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January 15, 2025

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

Dear Patrick 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
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 F2024 Demand Side Management Milestone Evaluation Summary Report dated January 2025.

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 F2024 Demand Side Management Milestone Evaluation Summary Report summarizes the evaluations completed during fiscal 2024 for the following:

1. Home Renovation Rebate: F2019 (Q3) to F2022.
2. Low Income Program: F2017 to F2022.
3. Small Battery Chargers Regulation: F2016 to F2022.

For further information, please contact Alicia Henderson at bchydroregulatorygroup@bchydro.com.

Yours sincerely,

Chris Sandve
Chief Regulatory Officer

sg/rh

Enclosure

Demand Side Management Milestone Evaluation Summary Report F2024

January 2025

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1 Introduction

This report summarizes the milestone evaluations of demand-side management (**DSM**) initiatives completed by BC Hydro in fiscal year 2024 (**F2024**). 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:

1. Objectivity and Neutrality: Evaluations are to be objective and neutral.
2. Professional Standards: Evaluation work is guided by industry standards and protocols.
3. Qualified Practitioners: BC Hydro employs qualified staff and consultants to conduct evaluations.
4. Appropriate Coverage: BC Hydro strives to achieve defined coverage levels for its evaluation of DSM initiatives.
5. Business Integration: The evaluation function is integrated into BC Hydro's DSM business process of planning, implementation, reporting and evaluation.
6. 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:

1. Home Renovation Rebate: F2019 (Q3) to F2022.
2. Low Income Program: F2017 to F2022.
3. Small Battery Chargers Regulation: F2016 to F2022.

2 Home Renovation Rebate Program: F2019 (Q3) to F2022

2.1 Introduction

The Home Renovation Rebate (**HRR**) program is a partnership between BC Hydro and FortisBC. The goal of the program is to help residential homeowners to reduce their energy use by providing rebates on a variety of home energy upgrades such as insulation, windows and doors, hot water and space heating systems. A bonus offer also encourages customers to install multiple eligible upgrades. Which utility provides a rebate depends on whether the upgrade results in electricity or gas savings. In 2018, the Government of B.C. introduced CleanBC Better Homes Rebates which are aimed at helping households primarily heated by fossil fuels to reduce greenhouse gas emissions by switching from fossil fuels to electricity for space and water heating. BC Hydro and FortisBC administer the CleanBC Better Homes rebates on behalf of the Government of B.C. using the existing HRR infrastructure. In addition to rebates, a key focus of these programs is to work together to transform the home renovation market through contractor engagement and training, and customer awareness and education.

Eligible dwellings for the BC Hydro program included single family detached homes, duplexes, townhouses or row houses, and mobile homes on a permanent foundation, with the requirement that they used electricity as their primary energy source for space heating and/or water heating. The evaluation covered the period from October 1, 2018 to March 31, 2022 (Fiscal 2019, third quarter to the end of Fiscal 2022), and only includes upgrades that received rebates under the BC Hydro program. Upgrades that received rebates through CleanBC or FortisBC are not included in this evaluation.

2.2 Approach

Table 2-1 below provides the evaluation objectives, related research questions, data sources, and methods for this evaluation.

Table 2-1 Evaluation Objectives and Research Questions

Evaluation Objectives	Data	Method
Objective 1: Profile program participants		
How many customer households participated in the program? What was the uptake for the different rebate activities? What were participants' characteristics as compared to program-eligible households (region, dwelling, demographic characteristics, etc.)? For what reasons did customer households participate in the program?	▪ Program administrative data ▪ 2021 & 2022 HRR/CleanBC Better Homes Participant and Non-participant Surveys ▪ 2020 Residential End-Use Study (n=7,939)	▪ Frequencies; cross tabulations

Evaluation Objectives	Data	Method
Objective 2: Examine participant experience with the program and program outcomes		
How did participants become aware of the program? What were participants' opinions of various facets of the program (i.e., rebates, contractors, processes, etc.)? What were the various outcomes of participating in the program (i.e., lower energy bills, more comfortable homes, etc.)?	▪ 2021 & 2022 HRR/CleanBC Better Homes Participant and Non-participant Surveys	▪ Frequencies; cross tabulations
Objective 3: Measure non-participant awareness of the program and any home upgrades they completed		
To what extent were program-eligible non-participants aware of the program? To what extent did program-eligible non-participants complete their own upgrade activities? For what reasons did some of these households not participate in the program?	▪ 2021 & 2022 HRR/CleanBC Better Homes Participant and Non-participant Surveys ▪ 2020 Residential End-Use Study (n=7,939)	▪ Frequencies; cross tabulations; extrapolation
Objective 4: Estimate gross electricity savings and peak demand impacts for home energy upgrades		
What were the annual gross electrical energy savings of each program upgrade? What were the seasonal (summer, winter) electricity impacts of heat pumps? What were the gross peak demand impacts of each program upgrade?	▪ Program administrative data ▪ BC Hydro billing system data ▪ BC Assessment property data ▪ Weather data	▪ Quasi-experimental design with a matched comparison group of non-participants ▪ Difference-in-differences billing analysis ▪ Peak hourly load-shape analysis
Objective 5: Estimate free ridership and spillover for home energy upgrades		
How much free ridership was associated with each type of upgrade implemented? To what extent did participants complete other upgrade activities without a rebate? What were the electricity savings from unrebated upgrades (spillover for participants and non-participants)?	▪ 2021 & 2022 HRR/CleanBC Better Homes Participant and Non-participant Surveys	▪ Frequencies; cross tabulations; extrapolation ▪ Free ridership and spillover algorithms ▪ Engineering equations
Objective 6: Estimate net electricity savings and peak demand impacts for the program		
What were the net electrical energy savings and peak demand impacts resulting from the program overall?	▪ Results from Objective 4 ▪ Results from Objective 5	▪ Net-to-gross adjustment for "direct" savings from rebated upgrades, summed with net "indirect" savings from unrebated upgrades among participants and non-participants

2.3 Results

Objective 1: Profile Program Participants

Number of Participants – A total of 13,677 households in British Columbia participated in the HRR Program in F2019 Q3 through to F2022. The overwhelming majority of program uptake was tied to heat pump installations as a total of 8,879 households – 65% of the participants – installed at least one with a rebate during the evaluation period. In second position, a total of 3,513 households (26%) completed insulation upgrades through the program, while further behind 1,681 households (12%) completed window/door upgrades and 305 (2%) completed heat pump water heater installations.

The counts of the four types of renovation activities were disaggregated into five mutually exclusive groups of participants to facilitate billing analysis: four groups – comprising 95% of all participants – who completed just one type of upgrade, and one group of 5% that completed multiple upgrades.

Region, Housing Type and Demographic Profile of Program Participants – At 79%, the majority of program participants resided on Vancouver Island – some 40 points higher than the region's estimated share of all program-eligible households. The second largest segment of program participants were in the Lower Mainland. At just 14%, however, this region's share of all participants measured 24 points lower than its share of all program-eligible households. A total of 6% of the program participants were located in the Southern Interior while only 1% were located in the North – each much lower than their share of program-eligible households.

Demographically, the HRR program was over-represented by individuals at least 65 years old, as well as those who had earned university degrees. The income distribution of program participants skewed somewhat higher than the distribution among all program-eligible households in the population.

Main Reasons for Making the Upgrade – With a 42% to 60% share of the mentions, the main reason for having completed any of the four upgrades was *"to save on home energy costs"*.

Objective 2: Examine Participant Experience with the Program and Program Outcomes

Source of Awareness of the HRR Program – Participants reported first becoming aware of the HRR program in many different ways, but two emerged with about one-half of the total mentions. A total of 29% of participants learned about it from their *"contractor/installer"*, while 25% learned about it via *"word-of-mouth"* such as from family members, friends or colleagues.

Perceptions and Views toward the Contractors – The majority of participants – eight in 10 – reported that their contractor/installer was aware of the HRR program when they hired them. Among these households, 83% went on to say that they *"viewed or experienced the contractor as an extension or ambassador of the program"*. Most others with an opinion were more likely to report that their contractor was seemingly *"indifferent about the program"* rather than to report that they tried to *"discourage my household from participating"* in it.

Nearly all participants – 94% – were satisfied with the *"quality of work by the contractor(s) hired to make the upgrade installation(s)"*. Furthermore, this top-two box score is comprised of some 80% of households who were "very satisfied" with the quality of the work – the firmest opinion of all the attitudinal dimensions explored in this evaluation.

Attitudes and Satisfaction towards the Program – The majority of program participants reported high satisfaction levels and positive attitudes associated with the program's elements and outcomes. As such, the overwhelming majority of them – 91% – were satisfied with the program overall. Their favourable sentiment is underscored by the finding that 56% of them were "very satisfied". Some 95% of participants agreed that they *"would recommend the program to other households thinking about beginning home renovation upgrades".*

Objective 3: Measure Non-Participant Awareness of the Program and Any Home Upgrades they Completed

Non-Participant Awareness and Experience with the Home Renovation Rebate Program – Based on the dwelling type and space heating and water heating fuel eligibility requirements, it was estimated that 630,000 households in British Columbia were potentially eligible to participate in the HRR program during the evaluation period. Among these program-eligible non-participants, a net total of 61% of them reported having been previously aware of the program on an aided basis[1]. This level of awareness is largely comprised of some 43% of households that reportedly had *"only heard of the program and knew it was about offering rebates for home energy efficiency upgrades".*

However, a total of 7% of non-participants revealed that they "knew of the program and got upgrade ideas and/or learned about home energy efficiency from it, but never intended to participate in it". Further along the continuum, an additional 10% said that they "knew of the program and intended to participate in it, but never completed the process of applying for a rebate". In the event that they completed home renovation activities during the evaluation period and subject to their responses to extensive lines of questions about such activities, these two groups of households – 18% in total – were candidates for possible spillover electricity savings attributable to the HRR program.

Upgrades made among Program-Eligible Non-participants – Program-eligible non-participants were queried about any home renovation upgrades and installations they had completed over the 3 ½ years covered in this evaluation. This investigation included the four program-eligible types of upgrades, and additionally draftproofing, in pursuit of estimating the electricity savings from upgrades that could be attributable to the program.

Reasons for Not Participating in Any Home Energy Efficiency Programs – No one particular mention dominated the list of the reasons why households did not apply to receive a rebate from any of the four types of upgrades covered by home energy efficiency programs in the province. However, two main reasons did emerge with comparably greater frequency than others: 1) believing that *"it was too much hassle or too complicated to apply for a rebate" and 2) "not knowing of home energy efficiency programs at the time the renovation activities were conducted".*

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[1] When measuring program awareness on an aided basis, survey respondents were given the program name and a brief description to assist (aid) them in their recollection of it in view of mitigating potential confusion with other programs and soliciting an unconfounded response.

Objective 4: Estimate Gross Electricity Savings and Peak Demand Impacts for Home Energy Upgrades

Per household annual electricity savings attributable to the Home Renovation Rebate Program participants were estimated via a billing analysis. A quasi-experimental design with a well-matched, non-participant comparison group provided sufficient sample for the analysis. Notably, the result of the billing analysis was considered as gross savings due to not fully controlling for participant free ridership.

Table 2-2 on the next page details the average annual electricity savings per household for the five mutually exclusive groups. Households that installed heat pump water heaters or heat pumps achieved the highest savings (at 1,456 kWh and 1,301 kWh per year, respectively). Building envelope upgrades achieved about half the amount of savings as heat pumps: 697 kWh per year for insulation and 558 kWh per year for windows and doors. Households where multiple upgrades were completed saved 1,783 kWh per year per household on average.

Table 2-2 Annual Electricity Savings per Household by Upgrade Category

Number of Upgrades	Participant Group	Sample Size	Annual Electricity Savings (kWh/year/unit)		
			Mean	Lower CL	Upper CL
Single upgrade	Heat Pump participants	6,202	1,301	1,218	1,384
	Heat pump water heater participants	160	1,456	973	1,939
	Insulation participants	1,732	697	569	825
	Windows/doors participants	974	558	390	726
Multiple upgrades*	Multi-Upgrade participants	461	1,783	1,419	2,144

Note: Lower CL and Upper CL are confidence limits representing the 90% confidence interval of the mean.

* The results shown here for multiple upgrades are a weighted average of results obtained for different combinations of upgrades.

Among households that completed only heat pump upgrades, 15% installed central ducted heat pumps and achieved the highest unit savings at 2,232 kWh per year. This was followed by 48% single-head ductless and 37% multi-head ductless heat pump upgrades which saved 1,177 kWh and 1,080 kWh per year respectively.

A breakdown of heat pump savings by secondary space heating fuels showed that 39% of homes kept their electric baseboards as a backup heating system. This group saved 1,492 kWh per year per household. Just over one-quarter of homes had no backup heating fuels and achieved savings of 1,815 kWh per year per household. The highest savings were from households with an electric furnace backup system (5% of homes), which saved 2,477 kWh per year per household. The lowest savings were realized by the 28% of households that used fossil fuel fireplaces (10%) or wood (18%) as their backup system. They saved 584 kWh and 233 kWh per year per household, respectively.

For households that had completed only insulation upgrades, 89% had installed insulation in only one location covering an average area of 1,057 square feet. Participants who added insulation at multiple locations, covering an average installed area of 1,661 square feet, achieved close to double the annual unit savings compared to single location upgrades – 1,208 kWh per year per household as compared to

635 kWh per year per household annually. The findings showed that insulation savings were strongly correlated to the total installed square footage rather than the location of the insulation.

The demand impact analysis studied both winter and summer[2] peak demand impacts using average weekday load shapes and focusing on the period between 5 p.m. and 7 p.m. It was derived from the actual metered hourly interval consumption of the participant group and the paired non-participant comparison group.

Table 2-3 Average Weighted Unit Gross Demand Impacts on a Typical Winter and Summer Day (kW)

Upgrade Type	Sample Size (homes)	Winter Peak Demand Savings (kW/home)	Summer Peak Demand Savings (kW/home)
Heat pump	5,994	0.42	-0.07
Heat pump water heater	153	0.41	0.19
Insulation	1,727	0.02	-0.01
Windows/doors	942	0.20	0.04

Total gross electricity and demand impacts were calculated using participant counts per year multiplied by unit electricity and demand impacts.

Table 2-4 Total Gross Energy Savings by Upgrade Type (F2019Q3 – F2022)

Upgrade Status	Participant Group	Electricity Energy Savings by Fiscal Year (GWh/year)				
		F2019 (Q3-Q4)	F2020	F2021	F2022	Total
Single upgrade	Heat pump participants	0.9	2.8	2.9	4.8	11.4
	Heat pump water heater participants	0.0	0.1	0.1	0.2	0.4
	Insulation participants	0.3	0.7	0.6	0.8	2.4
	Windows/doors participants	0.0	0.1	0.4	0.4	0.9
Multiple upgrades	Multi-upgrade participants	0.0	0.1	0.1	0.3	0.5
Total (GWh/year)		**1.2**	**3.8**	**4.1**	**6.5**	**15.6**

The main contributor to total energy savings for the evaluation period were single heat pump upgrades at 11.4 GWh per year, followed by insulation upgrades at 2.4 GWh per year. Multi-upgrade households contributed to 0.5 GWh per year to program savings over the evaluation period. The total overall energy savings across the evaluation period were 15.6 GWh per year.

2 The analysis studied both winter and summer peak time demand impacts, since heat pumps can contribute to new electricity loads in the summer through space cooling. Summer impacts were analysed over 4 p.m. to 6 p.m. on weekdays in July and August.

Table 2-5 Total Gross Winter Peak Demand Savings (F2019Q3 – F2022)

Upgrade Status	Participant Group	Winter Peak Demand Savings by Fiscal Year (kW)				
		F2019 (Q3-Q4)	F2020	F2021	F2022	Total
Single upgrade	Heat pump	293	912	917	1,550	**3,673**
	Heat pump water heater	1	17	25	63	**106**
	Insulation	9	20	18	23	**70**
	Windows/doors	1	55	142	137	**335**
Multiple upgrades	Multi-upgrade participants	10	30	33	82	**155**
	Total	**314**	**1,034**	**1,136**	**1,855**	**4,338**

Heat pumps in the single upgrade group were the main contributor to peak demand savings, with savings of 3.7 MW over the evaluation period; the total peak demand savings were 4.3 MW.

Objective 5: Estimate Free Ridership and Spillover for Home Energy Upgrades

Summary of Free Ridership and Attribution Scores for Rebated Upgrades – The estimate of free ridership was calculated via survey research at the measure level for each of the four main types of upgrades that participants completed with rebates via the program. For clarity, the mean free rider score for each upgrade is the estimated portion of gross electricity savings that still would have occurred had the program not existed.

Table 2-6 Summary of Free Ridership and Attribution Scores for Rebated Upgrades

	Participant Group and the Rebated Upgrade Activity				
	Heat Pump Participants	Insulation Participants	Windows/ Doors Participants	Heat Pump Water Heater Participants	Multi-Upgrade Participants
Free ridership	0.33	0.36	0.42	0.13	0.35
Attribution (program influence: 1 – free ridership)	0.67	0.64	0.58	0.87	0.65

The free rider scores for heat pumps and insulation were similar at 0.33 and 0.36, respectively. The score for windows/doors was somewhat higher at 0.42, but much lower for heat pump water heaters at 0.13. Free ridership for the multi-upgrade group was 0.35. It is the average free rider score from the other four upgrades, weighted by the count of each of these upgrades completed by this multi-upgrade group.

Net Indirect Spillover Electricity Savings from Unrebated Upgrades among Program Participants – Similar to the approach taken for the billing analysis, the spillover electricity savings were estimated for each of the five mutually exclusive groups of program participants – the four groups who completed single upgrades with rebates, as well as the fifth group who completed multiple upgrades with rebates. Within each of these five groups of participants, spillover savings were estimated for each of the five upgrade activities explored – the four types offered in the program, as well as draftproofing. These savings were calculated by leveraging survey research and engineering estimates – including derived program attribution scores – and then aggregated for a group total and ultimately a grand total. Program participants produced an estimated 2.6 GWh/year of spillover electricity savings, including 0.9 GWh/year of net spillover electricity savings attributable to the HRR program.

Net Indirect Spillover Electricity Savings from Upgrades among Program-Eligible Non-Participants – Similar to the approach taken to estimate participant spillover electricity savings, non-participant spillover was estimated for each one of the five types of upgrades investigated in this evaluation and then summed in total. This was done by first estimating the number of non-participating households who completed upgrades eligible for HRR program attribution, and then using engineering estimates along with derived program attribution scores to estimate savings. Non-participant households produced an estimated 33.5 GWh/year of electricity savings, including a net total of 6.2 GWh/year attributable to the program.

Objective 6: Estimate Net Electricity Savings and Peak Demand Impacts

Net Direct Electricity Savings for Program Participants – Through additional analysis facilitated by the survey research, it was concluded that the billing analysis yielded electricity savings estimates for each group of program participants that are considered to be close to gross savings. Additionally, these savings are believed to include savings from any home energy efficiency activities that they completed on their own without program assistance. Therefore, several adjustments – one of which was accounting for program attribution – were required to transform these gross “direct” and “indirect” electricity savings to net “direct” electricity savings strictly pertaining to the rebated upgrades.

For heat pump participants as one example, the estimated gross electricity savings from the billing analysis measured 11.4 GWh/year. After the adjustments, the net “direct” electricity savings strictly tied to their installation through the program were estimated to be 7.5 GWh/year.

For all five participants groups, their rebated upgrades were estimated to have yielded net direct electricity savings of 9.7 GWh/year.

Table 2-7 Net Direct Electricity Savings for Program Participants and their Rebated Upgrades

	Participant Group / Rebated Upgrade Activity					
	Heat Pump Participants	Insulation Participants	Windows/ Doors Participants	Heat Pump Water Heater Participants	Multi-Upgrade Participants	Total
Total gross electricity savings (GWh/year)	11.4	2.4	0.9	0.4	0.5	15.6
Adjustments	⇓	⇓	⇓	⇓	⇓	⇓
Net direct electricity savings (GWh/year)	**7.5**	**1.3**	**0.4**	**0.3**	**0.2**	**9.7**

Total Net Direct and Indirect Electricity Savings – Table 2-8 brings together the three streams of electricity savings arising from the upgrade activities completed by participants and non-participants. This includes the “direct” savings from participants’ rebated installations, and the “indirect” savings from all the upgrades that they, along with non-participants, made without program assistance.

Table 2-8 Total Net Direct and Indirect Electricity Savings (F2019Q3 – F2022)

			Total Electricity Savings	Gross Program Electricity Savings	Net Program Electricity Savings
Program Participants					
	(i)	Total direct electricity savings (GWh/year)	13.0*	13.0*	9.7
+	(ii)	Total indirect electricity savings (GWh/year)	2.6	n/a	0.9
=		Sub-total direct and indirect electricity savings	15.6	n/a	10.6
Program-Eligible Non-Participants					
+	(iii	Total indirect electricity savings (GWh/year)	33.5	n/a	6.2
Total Program Participants and Program-Eligible Non-Participants					
=		**Total direct and indirect electricity savings (GWh/year)**	**49.1**	**13.0**	**16.8**

* These are the same electricity savings shown in the two savings contexts.

For all participants and program-eligible non-participants in the province, their home energy efficiency upgrades completed during the evaluation period produced an estimated 49.1 GWh/year of electricity savings. These upgrades yielded an estimated 16.8 GWh/year of net electricity savings attributable to the HRR program.

Total Net Winter Peak Demand Electricity Savings – The program is estimated to have saved 4.2 MW of winter peak demand, much of it (3.2 MW, 76%) due to heat pump installations.

Summary of Reported and Evaluated Net Energy and Demand Savings – The total annual electricity savings for the Home Renovation Rebate Program for the evaluation period were estimated to be 16.8 GWh/year, whereas the reported savings were 29.6 GWh/year. The primary reason for this is the evaluated unit energy savings being lower than expected for most upgrade types.

Table 2-9 Summary of Reported and Evaluated Net Energy and Demand Savings (F2019Q3 – F2022)

	Net Energy Savings (GWh/year)		Net Demand Savings (MW)	
Fiscal year	**Reported**	**Evaluated**	**Reported**	**Evaluated**
Total	29.6	16.8	5.6	4.2

2.4 Findings and Recommendations

Findings

Participant Profile

1. A total of 13,677 households in British Columbia participated in the HRR program during the study period, from October 1, 2018 to March 31, 2022.
2. At 79%, the majority of program participants resided on Vancouver Island – some 40 points higher than the region's estimated share of all program-eligible households. The second largest segment of program participants were in the Lower Mainland. At just 14%, however, this region's share of all participants measured 24 points lower than its share of all program-eligible households.

3. A total of 6% of the program participants were located in the Southern Interior while only 1% were located in the North – each much lower than their share of program-eligible households.
4. Very similar to the region's share of all program participants, the majority of households that received rebates for new heat pump installations – 84% – resided on Vancouver Island.
5. Single detached houses and duplexes had a commanding 87% share of all program participants – 15 points higher than their estimated 72% level among all households eligible to participate in the program. Possibly related, the income distribution of program participants skewed higher than the distribution among all program-eligible households in the eligible population.
6. Nearly all program participants in the evaluation period – 95% – completed just one upgrade activity for which they received a rebate.
7. Program uptake was largely tied to heat pump installations, followed far behind by insulation upgrades.
    - In regards to heat pumps, a total of 8,879 households – 65% of the participants – installed at least one with an HRR rebate. The most frequently given main reason for having switched the main heating system to a heat pump was *"to save on home energy costs"* followed by the *"desire to obtain air conditioning"*.
    - A total of 3,513 households (26%) upgraded their insulation with a rebate. Most did so to mainly *"to save on home energy costs"* and *"to make my home more comfortable"*.
    - At 1,681 (12%) and 305 (2%), substantially fewer households completed window/door or heat pump water heater upgrades via the program.
8. In addition to having received rebates for their specific upgrade activities, some HRR participants were eligible to receive additional rebates for installing multiple measures or during special promotions. A total of 2,049 households (15%) received the Double-the-Rebate incentive, while 733 of them (5%) received the Two Upgrade Bonus of $300.

Participant Experience and Outcomes

9. Participants reported first becoming aware of the HRR program in many different ways, but two had about one-half of the total mentions – 29% said from their *"contractor/installer"* and 25% said via *"word-of-mouth"* such as from family members, friends or colleagues.
10. Program participants opined very favourably upon all investigated facets of the program. Reflecting their very high satisfaction levels and positive attitudes associated with the program's elements and outcomes, a total of 91% of them were satisfied with the program overall, including some 56% who were "very satisfied".

Non-Participant Awareness of the Program and Home Upgrades they Completed

11. It is estimated that 630,000 households in the province were potentially eligible to participate in the HRR program had they completed any of the upgrades covered by the program.
12. Broad awareness of the program measured 61% among these program-eligible households on an aided basis. A total of 18% of them had reportedly learned at least a little about home energy efficiency from the program to the extent that they could have possibly been influenced by it in any of their own home upgrade activities.

13. While not a rebatable activity in the program, an estimated 187,740 non-participants (30%) in the province completed draftproofing measures during the evaluation period.
14. An estimated 90,090 non-participants (14%) completed window/door upgrades during this time, while 74,970 (12%) completed insulation upgrades. Far fewer program-eligible households installed heat pumps (30,870, 5%) or heat pump water heaters (9,450, 2%).

Free Ridership and Spillover for Home Energy Upgrades

15. The free rider scores for heat pumps and insulation were similar at 0.33 and 0.36, respectively. The score for windows/doors was somewhat higher at 0.42, but much lower for heat pump water heaters at 0.13.
    - For clarity, the mean free rider score for each upgrade is the estimated portion of gross electricity savings that still would have occurred had the HRR program not existed.
16. In addition to the net "direct" electricity savings arising from their rebated upgrades (detailed further below), program participants produced an estimated 0.9 GWh/year of "indirect" spillover electricity savings attributable to the program. These savings were largely tied to heat pump, window/door and draftproofing upgrades that they completed without program assistance.
17. The home energy efficiency activities completed by program-eligible non-participants yielded an estimated net total of 6.2 GWh/year of "indirect" spillover electricity savings.

Gross Electricity Savings

18. Heat pump participants each produced an estimated 1,301 kWh/year of gross electricity savings. These gross savings include some savings from their unrebated spillover activities.
    - Households who installed a central ducted heat pump system saved 2,232 kWh per year. Those who installed single and multi-head ductless heat pump systems saved 1,177 kWh per year and 1,080 per year, respectively, which was about half of central ducted heat pumps due to the likelihood that they only heated partial areas of the home.
    - For heat pump participants without back-up heating sources, their installations saved 1,815 kWh/year. However, for those who used wood or fossil fuel fireplaces as a back-up, the savings were substantially lower at 233 kWh/year and 584 kWh/year, respectively.
19. Insulation participants each produced an estimated 697 kWh/year of gross electricity savings, while window/door participants each produced 558 kWh/year of gross electricity savings.
    - The total installed square footage of insulation had a greater effect on energy savings per household rather than the location (i.e., attic, basement or exterior walls). Analysis showed that insulation installed in one area (635 kWh/year) only saved roughly half as much as insulation installed in multiple locations (1,208 kWh/year).
20. Heat pump water heater participants each produced an estimated 1,456 kWh/year of gross electricity savings – the highest among the single upgrade groups.
21. Multi-upgrade participants saved an estimated 1,783 kWh/year of gross electricity savings.

22. The gross demand savings of heat pump upgrades was estimated at 0.42 kW per unit during the winter peak period, using hourly interval data. Heat pump water heaters were found to have similar demand savings at 0.41 kW per unit.
23. The winter peak-to-energy ratio derived from unit energy savings and unit peak demand savings estimated using hourly data, was calculated as 0.32 MW/GWh for heat pump installations and 0.14 MW/GWh for other single upgrades combined.

Total Net Direct and Indirect Electricity and Peak Demand Savings

24. The net “direct” electricity savings arising from the rebated upgrades summed to 9.7 GWh/year.
    - Most of these electricity savings – 7.5 GWh/year, 77% – are tied to the heat pump installations that participants completed via the program with rebates.
25. The HRR program in F2019, Q3 through F2022 is estimated to have saved a grand total of 16.8 GWh/year of electricity. This includes the 9.7 GWh/year of net “direct” electricity savings from rebated upgrades, as well as the 0.9 GWh/year and 6.2 GWh/year of net “indirect” savings from the unrebated upgrades completed by participants and from program-eligible non-participants, respectively (as detailed earlier).
26. The net peak demand savings from the program were estimated at 4.2 MW.

Recommendations

The following recommendations flow from the findings of this evaluation.

The following five recommendations are for Product Management:

1. For heat pumps, revise the unit savings to align with the results of this evaluation.
2. With respect to insulation savings, consider reporting savings based on actual installed area and added insulation value instead of based on overall average savings per installation that embed assumptions about these factors.
3. Consider increasing and/or improving program messaging in the Lower Mainland since the program is greatly under-represented by a sizeable pool of eligible homes in the region.
4. Consider increasing the promotion of heat pump water heaters since they yield among the greatest of savings, yet there is limited adoption as they are still early in their life cycle.
5. In consultation with Evaluation, review and conduct a quality assessment of program participant administrative data to correct for anomalies in the data brought about by the use of multiple data entry/tracking systems as well as different data entry and parameter naming practices over the years. Consider developing and maintaining a data dictionary for consistency and quality control of program administrative data going forward.

The following recommendation is for Conservation Portfolio Management:

6. Consider applying peak-to-energy ratios estimated in this evaluation from actual savings load shapes for reporting peak-demand savings.

2.5 Conclusions

The net evaluated energy and peak demand savings for the Home Renovation Rebate program from the third quarter of F2019 to the end of F2022 were 16.8 GWh/year and 4.2 MW, respectively. Air-source heat pumps and insulation upgrades were the most prevalent measures implemented by program participants. Program reported energy and peak demand savings for the same period were 29.6 GWh/year and 5.6 MW, respectively.

3 Low Income Program Evaluation F2017 to F2022

3.1 Introduction

The Low-Income Program aims to help BC Hydro's lower income customers[3] to overcome barriers to improving the energy efficiency of their homes, particularly affordability. The program provides free energy efficiency products and conservation measures to income qualified households through Energy Saving Kits (ESK or kit) and the Energy Conservation Assistance Program (**ECAP**). The program is offered in collaboration with FortisBC (electricity and natural gas customers) and with Pacific Northern Gas for customers in their respective service territories.

ESK is a self-install offer that provides free efficient lighting, water saving, and draftproofing products, as well as general energy savings tips and brochures to income eligible households. The ECAP offer includes two streams: ECAP Basic and ECAP Advanced. ECAP Basic provides similar free products as ESK and, where needed, can provide a free refrigerator replacement, but the products are installed by a third-party contractor paid by BC Hydro. ECAP Advanced provides free insulation and weatherization upgrades as well as programmable thermostats installed by a contractor paid by BC Hydro. Modified versions of ECAP are also offered to specific groups: Apartment Direct Install is available to social housing providers and the Indigenous Communities Conservation Program (**ICCP**) is available to Indigenous communities. All of these offers are available to customers and communities located in integrated or non-integrated areas[4] of the BC Hydro service territory. Savings from participating households and communities located in integrated areas are reported under the Low-Income Program and savings for those located in non-integrated areas are reported under the NIA Program.

Providing low-income households access to free products not only improves energy efficiency in low income households, it also addresses the affordability barrier by making it possible to shift household spending away from energy through bill savings, thus increasing the amount of disposable income that can go towards other necessities. The program can also contribute to outcomes that are broader than energy savings such as increased comfort and health and safety.

This report presents the results of an impact evaluation of the BC Hydro Low Income Program covering fiscal years F2017 to F2022 (April 1, 2016 to March 31, 2022). The results do not include the savings for participants that came through the ICCP. These savings could not be evaluated using standard methods for impact evaluation due to small sample sizes, differences in program delivery, and differences in the housing situations between these communities and the Low-Income program participant population overall. These differences also make it inadvisable to generalize the results from the general customer population to households in Indigenous communities.

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3 For the timeframe of this evaluation BC Hydro defined low-income households on the basis of Statistics Canada's Low-Income Cut-Off (**LICO**) for the most recent year plus another 30%, which was consistent with the definition in the Demand-Side Measures Regulation over the time period of this evaluation.

4 Non-integrated areas are remote areas of the province not connected to the main electricity grid. BC Hydro provides electricity to customers in non-integrated areas through a combination of diesel generating stations owned and managed by BC Hydro and small hydro plants.

3.2 Approach

Table 3-1 below provides the evaluation objectives, related research questions, data sources and methods for this evaluation.

Table 3-1 Evaluation objectives and research questions, and Data Sources

Evaluation Objectives and Questions	Data Sources	Methods
Objective 1: Profile program participants		
How many customer households participated in the program? What program offer had the most uptake? What were participants' characteristics? What were program-eligible households' characteristics? For what reasons did customer households participate in the program?	▪ 2022 Low Income Participant Survey ▪ Account information ▪ 2020 Residential End Use Study	▪ Frequencies; cross tabulations
Objective 2: Assess participant experience with the program		
How did participants become aware of the Low-Income Program offers? How satisfied were participants with the measures provided and program delivery?	▪ 2022 Low Income Program Participant Survey	▪ Frequencies; cross tabulations
Objective 3: Assess participant experiences with the products and measures		
How many participants received a given product? Had participants ever purchased the product on their own? If not, what were the barriers? What were the installation rates of the various products?	▪ 2022 Low Income Program Participant Survey	▪ Frequencies; cross tabulations
Objective 4: Estimate free ridership and explore spillover for ESK, ECAP Basic and ECAP Advanced		
What was the probability that participants would have purchased a given product on their own? What was the item level free ridership for the products in ESK, ECAP Basic and ECAP Advanced? What was the overall free ridership for each of the ESK, ECAP Basic and ECAP Advanced offers? Did participants take additional energy savings actions as a result of participating in the program?	▪ 2022 Low Income Participant Survey	▪ Means, frequencies, cross tabulations and logic tree analysis
Objective 5: Estimate net electricity savings for the ESK, ECAP Basic, ECAP Advanced offers		
What were the per household and total net savings for ESK? What were the per household and total net savings for ECAP Basic? What were the per household and total net savings for ECAP Advanced?	▪ BC Hydro account data ▪ Program tracking data ▪ Weather data ▪ 2022 Low Income Program Participant Survey	▪ Quasi-experiment with variation in adoption ▪ Engineering estimates

Evaluation Objectives and Questions	Data Sources	Methods
Objective 6: Estimate net electricity savings for Apartment Direct Install		
What were the per housing unit and net electricity savings for Apartment Direct Install? What were the per unit and net savings for refrigerator replacements in social housing units?	▪ BC Hydro account data ▪ Program tracking data	▪ Engineering estimates
Objective 7: Estimate the total net electricity and peak demand savings for the Low-Income Program		
What were the total net electricity savings by fiscal year for the program? What were the total net peak demand savings by fiscal year for the program?	▪ Results from Objectives 4, 5 and 6 ▪ Peak-to-energy factors	▪ Key results ▪ Variance calculation

3.3 Results

Results from the various lines of evidence and analysis are presented for each evaluation objective.

Objective 1: Profile Program Participants

Population of Program Participants by Volume – A total of 85,521 unique households and housing providers participated in BC Hydro's Low-Income Program in the six years F2017 through F2022. The count of participants measured higher at 89,437 since some of them participated in more than one program offer and/or participated in more than one fiscal year. Note also that some of them represented more than one housing unit.

The ESK offer served as the foundation of the program with 77,027 households having received energy saving kits during the evaluation period. Nearly all ESK participants – 99% – were unaffiliated households, i.e., not affiliated to a housing provider, government, etc.

The ECAP Basic offer reached 11,081 participants, covering a total of 11,500 individual housing units. For ECAP Advanced, which features insulation and thermostat upgrades, the count was much smaller at 1,029 participants, covering 1,085 individual housing units. Most of the participants in these ECAP offers were non-profit and Indigenous housing providers – 60% in ECAP Basic and 81% in ECAP Advanced.

The Apartment DI offer was comprised of 300 building registrants during the six years of interest, covering 7,008 suites. By design, most Apartment Direct Install participants – 95% – were non-profit housing providers. The remaining 5% were Indigenous housing providers.

Program participation levels decreased markedly in F2021 due to the impact of the COVID-19 pandemic, but participation partially rebounded in F2022.

Profile of Program Participants – Similar to the eligible population of households and organizations, the majority of program participants – 57% – resided in the Lower Mainland. Others were split between Vancouver Island (20%), the Southern Interior (14%), and the North (9%) regions. Participant housing types varied significantly by the offers, but at the total rolled-up level, single detached houses represented the largest share of participants at 46%, followed by apartments at 23%.

Reasons for Participating in the Program – The single largest segment of households – and a majority at 53% – reported that they participated in the program first and foremost "to save on home energy costs".

The total proportion of those who did so for this reason increased to 84% in view of the 31% who pointed to this as one of their other reasons.

Objective 2: Participant Experience with the Program

The majority of program participants reported high satisfaction levels and positive attitudes associated with the program's elements and outcomes. The overwhelming majority – 92% – were satisfied with the program overall, including 60% of participants reporting to have been "very satisfied". Furthermore, 93% of participants reported that they "definitely would" or "probably would" recommend the Energy Saving Kit or the Energy Conservation Assistance Program to other households thinking about improving their home's energy efficiency.

Objective 3: Participant Experience with the Products and Measures

Installation Rates of Products Common to ESK and ECAP Basic – Survey research pertaining to the three fiscal years F2020 to F2022 revealed that 87% of all LED light bulbs given out by the program were installed – the highest of all items. This is a weighted composite based on the reported self-installation of LEDs among ESK participants and any LED installations carried out at the discretion of the contractors for ECAP participants as documented in the program tracking database.

A total of 59% of the water-saving tap aerators and 53% of the water-saving showerheads were installed. These installation rates climbed to 62% and 56%, respectively, specifically among homes that relied on electric water heating – the only scenario where their installations could yield electricity savings.

The installation rate measured at approximately 30% for window film and electrical outlet foam gasket sealers provided in the energy saving kits. The installation rate measured much lower in the ECAP offer for window film – 20% among homes that received window film as a "leave behind[5]" item, and just 7% among those that were electrically heated.

Objective 4: Estimate Free Ridership and Explore Participant Spillover

The method for estimating electricity savings for the ESK and ECAP Basic offers is designed to be net of free ridership, but it does not provide a direct estimate of the level of free ridership. Understanding this, additional research was undertaken in this evaluation to quantify free ridership for these program offers, as well as for ECAP Advanced, as this was of interest to program administrators. The values reported below are the estimated portion of gross electricity savings that would have resulted from some participants likely having purchased and installed some of the items on their own had the program not existed.

Free Ridership for ESK – Based on the survey research, the mean free rider score measured 0.18 for the ESK offer. This overall score – a weighted composite of the individual scores pertaining to the products in the kits – was largely driven by the LED bulbs because of their high score of 0.26 and their prominent share of products installed. Among the other products in the kits, free ridership for the water-saving tap aerators and water-saving showerheads measured much lower at 0.10 and 0.09, respectively.

Free Ridership for ECAP Basic – Free ridership measured 0.09 for the ECAP Basic offer overall. At the item level, the scores fell into a tight band from 0.07 to 0.11 for the same types of products offered through

5 A leave-behind item is when a contractor 'leaves-behind' an item for the household to install if they so choose.

ESK. Free ridership for the more substantial items measured just 0.02 for refrigerators, 0.01 for hot water pipe insulation and 0.00 for metal kerf draftproofing.

Free Ridership for ECAP Advanced – Free ridership measured 0.00 for the ECAP Advanced offer overall. This reflected individual free rider scores of 0.00 for insulation (including draftproofing) and 0.00 for programmable thermostats.

Free Ridership for Apartment DI – Free ridership was not estimated for Apartment DI because it was assumed to be negligible (essentially zero) in this population of not-for-profit social housing organizations and because of the difficulty in accessing the decision-making individuals among them.

Participant Spillover – For participants of the program, spillover electricity savings would likely have come from the installation of additional energy efficient measures, as well as behaviour change. Out of the desire to mitigate respondent burden and fatigue in the survey, the lines of questioning around spillover were limited. The research showed evidence of it, but savings estimates could not be ascertained.

Objective 5: Estimate Net Savings for ESK and ECAP

A statistical analysis of the ESK participant group for each fiscal year from F2017 to F2020 was conducted, against a comparison group composed of future program participants (variation in adoption approach). The weighted average unit savings for those years were found to be 143 kWh/year. Those unit savings were also credited to participants in F2021 and F2022, who were left out of the statistical analysis because there was no corresponding pool of future participants to match them with for comparison. Table 3-2 summarizes the results. The total net energy savings for ESK were evaluated at 11.0 GWh/year for the evaluation period.

Table 3-2 Participation and Net Savings Estimates for ESK (F2017–F2021)

	F2017	F2018	F2019	F2020	F2021	F2022	Total
Number of individual kits (participants)	9,848	13,227	16,530	16,011	13,155	8,027	76,798
Net unit electricity savings (kWh/year)	143						--
Total Net Electricity Savings (GWh/year)	1.4	1.9	2.4	2.3	1.9	1.1	11.0

A statistical analysis of ECAP Basic program participants from F2017 to F2020 was also conducted against a comparison group composed of future program participants, although in this case the participants were pooled for all fiscal years owing to the more limited data set. The average electricity savings per household were estimated at 374 kWh/year and applied to all participants. ECAP Basic participation and net electricity savings per year are presented in Table 3-3. The total evaluated net savings for ECAP Basic were evaluated at 4.3 GWh per year.

Table 3-3 Participation and Net Savings Estimates for ECAP Basic (F2017–F2021)

	F2017	F2018	F2019	F2020	F2021	F2022	Total
Number of individual housing units	1,585	2,219	2,151	2,537	1,139	1,868	11,499
Net unit electricity savings (kWh/year)	374						--
Total Net Electricity Savings (GWh/year)	0.6	0.8	0.8	0.9	0.4	0.7	4.3

Evaluated electricity savings for ECAP Advanced were quantified using engineering estimates. The total net electricity savings for ECAP Advanced was 2.3 GWh/year (1.3 GWh/year from insulation, 0.9 GWh/year from draftproofing, and 0.1 GWh/year from programmable thermostats).

Objective 6: Estimate Net Savings for Apartment Direct Install

For Apartment DI the net electricity savings per housing unit ranged from 254 kWh/year to 623 kWh/year as the quantity of refrigerators, as well as LEDs, varied significantly from year to year. The total net electricity savings from participants in all six fiscal years was estimated to be 2.3 GWh/year.

Objective 7: Total Net Electricity and Peak Demand Savings for the Low-Income Program

Total net electricity savings included in the reported and evaluated results consist of savings from ESK, ECAP Basic, ECAP Advanced and Apartment DI. Total evaluated net savings for the Low-Income Program in the period from F2017 to F2022 period were 19.9 GWh/year, compared to reported savings of 35.1 GWh/year. Total evaluated peak demand savings were 4.1 MW as compared to 7.2 MW based on the reported net savings. Table 3-4 summarizes the evaluated net run-rate electricity savings and the program's reported savings for each fiscal year from F2017 to F2022.

Table 3-4 Summary of Energy and Peak Demand Savings

Fiscal Year	Electricity Savings (GWh/year)		Peak Demand Savings (MW)	
	Reported	Evaluated Net	Reported	Evaluated Net
F2017	4.5	2.4	0.9	0.5
F2018	5.7	3.3	1.2	0.7
F2019	6.7	4.3	1.4	0.9
F2020	8.8	4.6	1.8	1.0
F2021	4.7	2.6	1.0	0.5
F2022	4.5	2.6	0.9	0.5
Total	**35.1**	**19.9**	**7.2**	**4.1**

Total evaluated electricity savings were 57% of the program reported savings. The lower-than-expected electricity savings are due to the difference between unit savings assumptions applied in the ESK and ECAP savings forecasts and the values found in the evaluation analysis.

3.4 Findings and Recommendations

Findings

The main findings of the evaluation are summarized below by key theme.

Participant Profile

1. A total of 89,437 housing units in British Columbia participated in BC Hydro's Low-Income Program in the six years covered by the evaluation, F2017 through F2022. Extensive data review and preparation activities were required to construct a database containing the full population of program participants.
2. The impact of the COVID-19 pandemic on the program is seen in the participation levels by fiscal year, having fallen sharply in F2021.
3. In terms of volume, the ESK offer served as the foundation of the program with some 77,027 households having requested and received energy saving kits during the evaluation period.
4. In the evaluation period, the ECAP Basic offer covered 11,081 individual housing units, while ECAP Advanced covered 1,029 individual housing units.
5. The Apartment DI offer was comprised of 300 building registrants during the six years of interest. The total number of apartment suites that received the contractor-installed upgrades measured 7,008 units.
6. Among ESK and ECAP Basic participants, the survey research revealed that 48% relied on electricity for their space heating and 43% relied on electricity for their water heating. This has implications for achievable energy savings since electricity savings from some program-installed products and measures can be realized only in scenarios where space heating or water heating rely on electricity.

Participant Experience with the Program

7. Program participants opined very favourably upon all investigated facets of the program. Reflecting their very high satisfaction levels and positive attitudes associated with the program's elements and outcomes, a total of 92% of them were satisfied with the program overall.
8. As further testament to their experience and satisfaction with the program, 93% of participants reported that they would recommend the Energy Saving Kit or the Energy Conservation Assistance Program to other households thinking about improving their home's efficiency.

Participant Experience with the Products and Measures

9. LED bulbs were the main component of the Low Income Program with 87% of units given out by the program having been installed by the ESK participants themselves or by the ECAP program contractors.

Free Ridership and Spillover

10. In the ESK offer, LED bulbs and window film had the highest mean free rider scores at 0.26 and 0.22, respectively. LED bulbs also had the highest installation rate of all products in the kit, at 86%. The lowest free rider score pertained to the foam gasket sealers at 0.08; these items also had the lowest installation rate, at 27%. The free rider score for the entire ESK offer measured 0.18.
11. In the ECAP Basic offer, most free rider scores ranged from 0.06 to 0.12. However, free ridership measured just 0.02 in regards to refrigerators, 0.01 in regards to hot water pipe insulation and 0.00 in regards to metal kerfs. The free rider score for the entire offer measured 0.09.

12. In the context of this program, these levels of free ridership are very low. By extension, the findings underscore the importance of the program in making energy efficient products and measures accessible to households that have limited financial means to purchase the items on their own if they want to lessen their energy bills.
13. Window film was provided as part of the energy saving kits and was sometimes left behind by the installers for ECAP Basic for households to install themselves. In the ESK offer, 31% of all individual window film packages were installed in electrically heated homes. The installation rate measured much lower in the ECAP offer with just 7% among those that were electrically heated.
14. In the ECAP Advanced offer, the free rider score measured 0.00 for insulation (including draftproofing) and programmable thermostats.
15. Free ridership was not estimated for Apartment Direct Install because it was assumed to be negligible (essentially zero) in this population of not-for-profit social housing organizations and because of the difficulty in accessing the decision-making individuals among them.

Net and Peak Demand Savings

16. On average, between F2017 and F2020, ESK participants were evaluated as saving 143 kWh per year per home with each kit installed. The average savings were applied to ESK recipients across all regions and building types to obtain the total run-rate electricity savings of 11.0 GWh per year.
17. On average, between F2017 and F2022, ECAP Basic participants saved 374 kWh per year per home. This average was applied to participants of ECAP Basic across all regions, building types, and housing provider type. The total run-rate electricity savings for ECAP Basic were 4.3 GWh per year.
18. From F2017 to F2022, ECAP Advanced electricity savings were evaluated at 1.3 GWh per year for insulation, 0.9 GWh per year for draftproofing and 0.1 GWh per year for programmable thermostats. In total, ECAP Advanced achieved run-rate electric savings of 2.3 GWh per year.
19. Unit electricity savings for Apartment DI were estimated to range from 254 kWh/year to 623 kWh/year as the quantity of refrigerators and LEDs varied significantly from year to year, based on engineering estimates. In total, Apartment Direct Install resulted in run-rate electric savings of 2.3 GWh per year.
20. The evaluated net electricity savings for the Low-Income Program were 19.9 GWh per year and the net peak demand savings were 4.1 MW.
21. The evaluated net savings were 57% of program reported savings. Efficiency improvement measures offered by the program have not achieved electricity savings projected by the program.

Recommendations

The following recommendations flow from the findings of this evaluation.

1. Considering discontinuing the package of outlet gaskets in the Energy Saving Kits due to the negligible savings and the low installation rate.
2. Window film had a low installation rate as a “leave-behind” item in ECAP Basic, particularly in electrically heated homes. Consider deleting it from ECAP Basic as a leave behind, particularly during out of season (non-heating) months.

3. Consider reviewing and adjusting unit savings estimates used to forecast savings, examining in particular the assumptions where values appear to be too high relative to the program evaluation results (both difference-in-differences statistical results and engineering estimates).
4. In consultation with Evaluation, review and conduct a quality assessment of program participant administrative data to correct for anomalies in the data brought about by the use of multiple data entry/tracking systems as well as different data entry and parameter naming practices over the years. Consider developing and maintaining a data dictionary for consistency and quality control of program administrative data going forward.
5. Going forward, the evaluation group should consider taking an alternative approach to evaluating DSM offers that are designed for specific equity groups, such as low income, Indigenous, and non-integrated communities, to capture outcomes that are broader than what is considered in a traditional impact evaluation (i.e., energy savings). This is especially relevant for these groups because the low savings yield and small participant count can make them difficult or impossible to assess through statistical analysis and because the intent of these programs is to provide benefits that can go well beyond energy savings (e.g., increased disposable income, increased comfort, improved health and safety).

3.5 Conclusions

Evaluated electricity savings were 19.9 GWh per year, 57% of reported savings for the F2017 to F2022 period, due mainly to the lower average unit savings than the program estimates. Participants also benefitted from the monetary savings from not having to buy or install the energy efficient products and measures, increasing their disposable income. Participants had high satisfaction with the Low-Income Program offers, although installation rates for a few of the products were low.

4 Small Battery Chargers Regulation: F2016 to F2022

4.1 Introduction

This market and impact evaluation examines sales and prevalence in relevant battery powered products in B.C. in the context of regulation introduced through the B.C. Energy Efficiency Act to regulate the efficiency of consumer battery charging systems. It also presents an estimate of gross electricity savings in BC Hydro's service territory associated with the changes in efficiency of small battery chargers over a seven-year period from F2016 to F2022.

The Government of B.C. started regulating small battery charging systems through the Energy Efficiency Act by enacting regulation effective June 1, 2015. The regulation applied to electronic systems manufactured or sold in B.C. that contained battery charging circuits with an input capacity of less than 2 kW. The regulation was aligned with those in California and Oregon at the time it was enacted. In June 2016, the US Department of Energy (**DOE**) published a final rule for battery charging systems (effective June 18, 2018) that superseded the efficiency requirements that were in place in California. Natural Resources Canada then proposed a battery charging system standard aligned with the U.S. DOE, referencing the new CAN/CSA 381.2-17 testing standard and the relevant US standard. The new Canadian Energy Efficiency Regulation came into effect on June 13, 2019 as part of Amendment 14 of the Federal Energy Efficiency Standards. In consideration of these developments, B.C. updated the efficiency requirements in the provincial regulation to align them with the US DOE, with an earlier effective date of June 12, 2018.

BC Hydro forecasts and reports gross electricity savings associated with energy efficient product regulations in its demand-side management plan. BC Hydro supports the development and introduction of energy efficient product standards and regulations by funding market and technical research. This evaluation does not attempt to determine the share of savings directly attributable to specific actions by BC Hydro and the changes in regulation.

4.2 Approach

The evaluation objectives and research questions are shown in Table 4-1 below. Given the anticipated difficulties associated with gathering data for all the product categories affected by the regulation, the evaluation scope was limited to a relevant subset of products for which data can be obtained. These are listed in Table 4-2 and cover 93% of the savings reported by BC Hydro in relation to this regulation. Savings for the remaining categories of products were deemed too small to evaluate in a cost-effective manner. Data sources and methods are listed in Table 4-3 on page 28.

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

Table 4-1 Evaluation Objectives and Research Questions

Evaluation Objective	Research Questions
1. Estimate current stock and annual sales of battery chargers	▪ How prevalent are battery powered products of different types in B.C.? ▪ What were the average annual sales of relevant battery powered products from F2016 to F2022?
2. Gross electrical energy and peak demand savings	▪ What were the gross electrical energy and peak demand savings due to changes in energy efficiency requirements in the battery charger stock in B.C. from F2016 to F2022?

Table 4-2 Categories/Items in Scope for the Evaluation

Categories/Items	
Electronics & Communication ▪ Laptop/notebook computers ▪ Cordless landline phones (bases)	**Auto/Marine/RV** ▪ Chargers for 12-Volt automotive batteries ▪ On-board battery systems for RVs, travel trailers and fifth wheels ▪ Boat/marine battery systems
Household Items/Tools ▪ Cordless vacuums (handheld, stick) ▪ Robot vacuums/floor sweepers ▪ Charging docks for hand-held power tools ▪ Charging docks for landscaping equipment ▪ Battery-powered cordless lawn mowers	**Personal Transportation** ▪ Electric bicycles (e-bikes) ▪ Electric scooters ▪ Electric hoverboards/electric unicycles ▪ Battery-powered ride-on toy vehicles ▪ Personal mobility carts/power wheelchairs ▪ Electric golf cart style vehicles
Emergency Systems ▪ Built-in central home security system ▪ Uninterruptible Power Supply Units (UPS)	

Table 4-3 Evaluation Objectives, Data and Methods

Evaluation Objectives	Data Sources	Method
1. Estimate current stock and annual sales of battery chargers	▪ Small Battery Charger Survey ▪ NPD (National Purchase Diary) sales data ▪ Residential End Use Surveys ▪ NRCan (Natural Resources Canada) 2016 Battery Chargers Market Study ▪ US DOE SNOPR (Department of Energy Supplemental Notice of Proposed Rulemaking) National Impact Analysis Workbook	Cross tabulations
2. Gross electrical energy and peak demand savings	▪ Small Battery Charger Survey (duty cycle questions) ▪ Pacific Gas and Electric Company (**PG&E**) Codes and Standards Enhancement (**CASE**) Initiative Report ▪ CEC (California Energy Commission) Staff Report ▪ CEC Compliant Product Database ▪ NRCan Compliant Product Database ▪ CPUC (California Public Utilities Commission): California Statewide Codes and Standards Program Impact Evaluation Report for program years 2013 through 2015 ▪ BC Hydro Power Quality Study for battery-powered golf carts	Engineering algorithm

Objective 1 involved a quantitative analysis of survey results to examine the prevalence of different types of battery powered devices in B.C. and the average annual sales of relevant battery powered products. Sales data for a limited number of battery powered products in scope for the evaluation was obtained from a third-party aggregator.

For Objective 2, evaluated gross savings were estimated by multiplying the total number of sales that contributed to savings by estimated annual unit energy savings and compliance rates, and adjusting that total for cross effects. Savings were estimated in each of the typical modes of operation of battery chargers, including charge mode (when a battery is being charged), maintenance mode (when a battery is fully charged but still connected to a battery charger), and standby mode (when a battery charger is still connected to a power source but no battery is connected to it).

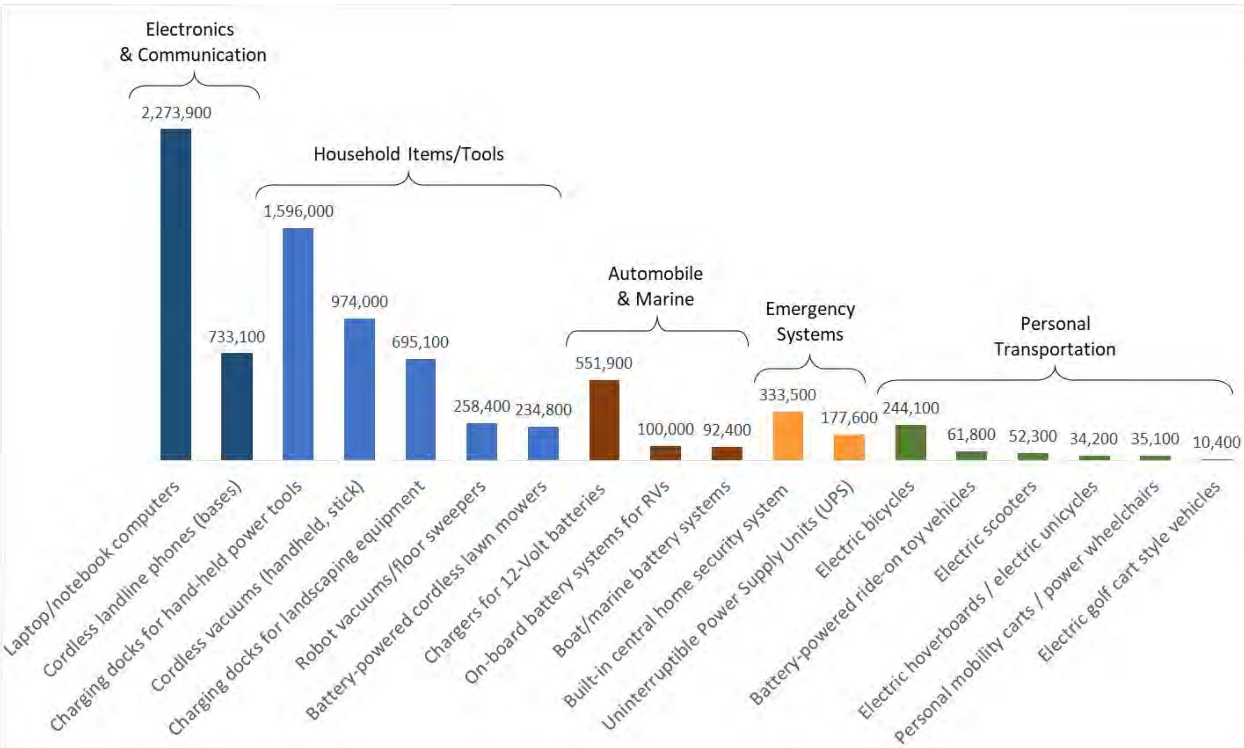
4.3 Results

Objective 1: Estimate current stock and annual sales of battery chargers

Residential ownership of the items covered in this evaluation was estimated based on a combination of survey data and sales data for the few items where sales data was available. Ownership was highest for laptops, with 85% of households owning at least one, followed by charging docks for hand-held power tools at 60% and cordless vacuums at 47%. Ownership of personal transportation items was generally the lowest of all items, with ownership of personal mobility carts/wheelchairs and golf carts having particularly low incidence at only 1%.

Residential sales of battery-powered items that had been purchased within the evaluation period are shown in Figure 4-1 below. Similar to the patterns for ownership, laptops had the highest total sales at 2.3 million, followed by charging docks for hand-held power tools at 1.6 million and cordless vacuums at 1.0 million. Items for personal transportation such as electric bicycles, scooters and hoverboards/unicycles, which are newer in the market, had among the lowest sales volumes, as did personal mobility carts/wheelchairs and golf carts, which had the lowest sales.

Figure 4-1 Estimated Total Sales of Battery-Powered Items Purchased between F2016 and F2022 (Residential)



Commercial sales volumes were also estimated for the F2016 to F2022 evaluation period. Laptops had the highest sales volumes at 1.3 million, followed by hand-held power tools at 470,000 and landscaping equipment at 205,000. Golf carts for commercial use had the lowest sales levels at 13,000.

Objective 2: Gross electrical energy and peak demand savings

The evaluated gross energy savings from F2016 to F2022 were 130.0 GWh per year, or 56.1 GWh per year lower than the reported gross savings of 186.1 GWh per year, as shown in Table 4-4 below. The average peak-to-energy factor of 0.205 MW per GWh for the residential rate class and 0.143 MW per GWh for the commercial rate class were applied to the gross savings to estimate peak capacity savings. The evaluated peak capacity savings were 25.3 MW, or 10.9 MW lower than the reported gross peak capacity savings of 36.2 MW.

Overall, the results show that energy savings in maintenance mode accounted for 46% of the total evaluated savings, followed by charge mode at 38% and standby mode at 16%.

The variance between evaluated and reported savings is due to a combination of factors. Larger than forecasted sales contributed to an upward adjustment in savings of 195% (363.5 GWh/yr); however, this was offset by a downward adjustment in savings of 221% (417 GWh/yr) resulting from lower evaluated unit energy savings than had been forecasted. A contributing factor to the lower evaluated unit energy savings was that several categories of devices were found to be turned off or unplugged, and thus consuming no power at all, for a greater share of the time compared to the assumptions used for reported savings, meaning that they spent less time than expected in maintenance and standby mode where much of the savings can be realized. Compliance rate and cross effects adjustments resulted only in a minor change to reported savings.

Table 4-4 Summary of Gross Reported and Evaluated Energy and Peak Capacity Savings (F2016 – F2022)

Fiscal Year	Energy Savings (GWh/yr)		Peak Capacity Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
F2016	18.5	11.7	3.6	2.3
F2017	32.4	14.0	6.3	2.7
F2018	33.2	16.9	6.5	3.3
F2019	33.7	18.1	6.6	3.5
F2020	27.7	20.7	5.4	4.0
F2021	21.1	22.8	4.1	4.5
F2022	19.5	25.5	3.8	5.0
Overall	186.1	130.0	36.2	25.3

*Values may not sum exactly due to rounding.

4.4 Findings and Recommendations

Findings

<u>Estimate Current Stock and Annual Sales of Battery Chargers</u>

1. Among residential customers, ownership of items with battery chargers was highest for laptops, with 85% of households owning at least one, followed by charging docks for hand-held power tools at 60% and cordless vacuums at 47%. Ownership of personal transportation items was generally the lowest of all items, with ownership of personal mobility carts/wheelchairs and golf carts having particularly low incidence at only 1%.

2. Similar to the patterns for ownership, laptops had the highest total sales at 2.3 million, followed by charging docks for hand-held power tools at 1.6 million and cordless vacuums at 1.0 million. Items for personal transportation, such as electric bicycles, scooters and hoverboards/unicycles, which are newer in the market had among the lowest sales volumes, but have experienced rapid growth in recent years.
3. Commercial sales volumes during the evaluation period were highest for laptops at 1.3 million, followed by hand-held power tools at 470,000 and landscaping equipment at 205,000.

Gross Savings

4. Among all product categories, laptop/notebook computers achieved the highest evaluated gross energy savings at 35.3 GWh per year, followed by cordless vacuums (handheld, stick) at 22.3 GWh per year, and landscaping equipment and cordless lawn mowers at 13.7 GWh per year.
5. Energy savings in maintenance mode accounted for 46% (60.3 GWh per year) of the overall evaluated savings, followed by charge mode at 38% (48.8 GWh per year), and standby mode at 16% (20.8 GWh per year).
6. Cross effects through interactions with space heating and cooling systems were estimated to reduce gross savings by 3%.
7. Evaluated gross energy savings for small battery chargers were 11.7, 14.0, 16.9, 18.1, 20.7, 22.8, and 25.5 GWh per year, respectively, for each year from F2016 to F2022. In contrast, the reported savings for each year over the same period ranged from 19 GWh per year to 34 GWh per year.
8. Peak capacity savings were estimated at 2.3, 2.7, 3.3, 3.5, 4.0, 4.5, and 5.0 MW per year, respectively, for each year from F2016 to F2022, based on applying a weighted average peak-to-energy factor of 0.195 MW per GWh derived from the load shapes for residential and commercial rate classes.
9. The evaluated gross energy savings from F2016 to F2022 were 130.0 GWh per year, or 56.1 GWh per year lower than the reported gross savings of 186.1 GWh per year. The associated peak demand capacity savings were 25.3 MW, or 10.9 MW lower than the reported gross peak capacity savings of 36.2 MW.

Recommendations

The following recommendations flow from the findings of this evaluation.

1. Revise reporting of historical and forecasted savings stemming from the Small Battery Chargers Regulation to align them with the results of this evaluation for the product categories that were covered.
2. If an evaluation of this regulation is repeated in the future, consider conducting primary research on the number of times per week or month that items are plugged in for charging.

4.5 Conclusions

Small battery chargers in B.C. became more energy efficient following the regulation first introduced on June 1, 2015. A total of 130.0 GWh per year in gross electricity energy savings were achieved between F2016 to F2022, with corresponding peak capacity savings of 25.3 MW. The greatest energy savings were achieved by laptop and notebook computers.

5 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.

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 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 action taken by the participants in a demand side management program or initiative irrespective of why they participated.

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

Net-to-gross ratio: 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.

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.