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January 27, 2023

Sara Hardgrave
Acting Commission Secretary and Manager
Regulatory Services
British Columbia Utilities Commission
Suite 410, 900 Howe Street
Vancouver, BC V6Z 2N3

Dear Sara Hardgrave:

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

In compliance with Directive 66 of the BCUC Decision on BC Hydro's 2004/05 to 2005/06 Revenue Requirements Application, dated October 29, 2004, BC Hydro writes to submit its F2022 Demand Side Management Milestone Evaluation Summary Report dated January 2023.

Directive 66 "directs BC Hydro to file the executive summaries of its milestone evaluation reports and full final evaluation reports of all its Power Smart programs". The terminology "Power Smart programs" includes rates and programs undertaken to conserve energy or promote energy efficiency.

The F2022 Demand Side Management Milestone Evaluation Summary Report summarizes the evaluations completed during fiscal 2022 for the following:

1. B.C. Building Code Evaluation - Residential Sector: January 2015 to December 2018;
2. Leaders in Energy Management - Commercial Evaluation: F2018 to F2020; and
3. Residential Retail Program Evaluation - Lighting Offer: F2015 (Q2) - F2019.

For further information, please contact Shiau-Ching Chou at 604-623-3699 or by email at bchydroregulatorygroup@bchydro.com.

Yours sincerely,

Chris Sandve
Chief Regulatory Officer

al/rh

Enclosure

BC Hydro
Power smart

Demand Side Management Milestone Evaluation

Summary Report F2022

January 2023

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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 2022 (**F2022**). 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.; and
- 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:

- B.C. Building Code Evaluation – Residential Sector: January 2015 to December 2018;
- Leaders in Energy Management – Commercial Evaluation: F2018 to F2020; and
- Residential Retail Program Evaluation – Lighting Offer: F2015 (Q2) – F2019.

2.0 B.C Building Code Evaluation – Residential Sector: January 2015 to December 2018

2.1 Introduction

This report presents the evaluated electrical energy savings related to the Residential Building code and Vancouver Building By-law energy efficiency requirements for residential buildings which were in effect between January 2015 and December 2018. The British Columbia Building Code (**BCBC**) is a provincial regulation that follows the National Building Code of Canada (**NBC**) and governs how new construction, building alterations, repairs and demolitions are completed. Subsection 9.36 of the building code regulation sets forth the minimum energy efficiency requirements for new Part 9 buildings.[1] The City of Vancouver is unique in B.C. in that it has the authority to establish its own building code by-laws to regulate the design and construction of buildings. The Vancouver Building By-Law (**VBBL**) may thus differ from the BC Building Code.

Two previous evaluations, conducted in 2010 and 2011 and covering the period from fiscal 2009 to fiscal 2011, have estimated gross energy savings for residential buildings associated with the adoption of the BCBC in 2008 and the VBBL in 2007. These were the first regulations to introduce comprehensive energy efficiency requirements for residential buildings in British Columbia.

This impact evaluation presents the evaluated gross electricity savings associated with the residential housing stock built under subsequent revisions of the provincial building code and VBBL adopted in 2014. In December 2014, the BCBC harmonized with energy requirements from the 2010 edition of the NBC published in December 2012. That same year, the City of Vancouver updated the VBBL to align with the BCBC. The code impacts were effective until December 2018, at which time a new edition of the NBC came into force and municipalities in B.C. started to introduce the Step Code.

The previous evaluations of the residential building code have produced estimates of unit energy savings for the code adopted in 2008 and applied those estimates to actual housing stock growth for fiscal 2009 to fiscal 2011. The unit energy savings were obtained based on energy models of archetypal buildings. These estimates of unit savings have remained valid until the code energy efficiency requirements were updated in December 2014. However, BC Hydro reported energy savings for the period from fiscal 2012 to fiscal 2016 are still based on assumptions of housing stock growth that have not been evaluated, and this evaluation also informs the residential housing stock growth from 2011 to 2015 in order to update energy savings reported for fiscal 2012 to fiscal 2016.

BC Hydro provides technical assistance and resources to support the research behind implementing, updating, and enhancing compliance with building codes energy efficiency requirements in the province. Support activities include participating in technical code committees; working with government stakeholders in order to help negotiate the advancement in the energy requirements of the building code; and developing strategies and testing new approaches to support and advance future building code updates. BC Hydro also designs and implements initiatives to ready the market for energy efficiency regulations.

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1 Part 9 buildings are defined as being three stories or less in height and having a footprint not exceeding 600 square metres, with intended occupancy as residential dwellings or for small commercial use. They include single-family detached, semi-detached, and row homes, as well as low-rise apartment buildings. High-rise apartment buildings (more than three stories) are regulated under Part 3 of the Building Code, which covers commercial and large residential buildings.

This study does not attempt to evaluate what share of the energy savings may be attributable to the influence of BC Hydro's work on building codes. Rather, the goal is to estimate electricity savings in BC Hydro's service territory due to a reduction in electricity usage for new residential building stock since the adoption of the Residential Building Code. Therefore, this evaluation is only concerned with estimating gross savings.

2.2 Approach

The evaluation objectives and research questions are shown below in Table 2.1, followed by the data sources and methods (Table 2.2).

Table 2.1 Evaluation objectives and research questions

	Evaluation Objective	Research Questions
1.	Characterize the new residential building stock constructed	What types of residential buildings were constructed after the introduction of changes to the provincial building code and Vancouver Building By-law? How many residential dwelling units were constructed between 2011 and 2018 for each dwelling type? What was the regional breakdown of new residential construction stock in the province for the evaluation period?
2.	Estimate unit electrical energy savings	What was the average annual electricity consumption per unit by region, dwelling type and heating type for the pre-code and post-code periods? What were the gross energy savings per unit by region, dwelling type and heating type?
3.	Estimate gross energy and peak demand savings	What were the total gross electricity savings by year (province-wide including regions and City of Vancouver)? What were the gross peak demand savings by year?

Table 2.2 Evaluation objectives, data and methods

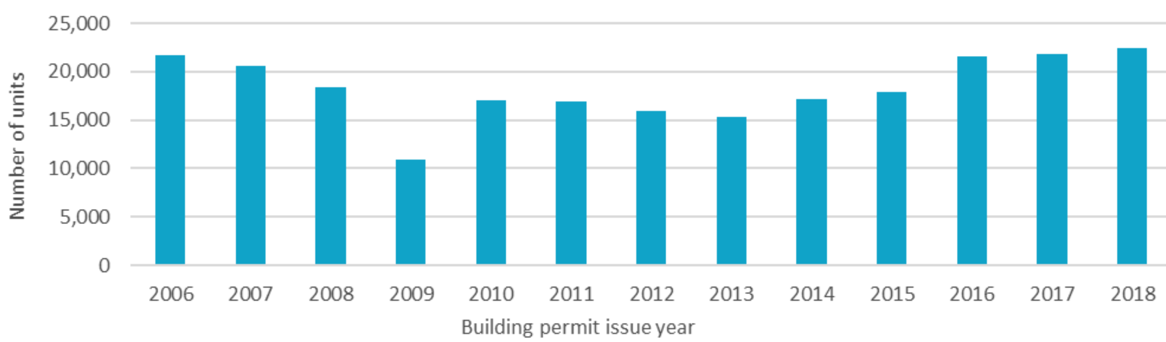
	Evaluation Objective	Data Sources	Methods
1.	Characterize the new residential building stock constructed	CMHC Housing Start Survey (2006-2018) BC Hydro account information	Cross tabulations Trends
2.	Estimate unit electrical energy savings	BC Hydro billing data (fiscal 2017-fiscal 2020) BC Assessment Data (2005-2019) Weather data	Billing analysis
3.	Estimate gross energy and peak demand savings	Results for Objectives 1 & 2 BC Hydro residential rate class Peak Demand to Energy Ratio	Engineering algorithm

2.3 Results

Objective 1: Characterize the new residential building stock constructed after the building code requirements were changed in January 2015

British Columbia's new build units[2] account for about 17% of the residential building stock growth in Canada. Approximately 93% of the dwellings are in the BC Hydro service territory. The trend of new residential unit growth is shown in Figure 2.1. Before 2009, the market was relatively stable with a 1% or 2% rate of change per year. Building activity plummeted in 2009, dropping 40% from the previous year, down to 10,903 total new units. This trend was observed in other provinces as well, likely due to the economic crisis. The struggling market showed a rebound in 2010, and slowly recovered back to 2006 levels of development in 2016. Growth remained steady from 2016 to 2018 when a peak of 22,407 new units was reached.

Figure 2.1 New residential housing stock in BC Hydro service territory



A detailed breakdown of unit counts by dwelling type and year is presented in Table 2.3.

Table 2.3 Detailed breakdown of housing starts in BC Hydro service territory

Dwelling Type	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Single-family detached*	12,650	11,040	9,343	6,642	9,708	7,359	6,997	7,463	8,542	8,943	10,095	10,105	9,183
Row	3,855	3,610	3,264	2,017	3,128	3,477	2,959	2,957	3,314	3,445	4,258	4,299	3,792
Low-rise apartment**	5,182	5,939	5,731	2,244	4,179	6,131	5,982	4,894	5,274	5,540	7,231	7,391	9,432
Total	**21,687**	**20,589**	**18,338**	**10,903**	**17,015**	**16,967**	**15,938**	**15,314**	**17,130**	**17,928**	**21,584**	**21,795**	**22,407**

Source: Canada Mortgage and Housing Corporation (CMHC) Housing Starts survey data at the subdivision level and limited to BC Hydro service territory.

Notes:

* Semi-detached dwellings are grouped under the "Single-family Detached" category.

** CMHC survey data provides unit counts for apartment and condominium building starts but does not segment the data between high-rise and low-rise structure types. Low-rise apartment unit counts were estimated by multiplying total counts under the "Apartment/Others" category by an estimated ratio validated through internal research. The ratio varied by fiscal year and averaged 37%.

2 Canada Mortgage and Housing Corporation (CMHC) provides Housing Starts survey data, informing new residential dwelling units which are likely to take place in the market. The survey data contains aggregated unit counts by dwelling type at the province and subdivision level. Source data are mostly collected from new building permits reported by municipalities in Canada. A new building permit can include one or more dwelling units.

Table 2.4 shows a breakdown of the same information grouped by BC Hydro's four service regions. About 72% of the residential units were built in the Lower Mainland, while 19% were on Vancouver Island, 5% in the Southern Interior, and 3% in the North region.

Table 2.4 Residential housing starts by region in BC Hydro service territory

Region	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Lower Mainland*	14,577	13,432	12,630	7,164	11,703	12,737	11,987	11,367	12,617	12,968	16,183	15,462	15,709
North	818	1058	574	474	638	494	685	769	1003	908	446	521	715
Southern Interior	1,542	1,693	1,351	821	1,030	740	752	737	903	871	1,010	1,195	1,516
Vancouver Island	4,750	4,406	3,783	2,444	3,644	2,996	2,514	2,441	2,607	3,181	3,945	4,617	4,467
Total	**21,687**	**20,589**	**18,338**	**10,903**	**17,015**	**16,967**	**15,938**	**15,314**	**17,130**	**17,928**	**21,584**	**21,795**	**22,407**

Notes: *Lower Mainland includes Vancouver.

Objective 2: Estimate Unit Electrical Energy Savings

A regression analysis approach based on electricity billing data was selected to estimate electrical energy savings per dwelling unit for this evaluation. A sample of buildings built after the 2014 code change was chosen as the treatment group and a sample of buildings built prior to the 2007 to 2008 building code adoption was used as a baseline for comparison. Due to an average lag of approximately one year from permit issuance to construction completion as well as requiring a full year of baseline consumption, the electrical energy consumption of these buildings from fiscal 2017 to fiscal 2020 was used in the analysis. The approach controlled for weather impacts by comparing normalized annual consumption (**NAC**) referenced to a standard weather year. Other factors influencing dwelling energy consumption, such as location, dwelling type, heating energy source, and parallel DSM initiatives were also considered.

Billing analysis may also capture energy savings from customers who participate in Power Smart residential programs and savings claimed separately for other standards such as energy efficient lighting and appliances, which could lead to double counting of savings. Participation in Power Smart programs was taken into consideration when developing the regression model used for the billing analysis, thus controlling for this factor. Savings due to other standards were estimated separately through an engineering model and deducted from the unit energy savings identified in the billing analysis.

The unit electricity savings for the BCBC are presented in Table 2.5 and those associated with the VBBL are shown in Table 2.6. The adjusted unit savings reported in these tables account for a deduction of 162 kWh/year applied for savings due to other efficiency standards. The single-family detached home category also includes semi-detached homes (duplex, triplex, quadruplex).

Table 2.5 Summary unit electricity energy savings (BCBC)

Dwelling Type	Heating Type	Regions*	$NAC_{baseline}$ (kWh/year)	$NAC_{code2014}$ (kWh/year)	Adjusted Unit savings (kWh/year)	Percentage Savings	P-value
Single family detached	Electric	LM (excl. Vancouver)	14,913	11,614	3,137	21%	<.0001
		NS	15,678	11,731	3,785	24%	<.0001
		VI	15,522	10,829	4,531	29%	<.0001
	Non-electric	LM (excl. Vancouver)	11,849	10,097	1,590	13%	<.0001
		NS	10,721	9,136	1,423	13%	<.0001
		VI	11,731	8,350	3,219	27%	<.0001
Row home	Electric	LM (excl. Vancouver)	10,509	10,615	(268)	n/a	0.3200**
		NS	10,721	11,271	(712)	-7%	0.1473
		VI	10,199	9,045	991	10%	<.0001
	Non-electric	LM (excl. Vancouver)	6,905	7,555	(812)	-12%	0.0002
		NS	7,555	7,631	(238)	n/a	0.6156**
		VI	7,187	7,332	(307)	n/a	0.6256**
Low-rise apartment	Electric	LM (excl. Vancouver)	6,124	5,486	476	8%	<.0001
		NS	7,115	6,311	643	9%	0.0007
		VI	7,044	5,825	1,057	15%	<.0001
	Non-electric	LM (excl. Vancouver)	4,722	4,273	287	6%	<.0001
		NS	5,271	4,230	879	17%	<.0001
		VI	5,324	4,537	625	12%	<.0001

* LM (excl. Vancouver) – Lower Mainland excluding Vancouver, NS – North, Southern Interior, and VI – Vancouver Island.

** P-value greater than 0.2 is considered as non-statistically significant at the 80% confident level. Therefore, no savings were implied.

Table 2.6 Summary of unit electricity energy savings (VBBL)

Dwelling Type	Heating Type	$NAC_{baseline}$ (kWh/year)	$NAC_{code2014}$ (kWh/year)	Adjusted Unit savings (kWh/year)	Percentage Savings	P-value
Single Family Detached	Electric	12,708	7,785	4,761	37%	<.0001
	Non-electric	8,691	6,063	2,465	28%	<.0001
Row home	Electric	9,509	8,350	997	10%	0.0002
	Non-electric	6,374	4,403	1,809	28%	<.0001
Low-rise apartment	Electric	5,541	4,537	842	15%	<.0001
	Non-electric	4,105	3,361	582	14%	<.0001

Objective 3: Estimate gross energy and peak demand savings

The reported gross energy savings and gross demand savings for the building code from fiscal 2017 to fiscal 2020 were 84.4 GWh/year and 31.9 MW, respectively, as presented in Table 2.7. The corresponding evaluated gross energy and peak demand savings were 110.9 GWh/year and 22.7 MW respectively. The cumulative variance between the reported and evaluated energy savings over the evaluation period was positive, at 26.5 GWh/year, while the peak demand savings variance was negative at 9.2 MW.

Table 2.7 Summary of total residential building code gross demand energy savings

Fiscal Year	Energy Savings (GWh/year)		Peak Demand Savings (MW)	
	Reported	Evaluated Gross	Reported	Evaluated Gross
2017	15.1	24.5	5.7	5.0
2018	23.2	29.1	8.8	6.0
2019	23.3	28.9	8.8	5.9
2020	22.9	28.5	8.7	5.8
Total	**84.4**	**110.9**	**31.9**	**22.7**

Notes: Totals may not sum exactly due to rounding of numbers.

The negative variance in peak demand savings is strictly due to the fact that a different peak demand-to-energy ratio was used to evaluate these savings. The peak demand-to-energy ratio used in the evaluation is from the residential rate class load shape, as opposed to the residential electric space heating load shape that was used to report savings. The latter was derived for electrical heating loads, and since a sizeable proportion of the building population targeted in this evaluation is made up of non-electrically heated homes, the rate-class load shape was deemed more appropriate.

The variance in energy savings can be explained by notable differences in unit counts and unit savings between the evaluation and the forecast used for reported savings. The evaluation found fewer single-family detached homes and more multi-unit dwellings than accounted for in the forecast. On the other hand, low-rise apartments contributed to a 35% share of the evaluation unit counts, which yielded 22.4 GWh/year of the total evaluated gross energy savings, but low-rise apartments were not included in the forecast results due to the difficulties associated with parsing out low-rise apartments from total apartment units in the source data. The evaluation developed a ratio estimate for counting low-rise apartments, which is recommended for future consideration.

Differences in unit energy savings also explain part of the variance between reported and evaluated gross savings. The largest variance was in Vancouver, where the forecasted energy savings amounted to 2.9 GWh/year for the VBBL (fiscal 2017 to fiscal 2020), and the evaluation analysis detected 21.4 GWh/year over the same period, leading to a positive variance of 18.5 GWh/year. Although 7 GWh/year of this variance can be attributed to low-rise apartment counts, the remaining 11.5 GWh/year variance strongly suggests that partial code savings were missing in the reported VBBL energy savings.

The forecast followed an engineering analysis approach using energy models to estimate savings for each iteration of the code. This approach also included a forecast of the code compliance rate for each fiscal year and each version of the code. An observation made during the evaluation is that the compliance rate time series used in the forecast appear to apply a greater compliance discount to the forecast VBBL savings than to the BC Building Code savings, even though the two codes are functionally equivalent. The effect is also significant, since the modelled unit savings used in the forecast for Vancouver were 39% lower than those in the rest of the Lower Mainland.

2.4 Findings and Recommendations

Findings

1. A total of 83,714 new homes in BC Hydro service regions were granted building permits under Part 9 of the building code from 2015 to 2018. The Lower Mainland had a 72% share of this new housing stock, followed by Vancouver Island at 19%, and the remaining 9% were shared between the North and Southern Interior regions. Vancouver contributed to 22% of the housing stock in the Lower Mainland.
2. Single-family detached and semi-detached homes accounted for the largest percentage of new units at 46%. Low-rise apartments also saw a rapid growth with 23% of total new units, and row homes accounted for the remaining share.
3. From 2011 to 2018, the forecast trend in housing stock growth was consistently lower than what was found in this evaluation, primarily because the forecast did not include counts of low-rise apartments. Excluding low-rise apartments, the forecast predicted 16% more units than the evaluation for single-family detached and row homes. By adding low-rise apartments units to the total count, the evaluation found 35% more units than anticipated in the forecast.
4. Billing data revealed an average lag of approximately one year from permit issuance to construction completion. Newly built homes initially have relatively low energy consumption due to move-in time delays. Newer buildings had higher vacancy rates during the first year after construction completion (i.e., the second year after permit issuance). From the third year onward, single-family detached homes and low-rise apartments had an average vacancy rate of approximately 2% to 3% annually.
5. The estimated unit electricity savings suggested that building energy performance improved after implementation of the code, increasing energy efficiency by 14% overall. The improvements varied by dwelling type with single-family detached, low-rise apartments, and row homes saving 25%, 12%, and 3%, respectively.
6. By location, apart from the City of Vancouver, Vancouver Island units achieved the greatest electrical unit energy savings, at 16% on average. The Lower Mainland saved the least at 6% due to the higher prevalence of low-rise apartments in the housing stock built in the region, compared to the rest of the province.
7. New housing units in Vancouver achieved 23% electrical energy savings. On average, single-family detached dwellings saved 33%, row homes saved 20%, and low-rise apartments saved 15%. Vancouver was ahead of the rest of the province in adopting high energy performance requirements for building, and other initiatives by the city may have encouraged the local market to build residential dwellings beyond the minimum code requirements.
8. The electrical energy performance of electrically heated single-family homes improved by 21 to 29% depending on the region under the 2014 edition of the BC Building Code, while non-electrically heated single-family homes saved 13 to 27%.

9. The evaluation considered the impact of parallel DSM initiatives and an analysis estimated that annual savings of 162 kWh per unit could be attributed to other Energy Efficiency Standards improvements during the evaluation period. These savings were netted out of the billing analysis savings used to estimate code impacts to avoid double counting.
10. The evaluated gross energy savings and the corresponding peak demand savings from fiscal 2017 to fiscal 2020 were 110.9 GWh/year and 22.7 MW, respectively.
11. A sizeable variance in total energy savings was found between the evaluation and forecasted savings in the City of Vancouver. Some of this variance may be due to the assumptions on code compliance embedded in the forecast, which effectively discounted savings in Vancouver relative to the rest of the Lower Mainland.
12. The evaluated energy savings were 26.5 GWh/year higher than the reported gross savings of 84.4 GWh/year over the evaluation period. The largest difference was due to the inclusion of low-rise apartments in the evaluation and the greater performance found in the evaluation for buildings in Vancouver.
13. At 22.7 MW, the evaluated gross demand savings were 9.2 MW lower than the reported gross demand savings of 31.9 MW. This is because the peak demand-to-energy ratio used in the evaluation is from the rate class load shape, as opposed to the residential electrical space heating load shape that was used to report savings. The latter was derived for electrical heating loads, and a sizeable proportion of the buildings targeted in this evaluation are non-electrically heated homes.

Recommendations

Recommendations No. 1 and No. 2 are for the BC Hydro Codes and Standards group. Recommendation No. 3 is for the Strategic Planning group.

1. Consider adding low-rise apartment units to the count of Part 9 buildings regulated by the building code when forecasting residential building code savings.
2. Review the assumptions used to estimate savings related to the Vancouver Building By-Law from 2014 onward, as it appears that code compliance assumptions result in discounted unit savings for buildings in Vancouver compared to similar buildings in the Lower Mainland.
3. Review the appropriateness of the peak demand-to-energy ratio used to report gross demand savings for the residential building code.

2.5 Conclusions

The residential building stock in B.C. became more energy efficient after energy efficiency requirements were incorporated in the 2014 BC Building Code. A total of 111 GWh/year in gross electricity energy savings were achieved between fiscal 2017 and fiscal 2020, with corresponding peak demand savings of 23 MW. The greatest energy savings were achieved by single-family detached dwellings, followed by low-rise apartments.

3.0 Leaders in Energy Management – Commercial Evaluation: Fiscal 2018 to Fiscal 2020

3.1 Introduction

This report presents the results of an impact evaluation of the BC Hydro Leaders in Energy Management – Commercial (LEM-C) program for fiscal years fiscal 2018 to fiscal 2020 (April 1, 2017 to March 31, 2020). The scope of the evaluation includes savings from electrical energy efficiency and conservation activities completed at commercial sites reported during the evaluation period.

LEM-C is available for commercial customers in both the public and private sectors. The public sector includes institutions (healthcare, advanced education, K-12 schools) and government (municipal, provincial and federal buildings). Private sector participants are diverse, covering a wide range of businesses and services, including property management, offices, food and non-food retail, hospitality, restaurants, telecommunications, and services.

Organizations with a BC Hydro Key Account Manager (**KAM**) have access to one of two Energy Manager options: partial funding for a full-time Energy Manager or an unfunded Energy Manager Associate. These organizations are provided access to an array of supports to facilitate energy management including workshops, energy management assessments, and energy studies. Organizations that do not have a KAM have access to Business Energy Advisors funded by BC Hydro. Commercial customers of all sizes can also access several online enabling tools towards energy management.[3]

The program also supports ENERGY STAR Portfolio Manager, an interactive energy management tool provided through Natural Resources Canada that can be used to track and assess energy and water consumption across a portfolio of buildings. By comparing building performance to a benchmark or to other buildings in the organization's portfolio, Portfolio Manager users can identify under-performing buildings, verify efficiency improvements and prioritize efficiency investments.

LEM-C also helps customers focus on opportunities to optimize their capital expenditures and leverage BC Hydro incentives to address financial barriers to implementing energy efficiency projects. Incentives are available for custom projects and the amount is determined on a per project basis based on estimated energy savings and capital costs. Custom project incentives are typically available to large commercial customers with annual consumption above 4 GWh. Business Energy Savings Incentives (BESI) are available to commercial customers of any size and provide incentives for simple, one-for-one replacements of inefficient technologies with energy-efficient ones, most commonly lighting. Energy savings are also achieved through what are called program enabled projects. These are custom projects that did not receive direct capital incentive funding from BC Hydro but were enabled by other BC Hydro resources and supports. Program enabled savings also include deemed savings related to the use of ENERGY STAR Portfolio Manager by eligible participants.

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[3] Other tools include: the Strategic Energy Management Hub on-line tool, building performance analytics, the Energy Wise Network, and on-line energy tracking.

3.2 Approach

The following table presents the evaluation objectives and related research questions addressed in this report.

Table 3.1 Evaluation objectives and research questions

	Evaluation Objective	Research Questions
1.	Assess the customer experience with LEM-C program design and delivery	What are participant and non-participant experiences related to program awareness, understanding? What is participant satisfaction for each of the custom and BESI offers? What are the main drivers of and barriers to program participation? Are there differences across commercial customer segments (sub-sector, size, KAM)?
2.	Examine outcomes associated with enabling activities towards strategic energy management	What factors had the greatest association with amount and type of project activity (e.g., energy managers, energy studies, others)? To what extent were energy managers, energy manager associates, and energy studies associated with project activity and energy savings? What was the coverage of energy savings of facilities with energy managers compared to those without?
3.	Evaluate additional electrical energy savings enabled through participants using ENERGY STAR Portfolio Manager	To what extent did participants with deemed electrical energy savings utilize Portfolio Manager to manage energy consumption and implement energy savings activities? What were the gross electrical energy savings additional to savings from capital projects for participants with deemed savings? What were the net electrical energy savings additional to savings from capital projects for participants with deemed savings?
4.	Estimate gross electrical energy savings for capital projects	What were the gross realization rates and evaluated gross savings by end use? What were the evaluated gross energy savings by type of custom (custom, program enabled) and prescriptive capital projects (BESI-KAM, BESI-non-KAM)?
5.	Estimate net electrical energy savings due to capital projects	How much free ridership occurred for custom, program enabled and prescriptive capital projects? How much participant and non-participant spillover occurred for the custom and prescriptive offers? What are the evaluated net energy savings for custom, program enabled and prescriptive capital projects?
6.	Estimate total gross and net electrical energy and peak demand savings due to the LEM-C program	What are the total evaluated gross energy and peak demand savings realized by the program by fiscal year? What are the total evaluated net energy and peak demand savings realized by the program by fiscal year?

Table 3.2 summarizes the data sources and methods used to generate the results for each evaluation objective.

Table 3.2 Evaluation objectives, data and methods

Evaluation Objectives	Data Sources	Method
1. Assess the customer experience with LEM-C program design and delivery	6 waves of program participant surveys covering fiscal 2018 to fiscal 2020 Non-participant survey (fiscal 2019) Alliance Survey (fiscal 2018) Small/Medium Businesses non-participant survey (fiscal 2020, secondary research)	Cross tabulations
2. Examine outcomes associated with enabling activities towards strategic energy management	Project files Participant surveys (fiscal 2018 – fiscal 2020) Non-participant survey (fiscal 2019)	Cross tabulations Qualitative analysis
3. Evaluate additional electrical energy savings enabled through participants using ENERGY STAR Portfolio Manager	Capital project tracking data Portfolio Manager participant survey Annual consumption data (fiscal 2017-fiscal 2020)	Discrepancy analysis Adjusted load difference regression Descriptive quantitative analysis Qualitative analysis
4. Estimate gross electrical energy savings for capital projects	Program tracking data Project files M&V results	Extrapolation of M&V results using stratified ratio estimation
5. Estimate net electrical energy savings due to capital projects	Results from Objective 4 Participant surveys (fiscal 2018 – fiscal 2020) Non-participant survey (fiscal 2019)	Survey-based free ridership and spillover algorithms BC Hydro Cross Effects Calculation Guidelines
6. Estimate total gross and net electrical energy and peak demand savings due to the LEM-C program	Results from Objective 3, 4 and 5 Average peak-to-energy factors	Engineering estimation Variance calculation

3.3 Results

Objective 1: Assess the customer experience with LEM-C program design and delivery

Overall satisfaction (“very satisfied” plus “somewhat satisfied”) was high for all of the LEM-C offers at 94% for custom participants, 83% for BESI KAM participants and 91% for BESI non-KAM participants. In terms of program experience, “service provided by contractors” was rated very favourably across all participant groups, with over 90% each rating the aspect as “excellent” or “good”. Other aspects that rated well across all three participant groups were the “quality of the energy efficient technology”, “installing the energy efficient technology” and “service provided by suppliers/distributors”. Elements which rated low across all groups include the “variety of products funded by the program” and the “level of incentives”. Among custom participants, a low rating was also given for the “length of time to receive project approval”, with only 40% rating it as “excellent” or “good”. Among BESI KAM participants, the other lowest ratings were related to information about the program, specifically information on the website at 60% and by direct mail/email at 68%. Among BESI non-KAM participants, the other lowest ratings were for “knowing who/how to contact BC Hydro” at 52% and “direct mail/email about the program” at 50%.

For all groups, “making operating costs as low as possible” was among the top motivators for managing their organization’s electricity use. Among the participant groups, the “Energy Manager” and the “LEM-C program/BESI offer” were also main motivators, as was “reducing electricity use to benefit the environment”. Among both participants and non-participants, the largest barriers to managing electricity use included “other operational priorities” and “lack of funds for energy efficient retrofits”. Based on the results from the Small and Medium Business non-participant survey, barriers to participating in BC Hydro’s programs also included lack of awareness and understanding of the programs that BC Hydro offers. Additionally, only 42% “strongly agreed” or “somewhat agreed” that there is a significant return on investment for energy management tools and only 30% agreed that there are good incentives to participating in BC Hydro’s energy management programs.

Objective 2: Examine outcomes associated with enabling activities towards strategic energy management

Strategic energy management (SEM) aims to change attitudes and behaviours toward energy efficiency, leading to changes in processes and practices and ultimately resulting in energy savings. The strategic energy management initiative provided participants with a suite of tools and offers intended to help build energy management into their ongoing business practices. However, what constitutes strategic energy management for this program has not been fully defined in relation to industry accepted guidelines, such as the ISO 50001 Energy Management Systems standard and the Consortium for Energy Efficiency’s guideline for minimum elements of strategic energy management. As a result, supporting evidence of meeting specific objectives could not be measured and tracked, including additional energy savings beyond what is already being captured. The evaluation focuses on participation in enabling activities rather than the outcomes of SEM.

For customers with a KAM, capital projects were completed at 13% of sites covering 37% of annual consumption, indicating that larger buildings were more likely to complete a capital project. A total of 60 energy managers and 13 energy manager associates were found among this group of customers and they were associated with the implementation of capital projects at 11% of all sites accounting for 31% of annual energy consumption among customers with a KAM. Overall, having an Energy Manager was related to project activity mostly at the larger buildings in their portfolio.

Objective 3: Evaluate additional electrical energy savings enabled through participants using ENERGY STAR Portfolio Manager

Program reported savings related to strategic energy management through the use of Portfolio Manager, as determined by the program administrators, relied on a deemed expected energy savings estimate of 2.4% of annual energy consumption with one year of persistence for qualifying participants. A total of 320 participating buildings were included during the evaluation period.

Evaluated savings for participants using Portfolio Manager, incremental to those from capital projects, were estimated using a two-step approach. First, a discrepancy analysis was conducted to compare participants characteristics with basic Portfolio Manager requirements and program information. The discrepancy analysis led to the exclusion of a number of sites from the savings estimate, resulting in an evaluated gross realization rate of 84%. The second step looked at the evolution of energy consumption relative to a baseline in the participant group, compared to the same metrics for a comparison group of non-participants to assess the reliability and validity of the deemed savings estimate. This analysis showed a difference of 2.2% in the average change in annual site energy consumption between the two groups, resulting in a net realization rate of 92% relative to the deemed expected savings estimate of 2.4%.

The overall evaluated net energy savings enabled through participants using Portfolio Manager was 77% of expected savings for 1.7 GWh per year in fiscal 2019 and 3.2 GWh per year in fiscal 2020.

Objective 4: Estimate gross electrical energy savings for capital projects

The overall gross realization rate of capital projects for the period fiscal 2018-fiscal 2020 was estimated as the ratio of evaluated to expected gross savings for all measures included in the evaluation analysis. The overall realization rate for capital projects was calculated at 95% meaning that, on average, the measures in the realization rate samples achieved 95% of their expected savings. Table 3.3 summarizes the expected and evaluated gross energy savings for capital projects by type of end use.

Table 3.3 Expected and evaluated gross energy savings from capital projects by end use

Type of End Use	Count of Measures	Expected Savings (GWh/year)	Evaluated Gross Realization Rate (GRR)	Evaluated Gross Energy Savings (GWh/year)
LED Lighting	3,951	88.0	97%	85.7
Non-LED Lighting	607	7.9	90%	7.1
Other End Uses	201	20.2	74%	14.9
Tag-on	246	0	101%	3.1
Total	**5,005**	**116.1**	**95%**	**110.8**

*Tag-on savings are reported spillover resulting from project work done above and beyond a project's original contract scope

Objective 5: Estimate net electrical energy savings due to capital projects

Net electricity savings are the change in energy consumption and demand that is attributable to the program. They exclude free riders and include spillover. The overall level of free ridership was estimated at 18% for capital projects and ranged from 16% to 27% across program offers. Participant spillover was estimated at 6% and non-participant spillover was estimated at 11%, for a total of 17%. Cross effects were calculated as 7% for custom, 8% for BESI KAM and 8% for BESI non-KAM projects. As shown in Table 3.4, together these factors result in a downward adjustment of the evaluated gross energy savings of 9.2 GWh per year during the evaluation period and a net-to-gross ratio of 92%.

Table 3.4 Net-to-Gross ratio by program offer

Program Offer	Custom	BESI KAM	BESI Non-KAM	Tag-on	LEM-C F18-F20 (Calculated)
Evaluated Gross Energy Savings (GWh/year)	78.4	11.4	17.9	3.1	110.8
Net-to-Gross Ratio	**92%**	**80%**	**95%**	**93%**	**92%**
Evaluated Net Energy Savings (GWh/year)	72.5	9.2	17.0	2.9	101.6

Objective 6: Estimate total gross and net electrical energy and peak demand savings due to the LEM-C program

Table 3.5 summarizes the reported and evaluated net energy savings and peak demand savings for the LEM-C program by fiscal year. Peak demand savings were estimated based on applying a peak-to-energy factor of 0.155 MW per GWh, which was the weighted average of 0.158 MW per GWh for commercial lighting and 0.143 MW per GWh for commercial rate class.

Table 3.5 Summary of net energy and peak demand savings

	Net Energy Savings (GWh/year)		Net Peak Demand Savings (MW)	
Fiscal Year	**Reported**	**Evaluated**	**Reported**	**Evaluated**
F2018	42.5	39.7	6.6	6.2
F2019	34.0	32.4	5.3	5.0
F2020	40.4	34.4	6.3	5.4

Overall, the program achieved 91% of reported savings during fiscal years fiscal 2018 to fiscal 2020. The program variance is primarily due to a lower than expected gross realization rate and the evaluated net-to-gross ratio being lower than the forecast net-to-gross ratio, mainly due to the impact of recent changes to the cross effects guidelines.

3.4 Findings and Recommendations

Findings

Customer experience with program design and delivery

1. Overall satisfaction (somewhat plus very satisfied) was high for all of the LEM-C offers at 94% for custom participants, 83% for BESI KAM participants, and 91% for BESI non-KAM participants. BESI non-KAM participants provided the highest “very satisfied” levels at 65%.
2. “Service provided by contractors” was rated particularly high across all participant groups. Other aspects that were rated well across all three participant groups were the “quality of the energy efficient technology”, “installing the energy efficient technology”, and “service provided by suppliers/distributors”.
3. Elements which rated low across all groups include the “variety of products funded by the program” and “level of incentives”. Areas which rated low among specific groups included “length of time to receive project approval” among custom participants, “information about the program” among BESI participants and “knowing who/how to contact BC Hydro” among BESI participants without a Key Account Manager.
4. Among all groups, “making operating costs as low as possible” was among the top motivators for energy management. The largest barriers to managing electricity use included “other operational priorities” and a “lack of funds for energy efficient retrofits”. Based on the results from the Small and Medium Business non-participant survey, barriers to participating in BC Hydro’s programs included lack of awareness and understanding of the programs that BC Hydro offers as well as low perceived return-on-investment.

Outcomes associated with enabling activities towards strategic energy management

5. BC Hydro-funded Energy Managers and Energy Manager Associates covered 23% of sites and 38% of the total energy consumption of commercial customers with a BC Hydro Key Account Manager. The coverage of BC Hydro-funded Energy Managers was likely constrained by the maximum number of energy managers funded by BC Hydro during the evaluation period.

6. Among commercial customers with a BC Hydro Key Account Manager and a BC Hydro-funded Energy Manager or an Energy Manager Associate, 48% of the sites with 81% of the total energy consumption had implemented energy savings projects.
7. Among program participants that had a BC Hydro Key Account Manager, 83% of the sites had an Energy Manager or an Energy Manager Associate, and these managers were associated with 82% of the energy savings. The high coverage of program participants by BC Hydro-funded Energy Managers or Energy Manager Associates is primarily due to the program's requirement to have an energy manager as an eligibility condition to participate in the custom incentive offer, which was in place for much of the evaluation period.
8. Although there are enabling activities towards strategy energy management provided through LEM-C, what constitutes strategic energy management for this program has not been fully defined in relation to industry accepted guidelines. As a result, supporting evidence of meeting specific objectives could not be measured and tracked, including additional energy savings beyond what is already being captured.

Additional electrical energy savings enabled through participants using Portfolio Manager

9. Participants for which deemed savings from SEM-Portfolio Manager were reported included 320 buildings. An analysis of participating buildings against Portfolio Manager criteria for benchmarking and recommended use led to the elimination of a number of buildings, resulting in an evaluation sample of 212 buildings for a gross realization rate of 84% of expected savings.
10. Regression analysis of annual energy consumption applied to a treatment and comparison group after adjustments to account for the impact of known capital projects exhibited an average net reduction in building energy consumption of 2.2%, for a net to gross ratio of 92% for savings from SEM-Portfolio Manager.
11. The evaluated savings from SEM-Portfolio Manager were above and beyond savings achieved through reported capital projects for the same buildings. The combined savings from SEM-Portfolio Manager and from capital projects resulted in a building electrical energy reduction of 3.4% on average, based on the results of this evaluation.

Gross Electrical Energy Savings for Capital Projects

12. Between fiscal 2018 and fiscal 2020, 1,477 capital projects were implemented through the LEM-C custom incentives, program enabled, and prescriptive incentives (BESI) program offers. Capital projects were mostly lighting retrofits, with LED lighting and Non-LED lighting respectively representing 80% and 7% of evaluated gross energy savings. A mix of other end uses accounted for the remaining 13% of savings.
13. The gross realization rate of energy savings from capital projects was 95%, indicating that the energy conservation measures largely performed as expected. The most common reasons identified through measurement and verification for why measures did not perform as expected were changes in baseline conditions and hours of use.
14. Evaluated gross energy savings from capital projects were 110.8 GWh from fiscal 2018 to fiscal 2020. Capital projects resulted in an average reduction in site energy consumption of almost 5% for program participants over the three-year evaluation period.

Net Electrical Energy Savings from Capital Projects

15. The net-to-gross ratio was 92% based on an overall level of free ridership of 18%, participant spillover of 6%, and non-participant spillover of 11%. Cross effects through interactions with space heating and cooling systems were estimated to reduce gross savings by 7%.
16. Evaluated net energy savings from capital projects were 101.6 GWh from fiscal 2018 to fiscal 2020.

Total Electricity and Peak Demand Savings

17. Evaluated net energy savings for LEM-C were 39.7 GWh per year in fiscal 2018, 32.4 GWh per year in fiscal 2019, and 34.4 GWh per year in fiscal 2020, which averaged 92% of reported savings.
18. Net peak demand savings were estimated at 6.2 MW in fiscal 2018, 5.0 MW in fiscal 2019, and 5.4 MW in fiscal 2020, based on applying a weighted average peak-to-energy factor of 0.155 MW per GWh derived from the load shapes for commercial lighting and the commercial rate class.

Recommendations

Recommendations No. 1, No. 2, No. 3 and No. 4 are for BC Hydro LEM-C program management and recommendation No. 5 is for Evaluation, based on the findings of this evaluation.

1. Adopt and integrate a definition of Strategic Energy Management that aligns with industry guidelines, with measurable outcomes.
2. Clarify the linkage between actively using ENERGY STAR Portfolio Manager to support Strategic Energy Management activities and achieving deemed energy savings.
3. Update program guidelines for including buildings with deemed savings to reduce common discrepancies with ENERGY STAR Portfolio Manager's intended use and benchmarking criteria.
4. Develop and implement a process for sharing the customer experience results with relevant staff in Conservation and Energy Management Operations and Customer Care.
5. Continue to explore evaluation methods to estimate savings from Strategic Energy Management participants using ENERGY STAR Portfolio Manager, including matching of buildings in the participant group to buildings in the comparison group. Also, develop additional lines of evidence to support program attribution for these savings, for example through interviews with participants.

3.5 Conclusions

BC Hydro's Leaders in Energy Management – Commercial program achieved 91% of reported savings during fiscal years fiscal 2018 to fiscal 2020, with the variance, in part, due to the revised cross effects calculation guidelines. Overall satisfaction with the program continued to be high. Strategic energy management contributed to higher levels of program activity and additional energy savings among participants.

4.0 Residential Retail Program Evaluation – Lighting Offer: Fiscal 2015 (Q2) to Fiscal 2019

4.1 Introduction

This impact evaluation examines the energy savings associated with the lighting offer of BC Hydro's Residential Retail Program for the period starting July 1, 2014 (Fiscal 2015, Q2) to March 31, 2019 (Fiscal 2019).

The program's key objective is to influence customer purchase decisions through different market channels and obtain energy savings. Two retail campaigns per year are implemented, one in the spring and the other in the fall. During the campaigns, customers receive instant discounts on selected energy efficient lighting products (bulbs, fixtures, controls and dimmers) and can mail-in to claim a rebate for eligible, energy efficient appliances purchased within the prescribed time period.

Residential customers receive information about the rebates through advertising and promotions executed by BC Hydro (e.g., paid, owned and earned media, and in-store execution), as well as through partner channels (e.g., owned channels print and online flyers, e-newsletters, channel paid media). The program also aimed to advance the adoption of more energy efficient products by working with market partners to have these products available on store shelves throughout B.C., promoted by knowledgeable sales staff.

This evaluation focuses on the lighting rebate offer, bulbs only.[4] Evaluation of the appliances offer was not completed due to the small amount of energy savings expected from appliances as a result of the extensive market transformation that has occurred in appliance products over the years.

4.2 Approach

The evaluation objectives and corresponding research questions are summarized in Table 4.1.

Table 4.1 Evaluation objectives and research questions

Evaluation Objective	Research Questions
1. Assess market trends in lighting	What were the trends in bulb installation in BC Hydro residential customer homes? What were the trends in shelf space shares for LED bulbs? What were the trends in LED bulbs prices?
2. Assess retail partner opinions and experience with the program	How valuable did the retail partners find the financial incentives and promotional materials provided by BC Hydro for promoting sales? What other factors influenced sales? What additional promotional activities did retailers undertake, if any? How influential was BC Hydro in these activities? How satisfied were the retail partners with the campaigns?
3. Estimate gross energy savings for the lighting offer (bulbs only)	What were the gross energy savings for each rebated lighting product type? What were the gross energy savings for the lighting offer overall?
4. Estimate net energy and peak demand savings for the lighting offer (bulbs only)	What influence did program activities have on the sales of LED bulbs? What was the free rider rate for the LED bulbs discounted by the program? What were the net savings of these discounted LED bulbs? What was the spillover rate and savings for LEDs purchased without discounts? What were the net energy and peak demand savings for the lighting offer?

4 Other lighting offers (e.g., controls and dimmers) were not included in the scope of the evaluation as participation and savings in these offers were low relative to bulbs, and rebates were phased out over the evaluation period.

Table 4.2 Evaluation objectives, data and methods

	Evaluation Objective	Data Sources	Methods
1.	Assess market trends in lighting	Residential End-Use Studies (2010, 2012, 2014, 2017, 2020) Shelf Space Studies (2014-2018)	Frequencies & cross tabulations Trends analysis Qualitative analysis
2.	Assess retail partner opinions and experience with the program	Retail Partner Surveys (Fall 2016-2018, Winter 2019)	Cross tabulations Qualitative analysis
3.	Estimate gross energy savings for the lighting offer (bulbs only)	Rebate sales data Residential Monitoring Study (2011) Customer Household Lighting Surveys (2015-2018) Shelf Space Studies (2014-2018)	Engineering algorithms Means, frequencies & cross tabulations
4.	Estimate net energy and peak demand savings for the lighting offer (bulbs only)	Gross energy savings results (Objective 3) Residential End-Use Studies (2014, 2017, 2020) Shelf Space Studies (2014-2018) Retail Partner Surveys (Fall 2016-2018, Winter 2019) Customer Household Lighting Surveys (2015-2018)	Means, frequencies & cross tabulations Attribution analysis: -consumers self-report -retailers self-report

4.3 Results

Objective 1: Assess Market Trends in Lighting

Types of Light Bulbs Installed in Customer Homes – In the latter years of the evaluation period, light-emitting diode (LED) bulbs ascended from third to first position in terms of the most widely installed type of bulb in BC Hydro service territory homes. In the 2020 Residential End-Use Study, conducted just one year after the fiscal 2019 end-point of this evaluation, the percent of homes with at least one LED installed measured 83% – a 22-point jump from 61% in 2017. Additionally, among the households with at least one LED bulb installed, the average number installed also climbed – from about 15 bulbs to 22 bulbs.

The proliferation of LED bulbs came with a concurrent demise of other types of bulbs. Having previously always been the most prevalent type of bulb in customer homes, incandescent bulbs were relegated to second position as their penetration – the percent of those with at least one installed – dropped from 78% to 66% between 2017 and 2020. Compact fluorescent lamps (CFL) held second position for many years prior, but they too were pushed down to third position as their penetration fell from 67% to 50%.

Shelf Space Share of Light Bulbs by Technology – Findings from the supply-side shelf space studies corroborated findings from the demand-side surveys of light bulb adoption by technology type. In the fall 2014 shelf space study, LEDs had only a 17% share of the total shelf space allotted to light bulbs – fourth behind incandescent bulbs, CFL bulbs and halogen bulbs. However, LEDs' share of the shelf space nearly doubled to 31% in the fall 2015 study and overtook the other three as being most prevalent. Through the subsequent three years, LEDs' share increased to 59% in the fall 2018 study.

Price of A-line Bulbs – The substantial year-over-year jumps in LED bulb installation was not only a result of their greater availability in the marketplace as seen in the shelf space studies, as sharp decreases in their retail prices were also gleaned from the same studies. The average price of an A-line LED measured $16.83 in the fall 2014 shelf space study – approximately $13 to $15 higher than for a CFL, halogen or incandescent bulb. In the last shelf space study of the evaluation period, the average price of an A-line LED measured $4.47 – only about $0.50 higher than for a CFL, and about $2.00 higher than for a halogen or incandescent bulb.

Objective 2: Assess Retail Partner Opinions and Experience with the Program

As the population of retail partners is small, the available survey samples are correspondingly small. As such, all findings are presented as absolute counts – rather than as percentages – and are interpreted in a directional context.

Partner Views of the Campaign Components – The majority of the five to six retail partners surveyed in the three campaigns assessed BC Hydro's provision of 1) *financial incentives to consumers*, 2) *point-of-purchase materials,* 3) *sponsored advertising*, and 4) *training to sales staff* as having been "very valuable" or "somewhat valuable" in terms of helping their organization to promote and sell the Energy Star LED "specialty" bulbs.

Having next been asked to rank the four components, nearly all of the partners through each of the three fall surveys ranked the *financial incentives* as the most valuable. None of the other three components dominated the 2nd or 3rd positions, but the *provision of training to retail sales staff* – while ranking generally in the middle in 2016 and 2017 – emerged as the least valuable in 2018.

Additional Marketing Activities Implemented by the Retail Partners – In addition to the campaign support and marketing materials provided by BC Hydro, all of the retail partners reported having implemented additional promotional activities on their own to help promote and sell Energy Star LED bulbs during the campaigns. Aside from increased internal communications that occurred, the most enhanced customer-facing activities had tended to center around Internet advertising, flyers and point-of purchase messaging. Most of the organizations credited BC Hydro's campaigns as influential on these additional efforts.

Overall Satisfaction with BC Hydro's Fall Lighting Campaigns – In each of the three fall surveys, most of the retail partners – if not all – were satisfied overall with the BC Hydro lighting campaign that they were a part of.

Objective 3: Estimate Gross Electrical Energy Savings

Gross energy savings were evaluated with several inputs including rebated sales volume of program targeted bulbs, wattage difference between program target bulbs and their replacement, hours of use, cross effect factor. They were measured as annual run-rate savings in GWh per year.

The wattage difference was calculated with the inputs of product wattage information, information about the replacement bulbs (type, wattage and share of each type of bulb being replaced). The average wattage difference (energy efficiency gain) of program targeted bulbs weighted by sales volume and the gross energy savings of the program rebated bulbs (direct program impacts) are shown in the following table.

Table 4.3 Gross electrical energy savings for direct program impacts

	Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019
	⇓	⇓	⇓	⇓	⇓
(1) Number of LED bulbs discounted in campaigns	368,932	830,753	954,330	284,567	234,274
(2) Average Difference (Watt/Bulb)	31	31	29	31	24
Gross Savings Run Rate (GWh/year)	**11.3**	**25.9**	**27.2**	**8.7**	**5.6**
	78.7				

Objective 4: Estimate Net Electrical Energy and Peak Demand Savings

The net energy savings credited to BC Hydro's lighting offer brings together savings on three separate fronts. First, it includes the net savings tied to the purchase of Energy Star LEDs discounted during BC Hydro's campaigns. Additionally, it includes in-campaign spillover savings tied to the purchase of other types of LEDs during the campaigns, as well as out-of-campaign spillover savings tied to the purchase of LEDs at other times of the year.

Net Electrical Energy Savings for Discounted LEDs – For each fiscal year, the net energy savings for the purchase of discounted LEDs was computed as the proportion of the gross energy savings estimated to be attributable to BC Hydro's lighting campaigns.

As shown in Table 4.4, the estimates of attribution – or conversely, free ridership – took the form of a fraction or ratio synthesized from the findings among purchasers found in the lighting surveys conducted at the conclusion of most of the fall campaigns. Estimates gleaned from findings in the retail partner surveys converged closely with them.

Table 4.4 Net direct electrical energy savings (GWh/year)

	Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019	Total
	⇓	⇓	⇓	⇓	⇓	⇓
Gross electrical energy savings for direct program impacts	11.3	25.9	27.2	8.7	5.6	78.7
Attribution (1 – free ridership)	0.50	0.51	0.49	0.53	0.38	n/a
Net Direct Electrical Energy Savings (GWh/year)	**5.7**	**13.2**	**13.3**	**4.6**	**2.1**	**38.9**

Figures are left unrounded to allow readers to follow them through the calculations. They are not meant to convey this degree of precision.

The total net direct electrical energy savings for the purchase of discounted LED bulbs were estimated to be 38.9 GWh/year across the five fiscal years.

In-Campaign Spillover Energy Savings – This section presents the estimated energy savings attributable to BC Hydro's lighting campaigns for the purchases of other types of LED bulbs during the campaign months – LEDs that went undiscounted by the program. Similar to those that were discounted, the other types of LED bulbs eligible for such in-campaign spillover savings were required to have the Energy Star rating. The types of bulbs eligible for in-campaign spillover varied year over year based on changes to the types that were discounted by the program. As all types of LED bulbs were discounted in the fiscal 2015 and fiscal 2016 campaigns, there were no outstanding bulbs eligible for such spillover savings. The estimates of in-campaign spillover savings for the three remaining fiscal years hinged on findings from the two household lighting surveys pertaining to the fall 2017 and fall 2018 campaigns. There was a fall 2016 survey, but it did not include the lines of questions needed to inform the purchase of other types of LEDs eligible for spillover.

Table 4.5 In-campaign spillover energy savings

	Fiscal 2017			Fiscal 2018		Fiscal 2019	
	Deemed for Spring 2016	**Deemed for Fall 2016**	**Deemed for Spring 2017 (March)**	**Deemed for Spring 2017 (April)**	**Fall 2017 Household Survey**	**Deemed for Spring 2018**	**Fall 2018 Household Survey**
	⇓	⇓	⇓	⇓	⇓	⇓	⇓
Total number of "other" LEDs purchased	292,468	204,727	282,719	126,736	1,458,435	715,399	943,026
(5) Gross unit savings (kWh/year/bulb)	25	25	25	25	26	27	27
(6) Attribution (mean program influence)	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Spillover Energy Savings (GWh/year)	**0.9**	**0.7**	**0.9**	**0.4**	**4.9**	**2.5**	**3.3**
	2.5			**5.3**		**5.8**	
	13.6						

Figures are left unrounded to allow readers to follow them through the calculations. They are not meant to convey this degree of precision.

Table 4.5 shows the estimated in-campaign spillover savings, along with the key figures used to calculate the savings. The total number of other types of Energy Star LED bulbs purchased during the campaigns was estimated based on survey research. The gross unit energy savings were calculated in a similar way as for the discounted bulbs. The estimates of attribution for in-campaign spillover were calculated using self-report inputs from the household lighting surveys and algorithms very similar to those used in the estimates of attribution of direct savings for discounted LEDs. Note that the values of 0.13 for each of the fall 2017 and fall 2018 surveys were in fact independently estimated.

Note that the attribution of 0.13 was applied to the other campaigns that went without survey research. This approach was considered to pose little threat to the validity of the evaluation results as the lighting market would likely have not evolved in such a short period of time in a manner that would render the inputs invalid.

For the three fiscal years, the total in-campaign spillover energy savings measured 13.6 GWh.

Out-of-Campaign Spillover Energy Savings – This section presents the estimated energy savings for market effects attributable to BC Hydro's lighting initiatives and promotional activities for the purchase of LED bulbs at other times of the year – the nine to ten months of the year when discounts were not provided. A portion of these LED bulb sales are influenced by program activities and recognized as a market effect in the form of out-of-campaign spillover. As with bulbs discounted by the program, these LEDs were required to have been rated as Energy Star. The types of bulbs eligible for out-of-campaign spillover varied year over year based on changes to the types that were discounted by the program.

For these out-of-campaign spillover savings, a deductive approach was adopted whereby for any fiscal year of interest, the total number of purchased Energy Star LEDs eligible for such spillover was first estimated. The volume of discounted LEDs already accounted for in the direct savings was then subtracted, as well as the volume of undiscounted LEDs already accounted for in the in-campaign spillover estimates. The balance of Energy Star LEDs lent themselves to the potential for spillover.

Attribution of these purchases to BC Hydro's lighting initiatives – 0.10 for all five fiscal years – was based on findings from two retail partner surveys administered in fiscal 2019.[5] This estimate was believed to be reasonable because 1) it is based on identical estimates to have emerged from two separate retail

5 Retail partner surveys are considered to be more appropriate for assessing out-of-campaign spillover than individual household surveys. Retail partners are in a better position to understand the initiative's impact on the overall marketplace.

partners surveys administered in fiscal 2019, and 2) the views expressed by the retail partners were believed to be credible given that their estimates of the attribution for direct savings and in-campaign spillover savings converged closely with in-campaign attribution estimates gleaned from the household surveys.

Table 4.6 shows the estimated out-of-campaign spillover savings, along with the key figures used to calculate the savings.

Table 4.6 Out-of-campaign spillover energy savings

	Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019
	⇓	⇓	⇓	⇓	⇓
Total num. of EStar LEDs of eligible type purchased	2,240,616	2,985,896	2,285,469	2,221,328	2,608,644
	⇓	⇓	⇓	⇓	⇓
(6) Less: num. of LEDs discounted in campaigns	368,932	830,753	954,330	284,567	234,274
(7) Less: num. of LEDs accounted for in-campaign	0	0	771,507	1,585,171	1,658,425
(8) Total num. of LEDs for out-of-campaign	1,871,684	2,155,143	559,632	351,590	715,945
	⇓	⇓	⇓	⇓	⇓
Final calculation of savings					
(9) Gross unit savings (mean kWh/year per bulb)	25	25	25	25	25
(10) Attribution (mean program influence score)	0.10	0.10	0.10	0.10	0.10
Spillover Energy Savings (GWh/year)	**4.7**	**5.4**	**1.4**	**0.9**	**1.8**
	14.1				

Figures are left unrounded to allow readers to follow them through the calculations. They are not meant to convey this degree of precision.

Figures may not sum exactly to the total due to rounding.

For the five-year evaluation period, the total out-of-campaign spillover electricity savings measured 14.1 GWh/year.

Summary of Electrical Energy Savings – Table 4.7 brings together the estimated direct energy savings for the purchases of discounted Energy Star LEDs during the campaigns in the five-year evaluation period, the in-campaign and the out-of-campaign spillover savings. The total annual energy savings for the Retail Lighting Program were estimated to be 66.6 GWh/year.

Table 4.7 Total annual net electrical energy savings Fiscal 2015 to Fiscal 2019 (GWh/year)

	Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019	Total
	⇓	⇓	⇓	⇓	⇓	⇓
Direct electricity savings for the purchases of discounted LEDs	5.7	13.2	13.3	4.6	2.1	**38.9**
Spillover electricity savings for other in-campaign LED purchases	n/a	n/a	2.5	5.3	5.8	**13.6**
Spillover electricity savings for out-of-campaign LED purchases	4.7	5.4	1.4	0.9	1.8	**14.1**
Total Net Energy Savings (GWh/year)	**10.4**	**18.6**	**17.2**	**10.8**	**9.7**	**66.6**

Figures may not sum exactly to the total due to rounding.

Summary of Reported and Evaluated Net Energy and Peak Demand Savings – Reported and evaluated energy savings, as well as peak demand savings for the Retail Program lighting offer are shown in Table 4.8 for the period from fiscal 2015Q2 to fiscal 2019. Net peak demand savings were estimated from the net energy savings using a peak to energy ratio of 0.31 MW/GWh corresponding to a residential lighting load shape.

Table 4.8 Summary of reported and evaluated net energy and peak demand savings Fiscal 2015 to Fiscal 2019

	Energy Savings (GWh/year)		Peak Demand Savings (MW)	
	Reported	Evaluated Net Energy Savings	Reported	Evaluated Peak Demand Savings
F2015(Q2-Q4)	7.4	10.4	2.3	3.2
F2016	13.3	18.6	4.1	5.8
F2017	18.3	17.2	5.7	5.3
F2018	7.2	10.8	2.2	3.3
F2019	3.2	9.7	1.0	3.0
Total	**49.3**	**66.6**	**15.3**	**20.6**

4.4 Findings and Recommendations

Findings

Market Trends

1. In the later portion of this evaluation period, LED bulbs ascended from third to first position in terms of the most widely installed type of bulb in BC Hydro service territory homes.

Retail Partner Opinions and Experience

2. Retail partners assessed BC Hydro's lighting campaigns as influential in terms of helping their organization to promote and sell Energy Star LED bulbs during the campaign periods. While there were other facets of the partnership, they viewed the provision of financial incentives as the most valuable.

Gross Energy Savings

3. Gross unit energy savings per bulbs were based on the wattage difference between the efficient LED bulbs discounted by the program and the baseline bulbs multiplied by hours of use. The evaluated gross unit savings were smaller than the program assumption mainly due to the lower wattage assumed for the baseline bulbs.
4. The evaluated gross energy savings of the program rebated sales were affected by the lower per bulb gross unit energy savings, which negatively impacted the program direct energy savings.

Net Energy and Peak Demand Savings

5. The total annual energy savings over the five-year evaluation period were estimated to be 66.6 GWh/year. This was comprised of some 38.9 GWh/year of direct savings, 13.6 GWh/year of in-campaign spillover savings and 14.1 GWh/year of out-of-campaign spillover savings.
6. Total net savings measured highest in fiscal 2016 and fiscal 2017 – primarily due to having more campaigns and comparably longer campaigns. The total sales volumes of discounted LEDs, therefore, were higher.
7. Program attribution around the purchase of discounted LEDs measured evenly at about 0.50 through the first four years of the evaluation. The estimate decreased to 0.38 in fiscal 2019.

Recommendations

The following recommendations flow from the findings of this evaluation. Recommendations No. 1 and No. 2 are for program management and Recommendation No. 3 is for Evaluation.

1. Program to update reported savings to better reflect savings from market effects.
2. Program to update reported savings assumptions, including free ridership and unit energy savings, for the remaining unevaluated years of the lighting rebate offer.
3. In view of the program transition underway because of the transformation of the lighting market, Evaluation to work in concert with program administrators to develop, as early as possible, a plan for the next evaluation of the Retail program.

Rebates for LED bulbs will no longer be offered as part of the Residential Retail program. The findings from this evaluation supports the decision that has been made to discontinue discounts for LED light bulbs in the near future due to transformation of this product market. Therefore, there are no further recommendations.

4.5 Conclusions

The net evaluated energy and peak demand savings for the Retail Lighting Program from fiscal 2015 through to fiscal 2019 were 66.6 GWh/year and 20.6 MW, respectively. A considerable amount of the savings was from spillover as there has been substantial transformation of the LED market.

5.0 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 behaviour.

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.

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

Evaluated Savings: Savings estimates reported after the energy efficiency activities have been implemented and an impact evaluation has been completed.

Free Riders: Free riders are program participants who would have taken the demand-side management (**DSM**) action, even in the absence of the DSM program. 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 Effects: Market effects refer to a change in the structure or functioning of a market or the behaviour of participants in a market that result from one or more program efforts. Typically, these efforts are designed to increase the adoption of energy-efficient products, services, or practices and are causally related to market interventions. Market effects may include participant and non-participant spillover and market transformation

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 demand-side management (**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 M&V 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 M&V 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 M&V results, as well as, a forecast net-to-gross ratio applied.

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.

Tag-on savings: A form of spillover savings resulting from project work done above and beyond a project’s original contract scope, which are identified and reported by DSM programs during a post-implementation review.