hydro and Power Authority (BC Hydro)
2004/05 and 2005/06 Revenue Requirements Application
Commission Decision: Order No. G-96-04, October 29, 2004, Directive 66 (page 197)

BC Hydro writes to submit its F2017 Demand Side Management Milestone Evaluation Summary Report (**the Report**), dated December 2017 in compliance with Directive 66 (page 197) of the Commission Decision dated October 29, 2004. Directive 66 directs BC Hydro to file the executive summaries of its milestone evaluation reports and full final evaluation reports for all its Power Smart programs. The Report summarizes the impact evaluations completed during F2017 for the following:

1. Residential Lighting: F2013-F2015 Q1;
2. Continuous Optimization: F2011-F2013;
3. High Performance Buildings and Commercial New Construction: F2008-F2011; and
4. Power Smart Partner - Transmission: F2012-F2014.

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

Yours sincerely,



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Enclosure

BC Hydro
Power smart

Demand Side Management Milestone Evaluation

Summary Report F2017

December 2017

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1.0 Introduction

This report summarizes the milestone evaluations of demand-side management (**DSM**) initiatives completed by BC Hydro in fiscal year 2017 (**F2017**). It is filed in compliance with Directive 66 of the British Columbia Utilities Commission (**BCUC**) decision on BC Hydro's F05/F06 Revenue Requirements Application (dated October 29, 2004), which "*directs BC Hydro to file the executive summaries of its milestone evaluation reports and full final evaluation reports of all its Power Smart programs*" (page 197).

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

DSM evaluation activities are guided by the following six principles:

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

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

1.1 Completed Evaluations

Impact evaluations summarized in this report include the following:

- Residential Lighting: F2013-F2015 Q1;
- Continuous Optimization: F2011-F2013;
- High Performance Buildings and Commercial New Construction: F2008-F2011; and
- Power Smart Partner - Transmission: F2012-F2014.

2.0 Residential Lighting: F2013-F2015 (Q1)

2.1 Introduction

The impacts and effects of BC Hydro's Residential Lighting program were evaluated for the period April 2012 through June 2014 (F2013 through the first quarter of F2015). Prior to June 2014 the program was dedicated only to residential lighting. After June, residential lighting became one component of a larger Retail Program that included a range of residential consumer products, including lighting. Prior evaluations of the Residential Lighting Program covered the period up to F2012.

The objectives of the Residential Lighting program included: (1) sustain and increase a greater market share of energy-efficient lighting in advance of regulations for more efficient lighting; (2) promote efficient lighting products not covered by regulations and newer products such as Light Emitting Diodes (**LEDs**); (3) promote and increase awareness of efficient lighting products province-wide and drive customers to retailers to purchase efficient products; and (4) provide residents province-wide with an accessible and simple lighting program.

The Residential Lighting program was first launched in 2002 and operated continuously from then until June 2014. The Residential Lighting program was initially launched as a Compact Florescent Lamps (**CFL**) pilot initiative in three communities. Bulk CFL purchases were made by BC Hydro and distributed free to customers using redeemable coupons at retail partners. The CFL pilot was later expanded to additional regions, and to include incentive coupons to encourage customers to purchase CFL torchieres rather than halogen torchieres. In October 2004 the program launched a province-wide fall campaign that focused on CFLs, seasonal LEDs and CFL torchieres. The program continued to update its product mix over the years that followed to reflect market changes. In June 2007, the program transitioned from spiral CFLs to specialty CFLs. Specialty CFLs continued to be promoted until 2013. From July 2011 to the end of the evaluation period, the program focused primarily on promoting LED lamps. CFL and LED fixtures that complied with the ENERGY STAR labelling program were also promoted. Instant in-store discounts and manufacturer buy-downs continued to be offered during time limited campaigns that ran in spring and fall. New major retail partners were added to increase market penetration of energy-efficient lighting technologies.

The program has provided retailer education for the residential lighting market since its inception. Retailer partnerships continued to be a key component of the Residential Lighting program over the period evaluated.

BC Hydro's service territory covers approximately 1.7 million residential accounts. Over the period evaluated, the program provided rebates for almost 800,000 lighting units, of which over 500,000 were LED lamps.

2.2 Approach

Four evaluation objectives were identified, each with specific researchable questions, as summarized in the following table:

Table 2.1. Evaluation Objectives and Research Questions

Objectives	Research Questions
1. Program effectiveness	• How did BC Hydro customer awareness, purchases, and promotion recall levels for energy-efficient lighting products compare to similar customers with a less extensive residential lighting program? • How satisfied were BC Hydro residential customers with CFL and LED lamps? • What were program participants' perceptions of program influence on their purchase decisions and their intended actions in the absence of the program? • How effective was the program in influencing retail partners' purchase and stocking decisions? • How influential was the program in encouraging retail partners to sell more energy-efficient products? • How satisfied were retail partners with the program?
2. Market trends	• What were trends in pricing and shelf space shares for lamps and fixtures? • What were trends in lamps in BC Hydro residential customer homes?
3. Evaluated gross unit electricity savings	• What were the hours of use for lamps and fixtures? • What was the peak coincidence of lamps and fixtures? • What was the power draw of the energy-efficient and baseline lighting products? • What was the installation rate for the various lighting types? • What were the unit energy savings per lighting product incented by the program?
4. Evaluated net electricity savings	• What was the free rider rate? • What was the spillover and market effects rate? • What were net energy and peak savings by lighting product type? • What were the annual, incremental evaluated savings for the program overall and how did they compare to reported savings? • What were the sources of any variances between evaluated and reported savings?

Table 2.2 summarizes, for each of the evaluation objectives, the evaluation data and methods used.

Table 2.2. Evaluation Objectives, Data and Methods

Objectives	Data sources	Method
1. Program effectiveness	• 2012 BC Hydro Residential Customer Survey (n = 601) • 2012 Comparison group survey (n = 450) • 2012, 2013, 2014 Retail Partners Surveys (n = 9, 8, 5) • • 2014 Lighting Program participant survey (n = 80)	• Cross tabulations • Trend analysis • Z-tests
2. Market trends and effects	• Annual Household Lighting Shelf Space Study from 2001 to 2014 (~ 40 stores per year) • BC Hydro residential end use surveys from 1998 to 2014 (n = 4,248 to 7,604 depending on year)	• Cross tabulations • Trend analysis
3. Evaluated gross unit electricity savings	• Program tracking data • 2010 Residential monitoring study (n = 292 lighting points) • Sales data from participating retailers • 2014 Lighting Program participant survey (n = 80) • BC Hydro Standard Procedure: Cross Effects	• Engineering algorithms • Load Shape analysis
4. Evaluated net electricity savings	• Results of objective 3 • Sales data from participating retailers • 2012 BC Hydro Residential Customer Survey (n = 602) • 2012 Comparison group surveys (n = 450) • 2014 Lighting Program participant survey (n = 80) • BC Hydro Standard Procedure: Cross Effects	• Market data analysis • Cross tabulation

2.3 Results

Results for Objective 1: Program Effectiveness

Program effectiveness was assessed using a set of residential customer surveys delivered in 2012. BC Hydro and comparison group customers had similar awareness levels for all lighting products with the exception of LED lamps. Awareness levels for LED lamps were greater for BC Hydro residential customers than for comparison group customers (73 per cent vs 66 per cent awareness, respectively) and this difference was highly statistically significant.

BC Hydro residential customers and comparison group customers were asked if they had purchased various lighting products over the past year. A greater share of BC Hydro customers had purchased halogen and LED lamps than did comparison group customers, and these differences were highly statistically significant. A lesser share of BC Hydro customers purchased incandescent lamps than did comparison group customers, and this difference was also statistically significant. BC Hydro residential customers and comparison group customers who indicated that they had purchased a particular lighting product over the past year were then asked how many they purchased. BC Hydro customers who purchased LED lamps purchased a greater number of them than did comparison group customers who purchased LED lamps (averages of eight versus five lamps, respectively). BC Hydro customers who purchased incandescent lamps purchased fewer than did comparison group customers who purchased such lamps (averages of eight versus 11 lamps, respectively).

The program's effectiveness in promoting energy-efficient product sales was examined by comparing recall of information, advertising or promotions between the treatment group and the comparison group. Recall of related promotions was higher for both CFL and LED lamps among BC Hydro customers than among comparison group customers and the differences were highly statistically significant.

BC Hydro customers reported high levels of satisfaction with LED lamps, with 92 per cent of respondents reporting being somewhat or very satisfied with them. Satisfaction levels were more mixed for specialty CFLs – with 72 per cent of respondents reporting being somewhat or very satisfied with them and 19 per cent reporting being somewhat or very dissatisfied.

Households identified as having purchased BC Hydro discounted bulbs and fixtures during the lighting campaigns were queried as to their likelihood of purchasing the units had the discount not been available. For households that purchased LEDs during the fall 2012 campaign, 55 per cent believed that they either 'definitely would have' or 'probably would have' purchased the bulbs anyway had the discount not been available. For households that purchased LEDs during the spring 2014 campaign, 61 per cent believed they 'would have purchased at least some of the bulbs anyway' had the discount not been available.

Retail partners were asked about their satisfaction with the program in each of the three years of the evaluation period. Satisfaction levels were high in each of F2013 and F2014, but declined to moderate levels in F2015.

Retail partners were also asked about the influence of the program on sales of energy-efficient lighting products. Retail partners rated the program as being more influential on sales of energy-efficient lighting products in F2013 and F2014 than they did in F2015. Retail partners viewed the program as being more influential on sales of energy-efficient lamps than on sales of energy-efficient lighting fixtures.

Results for Objective 2: Market Trends

Over the evaluation period, incandescent lamps had the largest shelf space share among residential lighting product retailers, ranging from 34 per cent to 38 per cent. CFL lamp shelf space share declined from 25 per cent to 20 per cent, while LED lamps shelf space share increased from 10 per cent in 2012 to

17 per cent in 2014. Shelf space devoted to ENERGY STAR fixtures appeared to be modest at between 4 and 7 per cent.

LED lamp prices declined from an average of $22.22 in 2012 to $16.12 by 2014. Prices for other lamp types were stable or exhibited no ongoing trend, while prices for fixtures increased.

Between 2002 (when the residential lighting program began) and 2014 the total number of lamps installed in BC Hydro residential customer homes increased from an average of 33 to 38. Over the same period, the average number of incandescent lamps per household in BC Hydro's service territory dropped from 24 to 16, while the average number of efficient lamps (CFL or LED) increased from one to 13.

Between 2012 and June 2014 (within the period covered by this evaluation), the total number of lamps installed in BC Hydro residential customer homes remained stable at 38. The average number incandescent lamps dropped from 17 to 16 per home, while the average number of LED lamps increased from one to three lamps per home. The number of CFL lamps was steady at an average of ten per home.

Results for Objectives 3: Evaluated Gross Unit Electricity Savings

Evaluated gross unit electrical savings are presented below for each of the four lighting product types rebated through the program over the evaluation period.

Table 2.3. Evaluated Gross Unit Savings

	Efficient Power Draw (Watts)	Baseline Power Draw (Watts)	Power Savings (Watts)	Annual hours	Peak Coincidence	(1 – cross effects)	Installation rate	Evaluated Gross Unit Energy Savings (kWh/yr)	Evaluated Gross Unit Peak Demand Savings (W)
	A	B	C = B - A	D	E	F	G	H = (C*D*F*G)/ 1,000	I = C*E*F*G
Specialty CFL lamps	16	54	39	934	0.31	0.95	0.76	26	9
LED lamps	10	54	45	934	0.31	0.94	0.79	31	10
LED fixtures	11	54	43	934	0.31	0.94	0.94	35	12
CFL fixtures	25	103	78	934	0.31	0.97	0.94	67	22

Free Ridership and Market Effects

Free ridership by lighting product type is presented below.

Table 2.4. Evaluated Free Ridership

	F2013 (%)	F2014 (%)	F2015 (%)
Specialty CFL lamps	58	58	N/A
LED lamps	9	9	39
LED fixtures	23	30	60
CFL fixtures	80	80	90

By analyzing differences between BC Hydro and comparison group customers, an overall estimate of the net effects of the program was developed for LED lamps and specialty CFL lamps, inclusive of market effects across the entire BC Hydro service territory. Due to limitations in the Dakotas as a representative comparison group for BC Hydro customers, the level of uncertainty associated with this estimate of the program's net effects is

higher than the uncertainty associated with the free ridership estimate alone. An estimate of market effects could not be produced for ENERGY STAR fixtures.

The net-to-gross ratio inclusive of market effects was 477 per cent for LED lamps for F2013 and F2014. This result indicates that the program played an important role in accelerating awareness, purchase and installation of LED lamps across BC Hydro's service territory. Evidence presented in this evaluation indicates that the LED market is changing rapidly. As such, the market effects observed in the evaluation period may not be applicable to future periods.

The net-to-gross ratio inclusive of market effects was zero for specialty CFL lamps. The program provided rebates for specialty CFL lamps in the first part of the evaluation period only, and discontinued the offer in F2014. One explanation of an overall net-to-gross ratio of zero may be that program promotional efforts influenced customers to purchase LED lamps, instead of CFL lamps, outside the campaign period.

Results for Objectives 4: Evaluated Net Electricity Savings

The evaluated and reported net savings by year is shown below. Evaluated savings are incremental annual saving, adjusted for the fact that not all lighting products are immediately installed.

Table 2.5. Reported and Evaluated Net Energy and Peak Savings

	Energy Savings (GWh/year)			Peak Demand Savings (MW)		
	Reported	Evaluated Net Direct	Evaluated Net with Market Effects	Reported	Evaluated Net Direct	Evaluated Net with Market Effects
F2013	14.6	8.2	30.2	5.2	2.7	10.0
F2014	6.6	5.5	25.0	2.4	1.8	8.3
F2015 First Quarter	4.9	3.1	3.1	1.8	1.0	1.0
Total	**26.1**	**16.7**	**58.4**	**9.3**	**5.6**	**19.4**

Evaluated net direct savings are estimated based on the number of rebated products, the evaluated gross unit savings per lighting product, and the evaluated free ridership estimate. The level of uncertainty associated with the evaluated net direct savings is low. Evaluated net direct savings are lower than reported savings because evaluated free ridership was higher than was assumed in reported savings, and because evaluated savings include an installation rate adjustment to account for the fact that some rebated lighting products were placed in storage, whereas reported savings do not include an installation rate adjustment.

Evaluated net savings with market effects are estimated in the same manner as evaluated net direct savings for ENERGY STAR fixtures. For LED lamps and specialty CFL lamps, evaluated net savings with market effects reflect the program's impact across the entire BC Hydro service territory, and they likely include the effects of program efforts promoting LED lamps in the year prior to the evaluation period. The level of uncertainty associated with evaluated net savings with market effects is high. Evaluated net savings with market effects are higher than reported savings and evaluated net direct effects because of market effects for LED lamps.

2.4 Findings and Recommendations

Findings

1. BC Hydro's residential lighting program provided rebates for almost 800,000 lighting units over the period evaluated, of which over 500,000 were for LED lamps.

2. Over the evaluation period, the average number of LED lamps installed in BC Hydro residential customer homes more than doubled from an average of one to three lamps per home. The retailer shelf space share dedicated to LED lamps increased from 10 per cent to 17 per cent while average LED prices declined from $22.22 to $16.12.

3. BC Hydro customers had higher levels of LED lamp awareness, share of customers purchasing LED lamps, and number of LED lamps purchased relative to comparable residential customers with a less extensive residential lighting program.

4. BC Hydro customers reported high satisfaction with LED lamps, and mixed satisfaction with specialty CFL lamps.

5. The majority of BC Hydro residential customers reported that the lighting program was influential in their purchase of energy-efficient lamps.

6. Retail partner satisfaction with the program was high in F2013 and F2014, but modest in F2015. Retail partners indicated that the program was more influential on sales of energy-efficient lighting products in the earlier part of the evaluation period than the later part.

7. The reliability of gross evaluated savings would be improved with additional data on the wattage of rebated lamps and an updated metering study of lighting hours-of-use and load shape among BC Hydro residential customers. The reliability of the net-to-gross ratio would be improved with additional data on the sales of lighting products throughout the entire year.

8. The net-to-gross ratio for LED lamps including market effects was 477 per cent for F2013 and F2014. The net-to-gross ratio for specialty CFL lamps including market effects was zero. These results indicate that the program accelerated adoption of LED lamps, and that the market for CFL lamps has now matured. The net-to-gross ratio for LED lamps including market effects is not applicable past F2014.

9. High levels of free ridership were measured for LED and CFL fixtures by analyzing differences in sales. However, evidence suggests that high free ridership may be more reflective of low levels of sales of energy efficient fixtures overall, as opposed to high levels of natural conservation. Only 33 per cent of BC Hydro customers were aware of ENERGY STAR fixtures and only 2 per cent reported purchasing one.

10. Evaluated net savings including market effects over the evaluation period were 58.4 GWh/year, while reported savings were 26.1 GWh/year respectively. The main source of variance was the large evaluated estimate of market effects for LED lamps in F2013 and F2015. Lesser sources of variance were the installation rate and unit power savings.

Recommendations

Recommendations one through four are for program management, while recommendation five is for Evaluation.

1. To improve the quality and reduce the cost of future evaluations, request data on the numbers and descriptions of all lighting products sold in each month of the year, from all retail partners.
2. Given that some lamps purchased with program assistance are temporarily placed in storage, consider applying an installation rate adjustment to reported savings in periods that have yet to be evaluated.
3. The ENERGY STAR fixture offer appears to be in the early adopter stage. Relatively few residential customers were aware of, or had purchased, these fixtures. To accelerate adoption, consider reviewing the approach used to promote ENERGY STAR fixtures.
4. The evaluated estimate of market effects due to program efforts on LED lamps may reflect an acceleration of the LED market and may therefore be transitory. It is not recommended that the market effects estimate presented in this evaluation be applied as is to forecast or reported program savings beyond F2014.
5. Consider the need for and costs of an updated lighting load shape and hours-of-use metering study of BC Hydro customers.

2.5 Conclusions

From F2013 to the end of the first quarter of F2015, BC Hydro's residential lighting program saved 58.4 GWh/year of electric energy, mostly due to LED lamps. Since its inception in 2002, the program has had widespread effects on the residential lighting market in BC Hydro's service territory, resulting in an increase in awareness, installations and purchases of energy-efficient lighting products.

3.0 Continuous Optimization F2011-F2013

3.1 Introduction

Section 3.0 presents an impact evaluation of electricity savings due to BC Hydro's Continuous Optimization (**C.Op**) demand side management (**DSM**) program for fiscal years F2011 to F2013 (from April 1, 2010 through March 31, 2013). This evaluation also includes elements of a process and market evaluation.

The Continuous Optimization program began in 2009 to help commercial building owners and operators implement and maintain improvements to their energy management practices. The key focus of the program is operational conservation measures, which are often referred to as "low/no-cost" because implementation does not require the purchase and installation of new equipment, and costs are generally limited to labour. The conservation potential for operational savings in a commercial building is largely tied to improving the performance of the building's heating, ventilation and air conditioning (**HVAC**) systems, as well as lighting and refrigeration systems.

Program access was available to commercial buildings larger than 50,000 square feet and since 2010, over 500 buildings enrolled in the program, with the majority of these buildings continuing through the program stages and components further described below. Program participants have been diverse, including the following commercial segments: offices, retail, healthcare, education, hospitality and recreation. As of September 2013, the program had reached its participation goals with an estimated 35 per cent of the eligible buildings participating. The program was then considered fully subscribed and no longer accepting new applications.

The program consisted of two primary components which were fully funded by the program:
1) recommissioning the building and 2) installing an Energy Management Information System (**EMIS**).

In the recommissioning component, consultants worked with customers to identify and implement energy conservation measures, and customers were required to implement the recommended measures with simple paybacks under two years. Each customer engagement lasted up to five years, requiring ongoing customer interaction, document reviews and administration. The main steps of the recommissioning component were: studying the building, recommending low- or no-cost energy efficiency improvements, reviewing the energy conservation measures with operations staff, implementing measures, validating implementation of measures through site inspections, and conducting follow-up coaching sessions to ensure energy savings continue.

The EMIS component was an energy information tool that took interval data from the customer's whole building meter and provided analysis and reporting on the building's energy use. If the customer's utility meter measured the consumption of the whole building, BC Hydro upgraded the meter to a pulse output meter at no cost to provide the interval data. Where the utility meter did not provide whole building data, such as with large university campuses, the customer was obligated to provide their own meters to provide the interval data. The EMIS vendors then installed the EMIS and configured it to provide information allowing building operators to identify processes that had a substantial impact on energy consumption and provided a good opportunity for energy savings. The original program intent was to use the EMIS functionality for quantifying energy savings, exception reporting (a "heads up" when building consumption is unexpectedly high), load profiles, benchmarking, and billing analysis.

3.2 Approach

Four evaluation objectives were identified, each with specific researchable questions, as summarized in the following table:

Table 3. 1. Evaluation Objectives and Research Questions

Evaluation Objective	Research Questions
1. Assess program participation and energy conservation measures	• What were the most common types of participating buildings? • What were the most commonly implemented recommissioning measures? • What were the implementation rates of the various recommended measures? • How did implemented measures perform relative to expectations?
2. Understand the participant experience	• How aware are participants of key program components? • To what extent do participants' understandings of the purpose and operation of key program components match their actual purpose and operation? • How early following program enrolment did participants start to implement recommissioning measures? • What is the qualitative assessment of free ridership?1 • To what extent did participants implement recommissioning measures at buildings that were not enrolled in the program (participant spillover)? • To what extent did participants implement hard-wired energy conservation measures as a result of the program?
3. Explore market effects and program influence	• To what extent did the number of active EMIS customers change? • What were the noticeable changes to building operating practices? • What evidence exists regarding the extent to which the above changes would have occurred in the absence of the program? • To what extent did implementation of EMIS systems and/or recommissioning studies occur outside the program?
4. Estimate net savings	• What are net electric energy savings? • What are net peak demand savings? • What is the approximate profile of energy savings during the BC Hydro system peak? • Do energy savings vary by season? • What evidence is available on savings persistence?

Table 3.2 summarizes, for each of the evaluation objectives, the evaluation data and methods used.

Table 3.2. Evaluation Objectives, Data Sources and Methods

Evaluation Objectives	Data	Method
1. Assess program participation and energy conservation measures	• Program tracking data • Project files • Measurement and Verification (**M&V**) reports	• Engineering desk review • Trends analysis
2. Understand the participant experience	• Participant interviews (22 organizations interviewed)	• Qualitative analysis
3. Explore market effects and program influence	• EMIS Vendor Interviews (3 organizations interviewed) • Recommissioning consultant interviews (5 organizations interviewed)	• Qualitative analysis
4. Estimate net savings	• EMIS hourly electricity data during F10-F15 • Program tracking data • Hourly weather data	• Quasi-experimental design: Variation in Adoption; ANCOVA statistical analysis

[1] A quantitative assessment of free ridership was not completed because the evaluation method used in Objective 4 to estimate net savings produces a direct estimate of net savings accounting for any free ridership. As a result there was no business need for a stand-alone free ridership estimate.

The first objective, related to assessing program participation and energy conservation measures, was completed using engineering desk reviews and trend analysis using three data sources: program tracking data, project files and M&V reports.

The second and third objectives, related to understanding the participant experience and exploring market effects and program influence, were addressed with qualitative research in the form of semi-structured interviews with program participants, recommissioning consultants and EMIS vendors. The twenty two participant interviewees represented 340 buildings that were enrolled in the program. The three EMIS vendors who were interviewed represented all EMIS vendors involved in the program. The five recommissioning consultants interviewed were estimated to have to have provided C.Op services to over 200 buildings that were enrolled in the program. The interviews lasted 45 to 90 minutes each, were conducted from January through March 2016 either in-person or via telephone.

The fourth objective, related to net savings, was addressed by conducting a statistical analysis of the 433 participating buildings for which quality data were available. The analysis involved five steps: 1) obtain hourly consumption and program tracking data and prepare it for analysis, 2) group the buildings by load shape, 3) set up a quasi-experiment, 4) model program effects, and 5) calculate net electricity savings. This evaluation method produces a reliable estimate of average net savings per participant. Note that the use of the EMIS modelling functionality, as well as the completion of a representative sample of M&V, were both considered for the evaluation of net savings, but were abandoned due to the cost and time involved in implementing these methods.

The method for estimating net electric energy savings was used to provide some insights into savings persistence, the average daily shape of savings and savings seasonality. Peak demand savings were calculated using the evaluated savings shape.

3.3 Results

Results for Objective 1: Program Participation and Energy Conservation Measures

Program tracking data for F2011 to F2013 revealed that four customer segments accounted for over 80 per cent of participating buildings and 77 per cent of expected savings: universities/colleges, offices, schools and hospitals. Buildings participating in the program achieved energy savings by implementing energy conservation measures related to building operations, with the most common being: reduction in excessive equipment operation (38 per cent of total measures implemented), building systems controls optimization (18 per cent) and equipment load reduction or efficiency increase (15 per cent). The majority of the energy conservation measures focused on four building systems: ventilation (67 per cent), lighting (11 per cent), boiler plants (9 per cent) and chiller plants (6 per cent).

Overall, 75 per cent of all energy conservation measures recommended by the recommissioning consultants were implemented at participating buildings. Energy conservation measures with implementation rates of 70 per cent or higher commonly involved changes to building management systems and, as such, aligned with the program intent to promote implementation of operational measures. Energy conservation measures with lower implementation rates commonly had higher capital costs and, as such, did not align with the program intent to target operational measures, but their recommendation by recommissioning consultants was not discouraged.

One of the program goals was to use the EMIS functionality for quantifying energy savings to measure savings for the program overall. That goal was ultimately not achieved because collecting and maintaining the required data was challenging for some participating buildings, and completing the required detailed investigation to

validate the EMIS savings estimates was costly and slow. The EMIS did measure savings in some buildings as intended.

Ten of the buildings were selected for a detailed investigation of energy savings, using M&V. These ten buildings were selected because they appeared to have the appropriate conditions for successful application of M&V. These ten buildings are not representative of all buildings in the program and results of their M&V were not used in the estimation of net program savings presented in this evaluation. Verified savings for the ten buildings were compared to the expected savings developed by the recommissioning consultant. Across the 10 projects, the median of verified savings was 82 per cent of expected savings.

Results for Objective 2: Understand the Participant Experience

In general, there was a high level of awareness and understanding of the program among participants. Participants generally understood most of the key program milestones, and their understanding of program components generally matched the actual purpose and operation of those components. However, there was a greater range in the understanding of the role of the coaching phase, particularly between recommissioning consultants and participating customers. Experience with the individual program milestones was generally positive with the exception of the coaching phase where feedback varied widely. Overall satisfaction with the program was high with participants, consultants and EMIS vendors all reporting a very positive experience with the C.Op program.

The qualitative research suggests that minimal free ridership occurred in the C.Op program. Participants reported that little to no recommissioning measures would have been implemented without the program's support. Likewise, the recommissioning consultants reported minimal recommissioning activity before the program and minimal activity outside of the program during its operation. Although the incidence of spillover was noted to be widespread among participants and by consultants, it typically occurred at buildings that were too small to participate in C.Op or were located in regions outside B.C. (among national chains), suggesting the magnitude of spillover from this particular program within B.C. was generally small.

Results for Objective 3: Explore Market Effects and Program Influence

Multiple participants highlighted the importance of C.Op in increasing building operators' awareness of the performance of their facilities, and that checking performance with EMIS was now part of the operators' weekly activities. Many participants also noted that positive organizational changes had occurred as a result of participation, such as providing the structure for Energy Managers to work more closely with building operational staff. The EMIS also provided a tool to communicate energy performance to operators and senior managers, increasing their awareness of energy conservation and interest in making further improvements. However, there was significant variation in the reported level of engagement by operational staff.

Only a few participants owned or were even aware of the existence of EMIS prior to participation in C.Op. The EMIS vendors reported that the market for EMIS grew significantly in B.C. from the beginning of the C.Op program up to 2012 after which it plateaued, and they attributed this growth to the C.Op program. All consultants were of the opinion that there was limited recommissioning before C.Op and the market developed rapidly for recommissioning services while C.Op was in place, with the majority of this growth directly from C.Op participation. Participants expressed some uncertainty about their organizations' willingness to pay for an EMIS or for recommissioning consultants without utility funding.

Results for Objective 4: Estimate Net Savings

Results for electric energy and peak demand savings are summarized below. Results are cumulative. This means that the annual savings results include any savings achieved in earlier years that continue to persist. Values presented in the rows of the table below should not be summed.

Table 3.3. Summary of Electric Energy and Peak Demand Savings

Fiscal Year	Cumulative Energy Savings (GWh/year)		Cumulative Peak Demand Savings (MW)	
	Reported	Evaluated Net	Reported	Evaluated Net
F2011	3.3	0.0	0.5	0.0
F2012	10.7	32.4	1.5	3.7
F2013	21.6	36.5	3.0	4.2

As shown, evaluated net savings were 36.5 GWh/year by F2013, which was 171 per cent of reported. Evaluated net savings of 32.4 GWh/year in F2012 and 36.5 GWh/year in F2013 are equivalent to average annual savings per participant of 4 per cent and 5 per cent, respectively.

Analysis of changes to savings over time among the earliest participating buildings showed that an increase in savings was observed from F2011 through F2015, supporting the hypothesis that gross savings persist for at least four years. Most program savings were achieved between 7 a.m. and 7 p.m., with peak savings occurring at 11 a.m. C.Op participants achieved greatest savings during the summer season, followed by the winter season.

3.4 Findings and Recommendations

Findings

Listed below are the main findings of this study.

1. The most common energy conservation measure was to limit mechanical or lighting systems that ran longer hours than needed and ran during unoccupied periods. The majority of the energy conservation measures acted on four building systems: ventilation (67 per cent), lighting (11 per cent), boiler plants (9 per cent) and chiller plants (6 per cent).
2. Program participants had a high level of awareness and understanding of key program milestones and a generally accurate understanding of the purpose and operation of the program's components, with the exception of the coaching phase. The coaching phase also had the most varied levels of satisfaction.
3. Overall, participants, consultants and EMIS vendors reported having a very positive experience with the C.Op program. Participants also expressed very strong commendations to BC Hydro staff for designing and implementing a sound program.
4. The qualitative research suggests that program free ridership was minimal. Although the incidence of spillover was widespread among participants, it generally occurred at buildings that were too small to participate in C.Op or that were located outside of B.C., suggesting the overall magnitude of spillover in B.C. was small. Note that the net evaluated savings in this evaluation account for free ridership and spillover at participating sites.
5. Evidence suggests that suitable assignment of roles and responsibilities, including responsibility for energy management, among employees of participating organizations is a success factor for the C.Op

program. The impact analysis suggested that C.Op participants with a dedicated energy manager in place may have responded faster to the program than did participants without this position. The qualitative research revealed that although positive organizational changes had occurred at many organizations as a result of participation in the program, there was significant variation in the reported level of engagement of operational staff. Many organizations reported that engaged building operators were a key ingredient in achieving program goals, but the operators were too busy keeping the building running, were not concerned with energy efficiency or did not have sufficient training.

6. Consultants and participants expressed the importance of maintaining utility involvement in supporting recommissioning because many felt that operating practices may revert to pre-program levels in the absence of a utility-sponsored program.
7. Evaluated net savings were 36.5 GWh/year by F2013, which was 171 per cent of reported. The primary cause of the positive variance was that savings were achieved earlier than anticipated. Average net weekday savings per participant were between 4 per cent and 5 per cent, which aligns with program expectations. Savings were greater on weekdays than weekends and holidays. They were also greater during the daytime than overnight and during summer and winter than during shoulder seasons.
8. There was variation in the speed with which participants responded to the program and started to achieve savings. Universities, hospitals and hospitality buildings responded faster than did office buildings. C.Op program participants who were concurrently enrolled in another BC Hydro DSM program responded to the C.Op program faster than did those who were not.
9. The original program goal to verify program energy savings by aggregating EMIS savings estimates across participating buildings was not achieved. The EMIS savings estimates commonly had large and unexplained variances from the engineering estimates developed by the recommissioning consultants.
10. Ten buildings with suitable energy consumption and savings patterns were selected for detailed investigation using Measurement and Verification techniques. Across the 10 buildings, the median of verified savings was 82 per cent of expected savings.
11. The statistical analysis of net savings used hourly electricity consumption data collected through the EMIS. Customers and stakeholders suggested using smart metering infrastructure (**SMI**) data instead. However, SMI data would not be feasible for many participants as they operate campuses where a single utility meter covers many buildings, and not all buildings participate in the program.
12. With the trend of decreasing participation due to the program being fully subscribed, the Variation in Adoption approach applied in this impact study may not be feasible for the next impact evaluation.
13. This evaluation relied on electricity consumption data collected through the EMIS. EMIS vendors started collecting these data in 2011. BC Hydro did not request the data until 2015. This lag delayed the evaluation analysis and led to challenges in data availability and quality.

Recommendations

Listed below are recommendations resulting from this study, starting with recommendations for program management followed by a recommendation for future evaluations.

Recommendations for program management:

1. Consider shortening the timing between the installation of the EMIS and the reporting of savings.
2. Continue to collect building-level hourly electricity consumption data for participants to ensure the feasibility of future impact analysis given the limitations of SMI data.
3. If coaching is offered in the future, review the objectives of this component and strengthen its delivery.
4. Develop a better understanding of building operators' responsibilities, capabilities and training needs in order to better support their role in the program.
5. Some participants indicated that they may need to have the buildings go through the recommissioning process again in future as operating practices may revert to pre-program levels in the absence of the program. Therefore, the program may consider investigating the need for repeat recommissioning of participating buildings in future.

Recommendations for future evaluations:

6. Evaluation should collaborate with program management to explore, investigate and design alternative evaluation methods for future evaluations given changes in program participation trends.
7. Centralize storage and management of the EMIS data to facilitate its use in future evaluations and program administration.

3.5 Conclusions

The Continuous Optimization program was successful in achieving energy savings through building recommissioning. Evaluated net savings were 36.5 GWh/year by F2013, which was 171 per cent of reported. Program participants expressed high levels of satisfaction with the program and reported a range of organizational benefits in addition to energy savings.

4.0 High Performance Buildings and Commercial New Construction: F2008-F2011

4.1 Introduction

Section 4.0 presents an impact evaluation of net electricity savings achieved by BC Hydro's High Performance Building program and its successor the Commercial New Construction program for BC Hydro fiscal years F2008 through F2011 (from April 1, 2007 through March 31, 2011), as well as elements of a process and market evaluation. The objective of these programs (collectively referred to as the CNC program) was to accelerate the demand for and construction of energy efficient commercial buildings.

The CNC program was targeted at developers and market actors who play a role in building and expanding commercial buildings in BC Hydro's service territory. Market actors included developers, building owners, architects, engineers and consultants. The five key objectives of the CNC program were as follows:

1. Energy Efficient Design: Create energy savings by promoting the design of energy efficient buildings.
2. Energy Efficient Construction: Create energy savings by promoting the construction of energy efficient buildings.
3. Energy Efficient Operation of New Commercial Buildings: Create energy savings by providing education and support to properly operate new buildings as they were constructed and designed.
4. Training and Recognition: Enable transformation of the market by training a team of industry professionals to act as energy efficiency and conservation advocates on all new construction projects that they work on in the future. In addition, publicly recognize energy efficient design teams and projects and create a market where consumers demand energy efficient buildings.
5. Advance Building Codes: Support the transformation of the new building market to higher sustained levels of energy efficiency and improved building code compliance. Move the market towards more efficient design so that government can increase the energy efficiency requirements in the BC Building Code and Vancouver building by-law.

As noted in the fifth key objective above, the program was designed to support increases in the energy efficiency requirements in building codes. Notable changes in this regard were the 2008 and 2013 updates to the BC Building Code and Vancouver Building by-law.

4.2 Approach

Shown below are the evaluation objectives and research questions, followed by the data sources and methods.

Table 4. 1. Evaluation Objectives and Research Questions

Objectives	Research Questions
1. Assess participant experience	• What is the level of participant awareness of the various CNC program components? • How do participants rate their program experience and overall satisfaction? • How influential is the CNC program on participant decisions around energy efficiency?
2. Assess trends related to market transformation	• To what extent has the CNC program developed support for design and construction of more energy efficient buildings (beyond code requirements) among designers and builders? • How is the CNC program influencing building design practices and the new construction market, even beyond incented projects? • Did the program help designers and builders prepare for changes in the building code (2013 changes) and help improve compliance rates?
3. Assess the influence of the program on compliance and adoption of building code energy efficiency requirements	• To what extent did the CNC program influence increased compliance with the 2008 BC Building Code and City of Vancouver Building Bylaw? • To what extent did the CNC program influence the adoption of the 2013 building code by “readying the market”?
4. Estimate gross energy and peak savings	• What are gross energy and peak savings?
5. Estimate net energy and peak savings	• What are the free-ridership, participant spillover and non-participant spillover rates? • What are the net energy and peak savings for the overall CNC program?

Table 4.2 summarizes, for each of the evaluation objectives, the evaluation data and methods used.

Table 4.2. Evaluation Objectives, Data Sources and Methods

Objectives	Data sources	Method
1. Assess participant experience	• Participant survey (n = 25)	• Cross tabulations
2. Assess trends related to market transformation	• Market actor survey (15 participants and 9 non-participants)	• Cross tabulations
3. Assess the influence of the program on compliance and adoption of building code energy efficiency requirements	• Market actor survey (15 participants and 9 non-participants) • Interviews with program staff • Program documentation • Program tracking data • Expert opinion	• Delphi method
4. Estimate gross energy and peak savings	• Program tracking data • Measurement and verification (n = 14)	• IPMVP Options A, B and D • Probability Proportional to Size (PPS) ratio estimation • Peak demand savings based on peak-to-energy factor
5. Estimate net energy and peak savings	• Statistics Canada data on commercial new construction activity, F2008-F2011 • Participating building area (sq. meters) • Workshop with program administration • Results from Objective 4 • Participant survey (n = 25) • Market actor survey (15 participants and 9 non-participants) • Project files (n = 7)	• Survey based free ridership and participant spillover algorithms • Case study free ridership assessment

The first objective regarding participant experience was evaluated using the results of detailed online survey of participants delivered in spring 2013. Participants were defined as the individuals who entered into the funding agreement with the CNC program, and they most commonly held the titles project manager, property manager, developer or general manager. The total population of participants over the four years evaluated was 131. A total of 25 surveys were completed by program participants out of 73 sent.

The second objective regarding market transformation was evaluated using the results of a telephone survey of market actors delivered in February 2014. Market actors included engineers, architects, developers, energy modellers and project managers who played a role in decisions related to new construction and design. Fifteen participants and nine non-participants completed the survey.

The third objective regarding the influence of the program on building codes was evaluated using the results of a Delphi panel. The Delphi panel was made up of four local professionals and four experts residing outside B.C. The panelists were provided the results of the market actor survey, along with summary and background information on the program. The panelists first provided their responses to a questionnaire, along with an explanation behind their answer. Panelists then reviewed the results and explanations provided by their peers and had an opportunity to change their initial responses. Results were scored to produce metrics related to the program influence on the building code.

The fourth objective regarding evaluated gross savings was conducted using the results of M&V of a sample of participating buildings.[2] Nine buildings underwent Option D M&V,[3] which involves calibrated energy modelling

[2] In some cases a "building" encompassed a development made up of several parcels.

[3] As defined in the International Performance Measurement and Verification Protocol (**IPMVP**).

of an entire building, informed by energy consumption data as well as sub-metering data of individual building systems. Five buildings underwent Option A or B M&V, which involves energy calculations informed by measured results for power or hours of use. The M&V sample was designed to provide high coverage of the population in terms of energy savings, and to be representative of the population overall on that basis. The final M&V sample coverage from the 14 buildings that underwent M&V was 33 per cent of electric energy savings and 58 per cent of building area. M&V results were extrapolated to the population of all 131 participating buildings using a statistical technique called probability proportional to size ratio estimation.

The fifth objective regarding evaluated net savings, relied on the results of objective four, evaluated gross savings, as well as free ridership and participant spillover estimates derived from the participant survey described above.

4.3 Results

Results for Objective 1: Participant Experience

Awareness of the CNC program was very high among program participants at 96 per cent. Those who were aware were asked additional questions about three individual program components: the energy study, the incentive structure and the Key Account Managers role as liaisons for the program.

Seventy-four per cent of participants were aware of the basics of the energy study component of the program. Among those aware of energy studies, 61 per cent gave it positive ratings overall, and the majority (59 per cent) gave it only a 'fair' rating for being easy to work with and act upon, rather than an excellent (11 per cent) or good (25 per cent) rating.

Sixty-eight per cent of participants were aware of the project incentive structure of the program. Among those aware of the incentive structure, 94 per cent gave it positive ratings overall, while 61 per cent provided positive ratings for it being easy to work with and understand.

Seventy five per cent of participants were aware of Key Account Managers (**KAMs**) in general, and among those who were, all were aware of the role that KAMs play as a liaison between the CNC program and its participants. Among those who were aware of the KAM role, 100 per cent gave it positive ratings both overall, and for being easy to work with.

Among program participants, overall satisfaction with the CNC program was very high with 95 per cent of participants reporting that they were either 'very satisfied' (65 per cent) or 'somewhat satisfied' (30 per cent) with the program. In total, 100 per cent would 'definitely' (70 per cent) or 'probably' (30 per cent) recommend the program to others and in fact, 54 per cent reported already having done so.

Results for Objective 2: Market Transformation Trends

Nineteen of the 24 respondents to the market actor survey said that some portion of their buildings met or exceeded the new energy efficiency requirements in the building code prior to their introduction in December 2013. Those who indicated a portion of their buildings were meeting or exceeding the 2013 code before it took effect were asked how influential the CNC program was in this achievement. Six of the 12 participant respondents said very influential. Five of the seven nonparticipants reported the program was at least somewhat influential, and one stated it was very influential.

If the CNC program had not been in place, eight of the 24 of the respondents said overall building code compliance would have been lower in British Columbia and ten of the 24 stated that compliance would have been lower in Vancouver. Of those that thought the program affected code compliance, six of eight estimated that the program improved compliance by 20 per cent or less.

Participating market actors were asked if what they learned through the CNC program helped them comply with the building code, even on projects that did not receive a program incentive. Close to half of respondents said yes. These respondents said that the lessons learned from projects that went through the program were so useful and meaningful that they utilized this new knowledge whenever possible, even on projects outside of the program.

Results for Objective 3: Program Influence on Compliance and Adoption of Building Code Energy Efficiency Requirements

The Delphi panelists showed strong consensus around the importance of the market drivers that were identified for "Improving Compliance." All eight panelists reported that two drivers of improved compliance, "Market Awareness of Code Requirements" and "Market Awareness of Strategies and Skills to Meet Code" were *very important*.

After reading information about BC Hydro's activities related to improving compliance with the previous code, the panelists were asked to "rate the program's influence using a zero to ten scale, where zero means the program had no influence and nine means the program was very influential." Ten on the scale meant the program was so influential that it should claim all the credit (100 per cent attribution). No panelists made that determination. Panelists rated the program's influence to be greatest on the "Availability of Tools and Technologies to Demonstrate Compliance", with a mean rating of 7.6.

Table 4.3: Influence Ratings for Market Drivers of Improving Compliance with ASHRAE 90.1-2004/2007

	Market Awareness of Code Requirements	Market Awareness of Strategies and Skills to Meet Code	Availability of Tools and Technologies to Demonstrate Compliance
Mean	6.8	5.6	7.6
Mode	8	5	9
Range	5 to 8	3 to 8	5 to 9

Panelists rated the CNC program's influence on "Market Awareness of Code Requirements" as the next most influential, with a mean rating of 6.8 and four panelists providing a rating of eight. These panelists reported that they believed the program was critical to educating market actors about the code. Those who provided a lower rating noted that while the program did have a role in educating the market, it seemed the program's reach may have been low, or that other initiatives or organizations (such as LEED, the City of Vancouver, and others) were similarly engaged on this topic, and thus the contribution of the CNC program was simply one part of a much larger effort.

Panelists were also asked to rate the importance of market drivers that ready the market for the next iteration of the building code. The majority of respondents felt the identified drivers for readying the market for the 2013 update to the building code (ASHRAE 90.1-2010) were *somewhat important*. According to panelist feedback, having sufficient technical workforce capacity to design and construct buildings to meet the new code requirements was the most important driver, with three panelists reporting this as *very important* and five reporting it as *somewhat important.*

Panelists rated the program's influence on each market driver using a scale from zero to ten. Panelists rated the program's influence to be greatest on the "Technical Workforce Capacity", with a mean rating of 6.4.

Table 4.4: Influence Ratings for Market Drivers of Readying the Market

Readying the Market for the Adoption of ASHRAE 90.1-2010			
	Industry Awareness and Buy-in	Technical Workforce Capacity	Availability of Tools and Technologies to Demonstrate Compliance
Mean	5.5	6.4	5.1
Mode	5	5	2
Range	4 to 7	2 to 9	2 to 9

There were two drivers where panelists did not converge on the program's influence. These were "Technical Workforce Capacity" and "Availability of Tools and Technologies to Demonstrate Compliance" where panelists' influence ratings ranged from two to nine.

Generally, results from the Delphi panel point to a moderate influence of the program on both improving compliance with the 2008 BC Building Code as well as readying the market for subsequent code revisions in 2013.

Results for Objective 4: Evaluated Gross Electricity and Peak Demand Savings

The evaluated gross electric energy savings and peak demand savings for the CNC program from F2008 to F2011 are 48.6 GWh/year and 6.7 MW, versus the expected savings of 50.4 GWh/year and 7.0 MW. The variance between expected and evaluated gross savings is due to the program realization rate being 97 per cent. Common reasons for the variance included differences between expected and verified plug loads, operating hours, fuel mix and building envelope characteristics.

Results for Objective 5: Net Electricity and Peak Demand Savings

Evaluated net savings are summarized below.

Table 4.3: Summary of Energy and Peak Demand Savings

Fiscal Year	Energy Savings (GWh/year)		Peak Demand Savings (MW)	
	Reported	Evaluated Net	Reported	Evaluated Net
F2008	3.6	2.4	0.5	0.3
F2009	10.2	7.5	1.4	1.0
F2010	25.9	17.2	3.6	2.4
F2011	9.5	6.9	1.3	1.0
Sum of F2008-F2011	**49.2**	**34.0**	**6.8**	**4.7**

Free ridership was 31 per cent, which was higher than expected and is the reason for the negative variance between reported and evaluated savings. Participant spillover was 1 per cent.[4] Due to data limitations, a point estimate of non-participant spillover could not be produced, and non-participant spillover is not included in the net evaluated savings. Evidence collected through this evaluation suggests non-participant spillover occurred and may have been substantial.

[4] Participant spillover was defined as additional energy savings measures implemented in participating buildings, but outside the program. Because the program targeted whole building energy efficiency, participant spillover was expected to be small.

4.4 Findings and Recommendations

Findings

Key findings of this evaluation are summarized below:

1. Among program participants, overall satisfaction with the CNC program was very high with 95 per cent of participants reporting that they were either very or somewhat satisfied with the program. All surveyed participants said they would definitely or probably recommend the program to others. In fact, 54 per cent reported already having done so.

2. The aspects of the program experience that rated the highest included 'service provided by BC Hydro', 'information about CNC on the website', 'service provided by contractors' and 'level of incentives offered'. Aspects which rated the lowest include 'length of time for the project to be completed', 'the variety of products funded under the program', and 'length of time to receive the incentive'.

3. Eighty nine per cent of participants reported that the program was either 'very influential' or 'somewhat influential' on their decision to implement the energy efficient measures.

4. Responses from market actors, as well as the Delphi panel, indicate that the CNC program likely improved compliance with historical BC and Vancouver building codes. The majority of respondents said the program helped improve the compliance through financial assistance, technical assistance, or quality assurance for design and installation in participating buildings. The experts who participated in the panel rated the program favorably in terms of its effect on compliance.

5. Market actors as well as the Delphi panel found the CNC program had some influence on readying the market for the 2013 building code update. Market actors said the program was influential in helping them understand the 2013 code prior to enactment and also in building and designing buildings that met (or exceeded) the 2013 code before it went into effect, indicating that the program helped ready the market for the adoption of the regulation.

6. Measurement and verification of 14 buildings (or development parcels) revealed that most realized savings that were substantially different from expected levels. One reason for this variance was that program rules for the treatment of fuel switching were not well defined until the later part of the evaluation analysis time frame and as a result the verified fuel mix was sometimes different than expectation. Other reasons included differences in operating hours, plug load, and building envelop characteristics. These variances tended to cancel each other out, and the overall realization rate across all buildings that underwent M&V was 97 per cent.

7. The net-to-gross ratio was 70 per cent, made up of 31 per cent free ridership and 1 per cent participant spillover. Cumulative evaluated net savings from F2008 through F2011 were 34.0 GWh/year, which is 70 per cent of reported savings of 49.2 GWh/year. Free ridership was higher than expected, in part because of some of the highest saving buildings in the early part of the evaluation analysis time frame were large, high profile buildings where government and public expectation played a substantial role promoting energy efficient building design. Such buildings became less common in the later part of the evaluation analysis time frame.

8. Evidence suggests that non-participant spillover occurred during the evaluation period. However a reliable point estimate could not be produced due to data limitations. Estimates of non-participant spillover ranged from 3 per cent to 18 per cent of evaluated gross savings. Due to the high level of uncertainty, non-participant spillover is not included in the net evaluated savings estimate.

Recommendations

Recommendations from this evaluation are shown below.

1. The free ridership rate of 31 per cent presented in this evaluation was based on projects and decision making for the time period up to F2011 and may not be suitable to use for program planning and reporting purposes outside this period.

2. Given the evidence that non-participant spillover occurred, consider designing and implementing a survey of a representative, randomly selected cross section of non-participating market actors to produce an updated estimate of program effects on non-participants. The data collected should allow for the estimation of any attribution of non-participant energy efficiency savings to the CNC program, and for the estimation of the proportion of the non-participating commercial new construction market influenced by the program.

3. To achieve cost savings in future M&V, consider obtaining and retaining the participating building design and modelling files as a condition of incentive approval.

4.5 Conclusions

The Commercial New Construction Program achieved very high participant satisfaction. Cumulative evaluated net savings from F2008 through F2011 were 34.0 GWh/year, which is 70 per cent of reported savings. Evidence suggests that the program played a role readying the market, and improving compliance, with the energy efficiency requirements of the BC and Vancouver building codes.

5.0 Power Smart Partner - Transmission: F2012-F2014

5.1 Introduction

Section 5.0 presents an impact evaluation of the BC Hydro Power Smart Partner – Transmission (**PSP-T**) DSM program for BC Hydro fiscal years F2012 to F2014 (April 2011 to March 2014). This evaluation also includes elements of a process and market evaluation.

BC Hydro's Power Smart Partner – Transmission Program (renamed Leaders in Energy Management – Transmission in 2015) is a multi-year energy acquisition and market transformation initiative that encourages large industrial customers, which receive electricity supply at transmission voltage, to reduce their electricity consumption. The program's target market is BC Hydro's 75 industrial transmission customers (with facilities at 174 sites). The key program objective during the period evaluated was to partner with program participants to obtain cost-effective electricity savings by encouraging them to integrate energy efficiency into their on-going business practices and supporting them to respond to the conservation price signal delivered by the Transmission Service Rate (**TSR**). This evaluation evaluates the combined effect of the program and rate for energy efficiency and conservation projects reported through the program.

The scope of this evaluation includes electrical energy efficiency and conservation projects at industrial transmission service sites. Facility wide savings resulting from strategic energy management efforts are not included in the scope of this evaluation as they were not reported by the program during the evaluating period. This encompasses the incentive offer and enabling activities, as further described below. During the three-year evaluation timeframe, 145 energy efficiency and conservation projects were completed at 57 sites and reported under the program. Program participants included the following industrial segments: pulp & paper, mining, wood, oil & gas, chemicals, cement and transportation. The program reported projects in various end uses with a primary focus on industrial process energy efficiency improvements. The main program components and enabling activities are summarized below:

- **Incentive:** Incentives of up to 100 per cent of project costs were available for custom projects. Since F2014, smaller lighting and compressed air projects were also eligible for prescriptive incentives under the self-serve incentive program (**SIP**).
- **BC Hydro Key Account Managers:** Acted as a liaison between the program and the customer.
- **BC Hydro Alliance of Energy Professionals:** A network of energy efficiency trade professionals registered with BC Hydro, formerly known as Power Smart Alliance.
- **Energy Studies:** Identified and built a business case for the implementation of energy conservation measures; fully funded by BC Hydro.
- **Energy Managers:** Helped participants adopt strategic energy management practices; partially funded by BC Hydro.
- **Strategic Energy Management:** Provided a structured approach to improve energy efficiency, including the use of Energy Management Assessment workshops that scored current energy management practices. Supported development and implementation of energy management systems.

The program relied on two approaches to recognize savings, program enabled and incentive:

- **Program Enabled:** Customer-funded electricity conservation measures that are linked to a program-funded enabling activity such as an energy study or energy manager.
- **Incentive:** Electricity conservation measures that received an incentive from BC Hydro.

5.2 Approach

Shown below are the evaluation objectives and research questions, followed by the data sources and methods.

Table 5. 1. Evaluation Objectives and Research Questions

Evaluation Objective	Research Questions
1. Assess participant and non-participant experience and satisfaction	• What is the participant experience related to awareness, understanding, and satisfaction with the various program offers? • What are the barriers to and drivers of program participation?
2. Assess the Strategic Energy Management initiative	• What was the coverage of energy managers among program participants? Were energy managers associated with increased project activity? • What changes were observed in customer commitment to energy conservation and efficiency over time? How did customer ratings progress in key areas of Energy Management Assessments over time? • What changes were observed in the customer capability of energy conservation and efficiency over time? What changes in energy management practices among participants were observed over time?
3. Assess trends related to market transformation in the industrial sector	• Has the program shifted or transformed the market for energy efficiency services offered by trade allies registered with the BC Hydro Alliance of Energy Professionals? • Over the past five years (2011-2016), how has industry capability to deliver energy efficiency services changed? • Aside from the program, what additional drivers of demand for energy efficiency services exist among industrial customers? How have these drivers changed over time?
4. Estimate gross electrical energy and peak demand savings for incentive and program enabled projects	• What were the most common energy conservation measures by end use and customer site type for incentive and program enabled projects? • What were the evaluated gross energy and demand savings realized by PSP-T incentive and program enabled projects?
5. Estimate net electrical energy and peak demand savings for incentive and program enabled projects	• How much free ridership occurred for program enabled and incentive projects? How much participant and non-participant spillover occurred for the program overall? • What was the attribution of energy savings to the combined effect of the PSP-T program and the TSR? • What were the evaluated net energy and demand savings due to the combined effect of the PSP-T program and the TSR for incentive and program enabled projects?

Table 5.2 summarizes, for each of the evaluation objectives, the evaluation data and methods used.

Table 5.2. Evaluation Objectives, Data Sources and Methods

Objectives	Data sources	Method
1. Assess participant and non-participant experience and satisfaction	• Participant Survey (n = 28 responses covering 46 projects) • Non-Participant Survey (n = 25)	• Cross tabulations
2. Assess the Strategic Energy Management initiative	• Program tracking data • Project file reviews of four participants	• Trends analysis • Qualitative analysis
3. Assess trends related to market transformation in the industrial sector	• Trade ally interviews (11 interviews)	• Qualitative analysis
4. Estimate gross electrical energy and peak demand savings for incentive and program enabled projects	• Program tracking data • TSR tracking data • Site visits, file reviews • Measurement and Verification (n = 67) • Energy studies (n = 90)	• Engineering algorithms • Extrapolation of measurement and verification using stratified ratio estimation • Rate class average peak-to-energy factor
5. Estimate net electrical energy and peak demand savings for incentive and program enabled projects	• Results of Objective 4 • File reviews • Participant surveys (n = 28 responses covering 46 projects) • Case Studies (n = 46 projects)	• Triangulation of case study and survey based free ridership estimates • Survey based spillover algorithm • Cross tabulations • Rate class average peak-to-energy factor

5.3 Results

Results for Objective 1: Participant and Non-Participant Experience and Satisfaction

As expected, PSP-T program awareness was very high among participants, with 96 per cent indicating that they were aware of the program by name. Awareness among non/partial participants was somewhat lower, although still high, at 84 per cent. In terms of individual program components, for participants, awareness was highest for the role that Key Account Managers play as liaisons for PSP-T, energy studies and the incentive structure. Non/partial participants expressed high awareness of Key Account Managers and energy studies, but only moderate to low awareness of other program components. With the exception of training and funding for energy managers, participants expressed high levels of understanding with all individual program components. Non/partial participants expressed lower levels of understanding, particularly with energy studies and the energy manager component.

Among participants, Key Account Managers' role as liaisons for the program emerged as the highest rated component in terms of satisfaction (92 per cent 'excellent' or 'good'), followed by energy audits/studies (76 per cent). Among non/partial participants, the PSP-T incentive structure was rated the highest (80 per cent), followed much further behind by energy audits/studies (42 per cent).

Overall satisfaction with PSP-T among program participants was high with 89 per cent of participants reporting that they were either 'very satisfied' (58 per cent) or 'somewhat satisfied' (31 per cent) with the program. In terms of program experience, 'service provided by BC Hydro' was the highest rated of all service elements with 85 per cent of participants rating it as either 'excellent' or 'good'. Aspects around timing were rated the lowest of all of the program elements, with favourable ratings of only 39 per cent for 'length of time to receive the incentive' and 35 per cent for 'length of time for the project to be completed'.

Results for Objective 2: Strategic Energy Management Initiative

The strategic energy management initiative provided participants with a suite of tools and offers intended to help them build energy management into their ongoing business practices, thereby reducing operating and maintenance costs and equipment wear. The tools and offers included funding for an Energy Manager position, energy management assessment workshops that ranked participating facility's energy efficiency and provided participants with a follow-up action plan, facility monitoring and modeling, as well as energy studies and incentives.

The evidence reviewed for this evaluation indicates that Energy Managers played an important role in program participation. Coverage of energy managers among program participants was widespread. Of the 57 sites included in the scope of this impact evaluation, 39 had energy managers. Among sites at which one or more incentive projects were implemented, 20 out of 35 had energy managers, covering 64 per cent of incentive gross savings. Among sites at which program enabled projects were implemented, 19 out of 22 had energy managers, covering 85 per cent of program enabled gross savings. During the evaluation period, sites with energy managers completed twice the number of projects per site relative to those without energy managers (on average, three projects versus 1.5 projects).

Qualitative assessment of participant experience and progress in the strategic energy management initiative was conducted for four participants in the following sectors: mining, pulp & paper, wood, and cement. Each of these participants was unique, and the energy management offer was customized to their situation and opportunities. Overall, review of these four participants indicated that they had ongoing, multi-year commitment to energy management, improved their energy management capabilities over time, and adopted new energy management practices. Note that results for these four participants may not be representative of results for other participants in the strategic energy management initiative.

Results for Objective 3: Trends Related to Market Transformation in the Industrial Sector

Market trends related to market transformation were based on interviews with 11 trade allies. The trade ally respondents generally reported that the range of energy efficiency services offered by their firms had not changed due to the program, but with the experience gained through the program their level of services improved. Although energy efficiency services were not generally the main business activity of these firms, conducting the BC Hydro-funded energy studies provided opportunities for business development and improved customer service.

Responses were mixed regarding the extent to which the program led to the development of new or greater subject matter expertise over the past five years. However, most of the respondents felt that BC Hydro-funded energy studies had supported knowledge transfer among multiple groups (e.g., program technical experts, trade allies, participants and non-participants), in particular regarding analytical methods and methodologies of energy engineering that could be applied to other studies that are not funded by BC Hydro. Most interviewees noted that they rarely, if ever, received information about whether projects performed as expected and saw this as a missed opportunity to expand their expertise and improve future energy studies.

Respondents were largely of the opinion that energy studies made customers aware of new options for energy efficiency that they had not previously been aware of. However, responses varied regarding whether energy studies were motivated by energy efficiency versus other factors such as capacity, de-bottlenecking, quality, etc. About half of the respondents noted that risk avoidance was a much more important factor for customers when considering energy efficiency upgrades than any incentive amounts received or potential energy savings. Changes in customer knowledge and engagement were seen as drivers of energy efficiency services, both of which were seen as having improved as a result of the program, particularly the energy manager component.

Results for Objective 4: Evaluated Gross Electricity and Peak Demand Savings

Evaluated gross savings provide an estimate of savings achieved by program participants. Evaluated gross savings are estimated by applying a realization rate to expected savings. An overall realization rate of 0.92 was calculated for the entire evaluation period using measurement and verification results.

Table 5.3. Expected and Evaluated Gross Savings and Demand for All Participants

Period	Number of Projects	Expected Gross Energy Savings (GWh/year)	Evaluated Gross Energy Savings (GWh/year)	Evaluated Gross Peak Demand Savings (MW)
F2012	41	152.3	136.1	15.4
F2013	39	117.6	110.2	12.4
F2014	65	85.1	81.2	9.2

Results for Objective 5: Net Electricity and Peak Demand Savings

Free ridership was estimated separately for the three types of projects reported by the program: incentive, program enabled with an energy study or an energy savings prediction and program enabled without an energy study or energy savings prediction. Free ridership provides an estimate of the proportion of savings that are not attributable to the combined effect of the PSP-T and TSR. Free ridership was calculated by fiscal year. Spillover was estimated for the overall evaluation period only.

Table 5.4. Summary of Energy and Peak Demand Savings

Period	Evaluated Gross Energy Savings (GWh/year)	Evaluated Gross Peak Demand Savings (MW)	Net-to-Gross Ratio	Evaluated Net Energy Savings (GWh/year)	Evaluated Net Peak Demand Savings (MW)
F2012	136.1	15.4	0.82	111.7	12.6
F2013	110.2	12.4	0.90	99.4	11.2
F2014	81.2	9.2	1.08	87.4	9.9

The overall level of free ridership is estimated at 32 per cent, driven by high free ridership among program enabled projects without an energy study or energy savings prediction. Participant spillover was estimated at 18 per cent and non/partial participant spillover was estimated at 5 per cent for a total of 23 per cent. Together they result in a net-to-gross ratio of 91 per cent.

Evaluated net energy savings in each fiscal year were calculated using the gross savings of each project multiplied by the net-to-gross ratio of its project type. Electricity savings are presented as incremental savings achieved within each fiscal year and expressed as an annual rate of savings (also known as run rate savings). Peak demand savings were calculated using the same peak-to-energy factor as for gross demand savings. Because the distribution of project types and energy savings varied by year, so too did the yearly net-to-gross ratios. Years with greater weighting of energy savings from projects that were program enabled without an energy study or energy savings prediction saw a lower net-to-gross ratio, such as F2012 and F2013.

Table 5.5. Comparison of Reported and Evaluated Net Savings

Period	Energy savings (GWh per year)		Peak demand savings (MW)	
	Reported	Evaluated Net	Reported	Evaluated Net
F2012	125.0	111.7	14.1	12.6
F2013	109.6	99.4	12.4	11.2
F2014	77.1	87.4	8.7	9.9

The variance between reported and evaluated net savings is primarily due to the gross realization rate being lower than forecast. The evaluated net-to-gross ratio was found to be similar as forecast.

5.4 Findings and Recommendations

Findings

1. Overall satisfaction with PSP-T among program participants was high with 89 per cent of participants reporting that they were either very or somewhat satisfied with the program. A similar proportion (92 per cent) reported that they would recommend the program to others, and in fact, 46 per cent reported already having done so.
2. Research for this evaluation suggests that beyond incentives, the key aspects of the program's success in terms of satisfaction, engagement and project activity levels include Key Account Managers, energy studies and Energy Managers.
3. Among participants, the factors that emerged as the greatest motivators of conservation were minimizing operating costs, program incentives and cost-cutting measures due to economic conditions.
4. Energy Managers played an important role in program participation. Coverage of energy managers among program participants was widespread, at 86 per cent of projects. On average, sites with energy managers completed twice as many projects per site than did sites without energy managers.
5. Trade allies reported that the level of customer engagement appeared to be heavily linked to the presence of an energy manager at a company. Companies with energy managers were viewed as being much more engaged and knowledgeable than companies without one.
6. The evaluability of the strategic energy management initiative would be improved by the adoption of standardized progress monitoring of program participants, as well as adopting standardized methods for determining energy efficiency savings for strategic energy management initiatives.
7. Trade allies were largely of the opinion that energy studies made customers aware of new options for energy efficiency. Only one out of the 11 respondents felt that customers were typically aware of energy efficiency options prior to having a study done.
8. Trade allies also noted that they rarely, if ever, received information about whether projects performed as expected and saw this as a missed opportunity to expand their expertise and improve future energy studies.
9. The gross realization rate was 92 per cent, indicating that the energy conservation measures largely performed as expected. In general, smaller projects had higher realization rates than larger projects. The most common reasons why measures did not perform as expected were changes in operating conditions and inappropriate baselines.
10. Evaluated gross energy savings averaged 1.1 per cent per year of facility energy consumption across all participants, and project savings per site ranged from less than 1 per cent to over 14 per cent.
11. By including additional data sources in the evaluation review, such as TSR records and customer post-implementation data, the coverage of the gross realization rate sample was doubled from what it would have been with M&V results alone. However, the rigour of the realization rate sample was less than what it would have been with M&V results alone.
12. The overall level of free ridership is estimated at 32 per cent, driven by high free ridership among program enabled projects without an energy study or energy savings prediction. Participant spillover was estimated at 18 per cent and non/partial participant spillover was estimated at 5 per cent for a total of 23 per cent. Together they result in a net-to-gross ratio of 91 per cent.
13. Projects with an energy study or energy savings prediction were found to have a substantially lower level of free ridership than projects without one (18 per cent versus 62 per cent, respectively). The net-to-gross ratio increased over time as more and more projects had an energy study.

14. Most of the participant spillover identified in this report came from sites with an Energy Manager.
15. Evaluated net savings were 111.7 GWh/year in F2012, 99.4 GWh/year in F2013, and 87.4 in F2014, which was 89 per cent of reported savings for F2012, 91 per cent for F2013 and 113 per cent for F2014.

Recommendations

Recommendations for program management:

1. Consider providing information on project performance back to trade allies in order to improve the quality of future energy studies and the recommendations they give to customers.
2. In order to address savings discrepancies due to inappropriate baselines, the program should investigate the merits of reporting for each project the estimated remaining useful life of the baseline equipment.
3. Consider ways to increase the prevalence of energy studies or energy savings predictions among program enabled projects in order to reduce the uncertainty of the counterfactual.
4. In consultation with the evaluation department, consider ways to improve the evaluability of the strategic energy management initiative.

Recommendations for future evaluations:

1. If strategic energy management savings are reported and/or evaluated in the future using a top-down method (i.e., facility-wide regression analysis), consider the extent to which there may be double counting between the participant spillover estimate presented in this evaluation and strategic energy management savings.
2. Consider testing and adopting the Strategic Energy Management Evaluation Protocol currently being developed by the US Department of Energy's Uniform Methods Project for determining energy efficiency savings for strategic energy management initiatives.

5.5 Conclusions

BC Hydro's Power Smart Partner – Transmission program achieved 96 per cent of reported savings during F2012 to F2014. The program also achieved high levels of customer awareness and satisfaction.

Glossary

Baseline: A baseline is the initial condition occurring when a DSM activity begins. It may be a market share for equipment, a current standard, or a current average behavior.

Cross Effects: Cross effects (also known as interactive effects) refer to the effect that some energy conservation measures (**ECMs**) have on other electricity end uses beyond what the ECM itself produces. An obvious example is building lighting. As more efficient lighting is installed, less heat is generated by the lighting system. This means that less heat must be removed from the building by the air conditioning system during the cooling season, but more heat needs to be supplied by the heating system during the heating season.

Demand Side Management (DSM): 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".

End Use: The final application or final use to which energy is applied. Recognition of the fact that electric energy is of no value to a user without first being transformed by a piece of equipment into a service of economic value. For example, office lighting is an end use, whereas electricity sold to the office tenant is of no value without the equipment (light fixtures, wiring, etc.) needed to convert the electricity into visible light. End use is often used interchangeably with energy service.

ENERGY STAR®: ENERGY STAR® is the mark of high-efficiency products in Canada that meet strict technical specifications for energy performance—tested and certified. These products save energy without compromising performance in any way. Typically, an ENERGY STAR® certified product is in the top 15 to 30 per cent of its class for energy performance.

Expected Savings: Estimate of gross energy savings based on customer initially reported savings, engineering review and site inspection. These estimates represent the unverified savings.

Free Riders: Free riders are program participants who would have taken the DSM action, even in the absence of the DSM program. They are a part of the reference case. These actions are not attributable to the program.

Gigawatt Hour (GWh): One billion watt-hours; one million kilowatt hours.

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

Market Changes: Market Changes refers to the changes in the structure or operations of markets during the course of an energy efficiency program that indicate increased levels of adoption of energy-efficient products and practices by customers and/or increased levels of promotion and delivery by suppliers.

Market Transformation: Market Transformation refers to a permanent change in the structure or functioning of markets, including more energy-efficient behaviour among customers and higher market

penetration of energy-efficient products, as a result of DSM programs that reduce barriers to energy efficiency. These market changes are likely to persist in the absence of continued program activity.

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

Net-to-gross ratio: A factor representing net demand side management program savings divided by gross program savings that is applied to gross program impacts to convert them into net program load impacts. The factor is made up of a variety of factors that create differences between gross and net savings, commonly including free riders and spillover. Other adjustments may include rebound, cross effects and measurement and verification results.

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

Persistence: Refers to how long the energy savings are expected to be attributable to the demand side management activity.

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.

Reported Savings: Estimate of energy savings being recorded in the program tracking database. Reported savings are based on best information available from technical review of the initial engineering estimate, post implementation review of documentation and/or inspection, or measurement and verification results, as well as, a forecast net-to-gross ratio applied.

Run Rate: Run rate is the rate at which the Conservation and Energy Management programs or projects are saving electricity at a given point in time. This is usually expressed as GWh/year at the end of the month or year being reported.

Spillover: Refers to program participants and non-participants whose energy savings measures occur through actions that are not part of a program, but which were influenced by the program (also called free drivers or tag-ons). Participant spillover is the additional energy savings that occur when a program participant independently installs energy efficiency measures or applies energy savings practices after having participated in the efficiency program, as a result of the program's influence. Non-participant spillover refers to energy savings that occur when a program non-participant installs energy efficiency measures or applies energy savings practices as a result of a program's influence. Spillover is expressed as a fraction of the increase of energy savings due to spillover to the gross energy savings of the program participant. Spillover may not be permanent and may not continue in the absence of continued program activity.