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January 10, 2024

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 F2023 Demand Side Management Milestone Evaluation Summary Report dated January 2024.

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 F2023 Demand Side Management Milestone Evaluation Summary Report summarizes the evaluations completed during fiscal 2023 for the following:

1. B.C. Commercial Building Code: F2016 to F2020;
2. Leaders in Energy Management - Industrial (LEM-I) Program: F2018 to F2021;
3. Thermo-Mechanical Pulp Initiative: F2015 to F2021; and
4. Transmission Service Rate (TSR): F2017 to F2020.

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

Yours sincerely,

Chris Sandve
Chief Regulatory Officer

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Enclosure

Demand Side Management Milestone Evaluation

Summary Report F2023

January 2024

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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 2023 (F2023). 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. B.C. Commercial Building Code: F2016 to F2020
2. Leaders in Energy Management - Industrial (LEM-I) Program: F2018 to F2021
3. Thermo-Mechanical Pulp Initiative: F2015 to F2021
4. Transmission Service Rate (TSR): F2017 to F2020

The Thermo-Mechanical Pulp initiative was a limited one-time offer, and the F2015 to F2021 evaluation represents the final evaluation of this initiative. Likewise, the Transmission Service Rate: F2017 to F2020 evaluation is the final evaluation of this initiative, since the BCUC, in December 2023, approved a new default flat rate structure for Transmission Service customers. In compliance with Directive 66 of the British Columbia Utilities Commission (BCUC) decision on BC Hydro's F05/F06 Revenue Requirements Application, the full evaluation reports for these initiatives are provided as Attachments A and B respectively.

2 B.C. Commercial Building Code Evaluation: F2016 to F2020

2.1 Introduction

This report presents the evaluated gross electricity savings associated with the provincial building code and the Vancouver Building By-law (VBBL) requirements for energy efficiency in commercial buildings which were updated in December 2013 and January 2014 respectively. The scope of this evaluation includes all new[1] commercial and institutional Part 3 buildings[2], including Multi-Unit Residential Buildings (MURBs) higher than three storeys, for which permits were issued under the commercial building code from January 1, 2014 to December 31, 2018.

The BC Building Code is a provincial building regulation that applies to the construction of new residential, commercial, institutional and industrial buildings, as well as alterations and additions to existing buildings. The BC Building Code sets forth the minimum standards and rules by which the construction industry must abide.[3] Prior to September 2008, the BC Building Code did not have energy efficiency requirements for new buildings constructed in the province. In September 2008, the province revised the BC Building Code and adopted ASHRAE 90.1-2004 as the minimum acceptable standard for energy efficiency in commercial buildings. Additionally, the City of Vancouver adopted a by-law in May 2007 whereby the ASHRAE 90.1-2007 standard had to be met. Revisions to the Code were subsequently made and, effective December 20, 2013 (January 24, 2014 for Vancouver), applications for Part 3 building permits in British Columbia were required to comply with one of two new energy codes: ASHRAE 90.1-2010 or the 2011 National Energy Code for Buildings (NECB 2011). Further Code advancements were made, effective December 10, 2018, when B.C. adopted the 2016 version of the ASHRAE 90.1 standard and the NECB-2015. Shortly after this provincial regulation went into effect, the City of Vancouver announced it would harmonize with the Provincial energy efficiency requirements for its commercial building code.

BC Hydro provides technical assistance and resources to support the research behind implementing, updating and enhancing compliance with building codes for energy in the province. Supporting activities include participating in technical code committees, working with government stakeholders 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. To support the implementation of the BC Building Code in the commercial sector, BC Hydro implemented the Commercial New Construction program, which provided funding and training to support the advancement of energy efficient design and offset the cost of more expensive technologies and design.

This study does not attempt to evaluate the influence of BC Hydro’s work on energy efficiency in building codes. Instead, the goal is to estimate electricity savings in BC Hydro’s service territory due to a reduction in electricity usage by new commercial building stock subject to the BC Building Code adopted in December 2013 (and the VBBL in January 2014) relative to buildings constructed prior to the enactment of energy efficiency requirements. The gross electricity savings associated with an earlier version of the code (ASHRAE 90.1-2007 standard for Vancouver and ASHRAE 90.1-2004 for the rest of

[1] Savings from additions or alterations to existing buildings were not included due to limited data.

[2] Part 3 buildings refer to buildings over three stories in height or with a floor area of over 600 square metres. Examples include shopping malls, office buildings, apartment buildings, schools and restaurants.

[3] BC Office of Housing and Construction Standards, June 2015. *Understanding B.C.’s Building Regulatory System*.

the province) were evaluated in 2019, covering savings for fiscal years F2010 to F2015. The current evaluation covers code impacts of the ASHRAE 90.1-2010 standard and NECB 2011 standard for building permits issued from January 2014 to December 2018, with savings attributed to fiscal years F2016 to F2020. The lag from the building permit issue period to attributed savings is required to account for permit issuance and the construction time required for commercial buildings.

2.2 Approach

Table 2.1 Evaluation objectives and research questions

Evaluation objective	Research questions
1. Characterize the new commercial building stock constructed after the building code requirements were changed in 2014[4]	• What types of commercial buildings were constructed after the introduction of the 2013 provincial building code and 2014 Vancouver Building Bylaw (VBBL)? • How many square feet of commercial floor space by building type were constructed during each year of the evaluation period? • What was the regional breakdown of new commercial construction stock in the province for the evaluation period?
2. Estimate electricity usage intensity (EUI) savings	• What was the average annual electricity consumption per square foot by building type for buildings built prior to the first building code (2005-2008 permit issuance years) and post-code buildings (2014-2018 permit issuance years)? • What were the gross electricity savings per square foot by building type?
3. Estimate gross energy and peak demand savings	• What were the gross electricity savings by building type and year? • What were the gross peak demand savings by building type and year?

Note: for the purposes of this report Baseline refers to 2005-2008 permit issuance years, also referred to as the pre-code period. Post-code or Code 2014 refers to the 2014-2018 permit issuance years.

[4] The first energy efficiency requirements for buildings were introduced in September 2008 under the BC Building Code and May 2007 under the Vancouver Building By-Law. This period is referred to as Code 2008 in the report. These energy efficiency requirements were subsequently updated, effective December 2013 in the BC Building Code and January 2014 in the Vancouver Building By-Law. This period is referred to as Code 2014 hereafter.

The data sources and analytical methods used to address the objectives are summarized in Table 2.2.

Table 2.1 Evaluation objectives, data sources and methods

Evaluation Objective	Data Sources	Methods
1. Characterize the new commercial building stock constructed after the building code requirements were changed in 2014	• Statistics Canada Building Permits Survey (2008-2018) • BC Hydro account information • Hanscomb Yardsticks for Costing 2013, 2016, and 2019 editions	• Cross tabulations • Trends
2. Estimate electrical usage intensity (EUI) savings	• BC Hydro billing data (monthly) • BC Assessment data • Commercial New Construction program data • Continuous Optimization program data • Canada Green Building Council LEED building list • Weather data	• Engineering algorithm • Weather normalization modelling • Billing data analysis
3. Estimate gross energy and peak demand savings	• Results from Objectives 1&2 • BC Hydro billing data (hourly)	• Engineering algorithm • Billing data analysis

2.3 Results

The results of the evaluation are presented by objective.

Objective 1: Characterize the new commercial building stock constructed after the building code requirements were changed in 2014

A total of 123 million square feet of commercial building stock was approved to be built from F2015 to F2019 under the code adopted in January 2014. This was 34% more than the 92 million square feet approved under the previous edition of the code, which was in effect from September 2008 to December 2013.

The vast majority of commercial new construction under the 2014 code continued to concentrate around the Lower Mainland and Vancouver Island. The Lower Mainland accounted for 82% of the total floor area and Vancouver Island accounted for 10%.

High-rise MURBs accounted for 60% of the new floor area, followed by warehouses and retail, which accounted for 13% and 10%, respectively. The remaining 17% was distributed among offices, other commercial projects, educational facilities, hospitals, hotels and restaurants. The share of high-rise MURBs built under the 2014 code increased 14% compared to the period covered under the 2008 code. This upward trend was fueled by a strong demand for housing during that period.

Table 2.3 summarizes the total floor area, by building type and year, that contributed to the gross savings. The overall floor area added every year shows a fairly steady increasing trend, with the exception of a slight dip in F2017.

Table 2.2 Floor area of building type by year (ft^2)

Building type	F2015	F2016	F2017	F2018	F2019	F2015 to F2019	Percentage
High-rise MURB	11,077,072	13,256,192	12,625,612	17,318,653	19,319,732	73,597,261	60%
Warehouse	2,507,821	3,169,895	2,870,511	3,468,989	3,857,530	15,874,746	13%
Retail	2,370,904	4,065,672	1,814,556	1,785,882	2,528,397	12,565,411	10%
Others	1,842,955	1,077,911	1,148,696	1,432,503	1,320,039	6,822,104	6%
Office	647,969	1,159,649	662,014	667,276	1,493,335	4,630,242	4%
Education	579,714	626,255	1,130,332	1,419,359	715,250	4,470,911	4%
Hotel_restaurant	1,547,437	398,215	291,372	237,268	1,486,315	3,960,607	3%
Hospital	754,199	148,137	2,161	98,428	316,046	1,318,971	1%
Total	**21,328,071**	**23,901,926**	**20,545,253**	**26,428,358**	**31,036,646**	**123,240,253**	**100%**

*Percentages do not sum to 100 due to rounding.

Objective 2: Estimate electrical usage intensity (EUI) savings

The EUI savings for each building type were taken as the difference between the pre- and post-code median EUIs, and the results are shown in Table 2.4. The p-values in the table are the results of a nonparametric statistical test that was used to determine, based on the EUI distributions, whether the pre- and post-code samples could be deemed to come from different populations. A p-value below 0.2 was considered significant. If a tested building type did not pass the significance test, an aggregated group was formed based on a distribution similarity test, and the significance test was repeated.

In conclusion, at the provincial level, energy efficiency requirements for commercial buildings under the 2014 building code resulted in 15% savings in electricity usage per square foot compared to what would have been consumed in the absence of any energy efficiency requirements. The savings by building type ranged from 10% for high-rise MURBs, to 25% for “office/retail/others”, and up to 36% for “education/hotel/hospital”. Warehouse savings were not statistically significant at the 0.2 significant level.

Table 2.4 Electricity use intensity savings

Building type	Pre-code median EUI (kWh/ft^2)	Post-code median EUI (kWh/ft^2)	Evaluated EUI savings (ΔkWh/ft^2)	Energy efficiency improvement (%)	P-value
Overall	6.5	5.5	1.0	15%	<.0001*
High-rise MURB	5.9	5.3	0.6	10%	<.0001*
Warehouse	5.0	4.3	0.7	14%	0.2425
Office/retail/others	12.5	9.4	3.1	25%	0.0382*
Education/hotel/hospital	11.9	7.6	4.3	36%	0.0026*

* 1) The Kruskal-Wallis statistical test and the Dwass, Steel, Critchlow-Fligner (DSCF) statistic were applied to determine the building type grouping method.

2) P-value was from the Wilcoxon Mann-Whitney U test. P-values lower than 0.2 indicate that the distribution of pre and post-code building EUI differ significantly at the 0.2 significance level.

Objective 3: Estimate gross energy and peak demand savings

The evaluated gross energy savings for each fiscal year covered by the evaluation period are presented in Table 2.5. Reported savings were calculated based on a projection of the annual growth in commercial floor stock and engineering estimates of EUI savings. Evaluated savings were based on estimated actual floor stock of newly constructed buildings and EUI savings estimated from actual building electricity usage intensity data. Evaluated gross electricity savings ranged from 25 GWh/year to 39 GWh/year from F2016 to F2020 and totaled 161 GWh/year over the evaluation period. The associated peak demand savings were estimated at 25 MW based on an analysis of hourly energy savings profiles.

MURBs contributed 44 GWh/year in total savings from F2016 to F2020, or a combined 28% of the total evaluated energy savings. This reflects the dominance of MURBs in terms of added floor area from new construction. The code impact for the aggregated group of office, retail, and others categories was 74 GWh/year in energy savings, or a 46% share of the total gross energy savings. The remainder of energy savings was attributed to the combined group of education, hospitals, hotels, and restaurants, with a total of 42 GWh/year or 27% of the total gross energy savings. Although warehouses represented 13% of new building floor area, the statistical evidence was not strong enough to support claiming EUI savings from this building type. Therefore, warehouses did not contribute to the total energy gross savings.

Table 2.5 Summary of energy and peak demand savings

Fiscal year	Energy savings (GWh/year)		Peak demand savings (MW)	
	Reported	Evaluated gross	Reported	Evaluated gross
F2016	35	34	5	5
F2017	31	33	4	5
F2018	32	25	5	4
F2019	34	30	5	5
F2020	18	39	1	6
Total	**150**	**161**	**20**	**25**

The cumulative variance between reported and evaluated gross energy savings was 11 GWh/year and the cumulative variance in gross demand savings was 5 MW. The differences in energy savings were relatively small for most of the evaluated years, with the exception of F2018 and F2020. The evaluated savings were 7 GWh/year lower than the reported values in F2018. The largest variance occurred in F2020, where evaluated energy savings were 21 GWh/year higher than reported results.

The variances can be attributed to differences in building floor area and differences in EUI savings. The evaluated high-rise MURB floor area was almost double the reported total floor area. Comparing offices, retail, and others as a combined group, the evaluated total floor area was about 42% of the reported total. Similarly, education, hospitals, hotels and restaurants were combined, and the evaluated floor area was about 82% of the reported value. On the other hand, the evaluated EUI savings were 30% lower than the reported value for high-rise MURBs, but 140% higher for the combined group of offices, retail, and other buildings. Additionally, the combined group of education, hospitals, hotels, and restaurants had evaluated EUI savings that were 40% higher than reported.

2.4 Findings and Recommendations

Findings

1. The majority of building permits issued between 2014 and 2018 for new commercial buildings were in the Lower Mainland (82%), followed by Vancouver Island (10%). Based on the relative total floor area of these buildings, those constructed in the Lower Mainland were larger than those constructed on Vancouver Island.
2. High-rise Multi-Unit Residential Buildings (MURBs) represented 60% of the total new floor area approved to be built under Part 3 of the BC Building Code during the evaluation period, followed by 13% for warehouses, and 10% for retail buildings. The remaining 17% was shared among office, education, hospital, hotel and restaurants, and others building types, each representing 5% or less individually.
3. Billing data revealed an average lag of approximately 18 months from permit issuance to construction completion, and a further 6-month lag to establish building energy usage at the typical occupancy level in MURBs, or under regular business operation for commercial businesses. From the third year onward, the majority of buildings are likely to generate energy savings at a full run rate.
4. The estimated EUI savings suggested that buildings that received permits under the 2014 BC building code improved energy efficiency by 15% compared to buildings that received permits before 2008. Further comparisons showed that high-rise MURBs saved 10%, buildings under the aggregated categories of offices, retail, and other general commercial buildings, saved 25%, and the remaining aggregated group of education, hospitals, hotel and restaurant buildings saved 36% compared to corresponding baseline buildings.
5. The evaluated gross energy savings from F2016 to F2020 were 161 GWh/year. The highest savings were achieved in F2020, reflecting the rapid growth of high-rise MURB buildings. The associated peak demand savings were estimated at 25 MW based on an analysis of hourly energy savings profile.
6. The evaluated gross electricity savings were 11 GWh/year higher than the reported gross savings of 150 GWh/year. The evaluated gross demand savings were 5 MW higher than the reported gross demand savings of 20 MW.

Recommendations

The following recommendations flow from the findings of this evaluation. Recommendation #1 is for the BC Hydro Codes and Standards group. Recommendation #2 and #3 are for Evaluation.

1. When forecasting energy savings, consider updating the construction lag time assumption to 18 months to allow buildings to achieve typical occupancy levels after the building permit approval stage.
2. In consideration of the long construction period required for large commercial buildings, and the length of time required to accumulate representative energy consumption data, allow for a longer time span before conducting a new evaluation of the commercial building code. A longer evaluation period following a code change would improve the analysis, with greater sample sizes that may enable a more granular identification of savings at the building type level.

3. In collaboration with the Customer and Energy Analytics group, continue to seek ways to improve data matching between the BC Assessment database and the BC Hydro billing system to maximize the amount of data available for future analyses.

2.5 Conclusions

The commercial building stock in B.C. became more energy efficient after the energy efficiency requirements were tightened in 2014 for both the BC Building Code and the Vancouver Building by-law. Buildings that received permits under the 2014 BC building code consumed 15% less electrical energy compared to buildings that received permits before 2008. High-rise multi-unit residential buildings had the greatest share of overall energy savings, at 28%, followed by retail at 24%.

3 Evaluation of the Leaders in Energy Management - Industrial (LEM-I) Program: F2018 to F2021

3.1 Introduction

This report presents the results of an impact evaluation of the BC Hydro Leaders in Energy Management – Industrial (LEM-I) program covering fiscal years F2018 to F2021 (April 1, 2017 to March 31, 2021). LEM-I is a demand side management program targeting industrial customers in the transmission and distribution rate classes. Transmission customers include over 170 large industrial sites receiving service at transmission voltages (> 60 kV) in the pulp and paper, wood products, mining, oil and gas, chemical, cement, transportation and manufacturing sectors. Distribution customers include more than 47,000 BC Hydro small, medium and large industrial sites in the wood products, food and beverage, manufacturing, and transportation industries that receive power through the regular distribution system.

A key objective of LEM-I is to integrate Strategic Energy Management (SEM) into BC Hydro's industrial customers' organizations. The LEM-I program provides the following SEM offers:

- Industrial Energy Manager (IEM): Funding is provided to customers that consume more than 20 GWh/year to partially cover an IEM position within the organization. IEM contracts are performance-based contingent on the IEM delivering on activity and energy-saving targets. Expected savings were claimed by the program as a deemed percentage of site annual energy consumption for participants meeting minimum SEM program requirements.
- Industrial Cohort: Customers that consume between 4 and 20 GWh/year have the option to choose one or more sites to participate in a two-year SEM program with a cohort of industry peers. A consultant is appointed as the Energy Manager coach and leads the cohort through a series of workshops on energy efficiency with a focus on energy model development and the identification of operational and behavioural savings. The Industrial Cohort contracts are partially performance-based as participants must submit the required data and SEM Plan deliverables to fulfill the contract. Expected energy savings for participating sites were estimated based on the facility energy use model and bottom-up engineering estimates.

Energy Efficiency Feasibility Studies are available to customers with systems (e.g., pumping, fans and blowers, compressed air) that consume more than 1 GWh per year of electricity. LEM-I also offers funding to identify energy-saving opportunities through plant-wide audits and end use assessments.

Capital Projects

Project incentives are offered to help reduce the financial barriers that prevent customers from implementing an energy-efficiency project. The offer varies depending on the rate class that a customer belongs to, whether they are retrofitting an existing facility, building a new one, or looking to investigate a new technology. Capital project incentives fall into three categories: custom project incentives, the Self-serve Incentive Program (SIP) and Business Energy Saving Incentives (BESI). Custom projects can further be divided into incentives for system retrofits, new plant design (NPD) incentives, and program enabled projects (PE).

3.2 Approach

Table 3.1 presents the evaluation objectives and associated research questions that guided the evaluation, followed by Table 3.2 summarizing the data sources and methods used for each evaluation objective.

Table 3.1 Evaluation Objectives and Research Questions

Evaluation Objective	Research Questions
1. Assess participant and non-participant experience with the program offers	What was participant and non-participant awareness and understanding of the various program offers and supports? What was participant satisfaction with the various program offers and supports?
2. Examine trends and outcomes of capital projects associated with Strategic Energy Management	What was the coverage of energy savings for facilities with energy managers compared to those without? Are there any trends between strategic energy management practice and energy savings? Are there any processes or procedures to sustain energy savings achieved through projects and other activities further into the future?
3. Estimate gross electrical energy savings from capital projects	What were the most common energy conservation measures by end use among custom and prescriptive incentive projects, and program enabled projects? What were the evaluated gross electrical energy savings and gross realization rate (GRR) by end use?
4. Estimate net electrical energy savings from capital projects	How much free ridership occurred for custom incentive and program enabled by transmission and distribution customer groups? How much free ridership occurred for the prescriptive offers? How much participant and non-participant spillover occurred for the program overall? What are the evaluated net energy savings and peak demand savings realized by capital projects?
5. Estimate additional energy savings from SEM	What were the evaluated gross energy savings generated through SEM activities (beyond capital projects) from SEM-IEM (transmission customers only) and SEM-Cohort activities?
6. Estimate total net energy and peak demand savings	What are the evaluated net energy savings and peak demand savings realized by the program by fiscal year?

Table 3.2 Evaluation Objectives, Data and Methods

Evaluation Objectives	Data	Method
1. Assess participant and non-participant experience with the program offers	• Ongoing Participant Surveys covering F2018-F2021 • F2019, F2022 Non-Participant Surveys • F2022 SEM Cohort Survey	• Cross tabulations; frequencies
2. Examine trends and outcomes of capital projects associated with Strategic Energy Management	• Project tracking data • Project files (including energy manager reports, Monitoring and Targeting reports, Energy Studies, etc.) • F2022 SEM Cohort Survey	• Cross tabulations; frequencies • Engineering review and analysis • Qualitative analysis
3. Estimate gross electrical energy savings from capital projects	• Project tracking data • M&V (Measurement and Verification) results based on the application of IPMVP[5] • Project files & energy study reports	• Extrapolation of M&V results • File reviews and engineering desk reviews • Development of realization rates using stratified ratio estimation
4. Estimate net electrical energy savings from capital projects	• Ongoing Participant Surveys covering F2018-F2021 • F2019, F2022 Non-participant Survey	• Estimation of free ridership for participants from survey results and decision tree • Free rider case studies (as required) • Estimation of spillover for participants and non-participants from survey results and decision tree
5. Estimate additional energy savings from SEM	• Account billing data • Metered hourly interval data • Project files (including SEM-Cohort reports, and energy manager reports, etc.)	• Load distribution curve analysis (SEM-Cohort n=23, SEM-IEM n=16) • Engineering review and analysis • Qualitative analysis
6. Estimate total net energy and peak demand savings	• Results from Objectives 3, 4 and 5 • Rate class average peak-to-energy factors	• Key results (segmentation as required) • Variance calculation

5 The International performance measurement and verification protocol (IPMVP) defines standard terms and suggests best practice for quantifying the results of energy efficiency investments and increase investment in energy and water efficiency, demand management and renewable energy products.

3.3 Results

Objective 1: Assess participant and non-participant experience with the program offers

Overall Satisfaction and Program Experience. Overall satisfaction was very high for all of the LEM-I offers with 100% of custom participants, 99% of SIP participants and 81% of BESI participants reporting to be 'very satisfied' or 'somewhat satisfied' with the program.

Ratings for service provided by BC Hydro personnel, contractors or suppliers/distributors were very high across all groups, with the exception of 'service provided by BC Hydro personnel' among the BESI group. Knowing how/who to contact at BC Hydro was rated well by custom and SIP participants, the most likely of the groups to have a Key Account Manager but was among the lowest rated elements by BESI participants. Among BESI participants, areas with the strongest ratings included 'length of time for the project to be completed', 'quality of the energy efficient technology' and 'installing the energy efficient technology'. Aspects with the lowest ratings included 'length of time to receive project approval', which was among the lowest rated elements among participants of both custom offers and SIP.

SEM-Cohort Satisfaction and Experience. A separate survey was conducted among Cohort 4 and 5 participants to assess their experience with the offer. Overall, they reported moderately high levels of satisfaction with their participation in the program with 78% being 'very satisfied' (56%) or 'somewhat satisfied' (22%).

All four of the aspects related to the energy coaches received very strong ratings, with all respondents (100%) rating these as 'excellent' or 'good'. The energy coaches' experience with SEM had the highest 'excellent' score at 78%, followed by their ability to conduct workshops at 67% and their knowledge and technical experience at 56% each. In terms of other aspects of the program, ratings were high for the ease of maintaining and utilizing the energy model, with all respondents rating it as either 'excellent' (11%) or 'good' (89%). Ratings were also high for service and support provided by BC Hydro with 89% rating this aspect as 'excellent' (33%) or 'good' (56%).

Objective 2: Examine trends and outcomes associated with Strategic Energy Management

The coverage of Energy Managers at the 180 sites with a BC Hydro Key Account Manager reveals that 67% of the capital projects, which accounted for 89% of the savings, were enabled by Energy Managers. Energy managers at sites that met the program threshold for an SEM savings claim were more active, completing 1.33 capital projects per site, compared to energy managers at sites that did not qualify for an SEM savings claim, who completed only 0.48 capital projects per site.

Objective 3: Estimate gross electrical energy savings from capital projects

The overall gross realization rate of capital projects for the period F2018 to F2021 was estimated as the ratio of evaluated to expected gross savings for all measures included in the evaluation analysis, but not including savings from strategic energy management. The overall realization rate for capital projects was calculated at 94%. This means that, on average, the measures in the realization rate samples achieved 94% 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	Number of Measures	Expected Savings (GWh/year)	Evaluated Gross Realization Rate (GRR)	Evaluated Gross Energy Savings (GWh/year)
Lighting	883	66.8	94%	62.6
Compressed Air	42	15.7	104%	16.5
Process	28	102.1	88%	89.9
Other End Uses	77	71.6	100%	71.3
Tag-on Savings*	31	-	98%	0.7
Total	**1,061**	**256.2**	**94%**	**241.0**

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

Objective 4: Estimate net electrical energy savings from capital projects

Net electricity savings are the change in energy consumption attributable to the program. They exclude free riders and include spillover. The overall level of free ridership was estimated at 24% for capital projects, ranging from 5 to 38% across program offers. Participant spillover was estimated at 5% and non-participant spillover was estimated at 2%, for a total spillover effect of 7%. As shown in Table 3.4, together these factors result in a downward adjustment of the evaluated gross energy savings of 40.9 GWh per year during the evaluation period and a net-to-gross ratio of 83%.

Table 3.4 Free Ridership, Spillover, and Net-to-Gross Ratio by Program Offer

Capital Projects by Program Offer	Custom-Transmission	Custom-Distribution	New Plant Design	Self-serve Incentive Projects (SIP)	BESI	Overall Capital Projects (F18-F21)
Evaluated Gross Energy Savings (GWh/year)	129.5	16.6	52.2	37.4	5.3	241.0
Net-to-Gross Ratio	**79%**	**102%**	**75%**	**98%**	**106%**	**83%**
Evaluated Net Energy Savings (GWh/year)	102.0	16.9	39.0	36.6	5.7	200.1

Objective 5: Estimate additional energy savings from Strategic Energy Management

Energy Savings additional to those from capital projects were estimated for facilities with an Industrial Energy Manager and engaged in Strategic Energy Management (SEM-IEM participants) and for participants in an SEM-Cohort during the evaluation period. These results were used to estimate the evaluated net energy savings from strategic energy management. A site-specific analysis of changes in energy consumption was conducted for participants, spanning a baseline period and the period of engagement in SEM, to quantify through hourly load distribution curve analysis the average savings due to SEM engagement, net of any impacts from known capital projects or non-routine events estimated from engineering calculations.

SEM-IEM Savings

A total of 26 sites from 16 companies met the program criteria for reporting deemed savings from SEM-IEM, generating a total of 48 annual records of expected SEM savings during the evaluation period. Repeat participants covered 65% of records and 71% of expected savings. The realization rate of SEM-IEM savings increased from 26% of deemed expected savings in F2018 to 81% in F2021. Table 3.5 summarizes the expected and evaluated gross energy savings for SEM-IEM Savings. Overall, SEM-IEM participants exhibited an average yearly reduction in energy consumption of 0.4% per year.

Table 3.5 Results for SEM-IEM Savings (F2018-F2021)

Fiscal Year	Number of sites with SEM-IEM Savings	Expected Savings (GWh/year)	Evaluated Net Savings (GWh/year)	SEM-IEM Realization Rate
F2018	10	64.9	17.0	26%
F2019	10	67.2	20.1	30%
F2020	7	69.5	42.6	61%
F2021	21	98.0	79.6	81%

SEM - Cohort Savings

A total of 26 sites from 23 companies participated in an SEM cohort during the evaluation period. Table 3.6 summarizes the expected and evaluated gross energy savings for SEM-Cohort. The realized savings were primarily from behavioural and operational measures which were also supported with a formal sustainment plan and implemented in the facility’s standard operating procedures. SEM-Cohort savings were increasing and sustained during the four-year evaluation period and reached 5.2% of aggregated site energy consumption by F2021. Differences between expected and evaluated savings were primarily due to discrepancies in accounting for capital project savings at participating sites.

Table 3.6 Results for SEM-Cohort Savings (F2018-F2021)

Fiscal Year	Number of sites with evaluated SEM-Cohort savings	Expected SEM-Cohort Savings (GWh/year)	Evaluated Net SEM-Cohort Savings (GWh/year)	SEM-Cohort Realization Rate
F2018	10	0	5.1	---
F2019	18	6.9	7.8	112%
F2020	20	17.2	8.4	49%
F2021	22	18.2	12.2	67%

Objective 6: Estimate total net energy and peak capacity savings for LEM-I

Table 3.7 summarizes the evaluated net energy savings and peak capacity savings for the LEM-I program by fiscal year. Peak capacity savings were estimated by applying the average peak-to-energy factors of 0.117 MW per GWh for the transmission rate class and 0.136 MW per GWh for the industrial distribution rate class.

Table 3.7 Summary of Net Energy and Peak Capacity Savings

	Net Energy Savings (GWh/year)		Net Peak Capacity Savings (MW)	
Fiscal Year	Reported	Evaluated	Reported	Evaluated
F2018	120.2	71.1	14.1	8.4
F2019	120.3	76.2	14.2	9.0
F2020	139.6	103.0	17.0	12.5
F2021	176.3	145.1	21.8	17.9

Overall, the program achieved 59 to 82% of yearly reported savings, depending on the year considered. The program variance is primarily due to lower than expected additional savings from strategic energy management, higher than expected free ridership of custom program enabled projects for transmission customers, and lower than expected gross savings from capital projects.

3.4 Findings and Recommendations

Findings

Participant and Non-Participant Experience

1. Overall satisfaction was very high for all of the LEM-I offers with 100% of custom participants, 99% of SIP participants and 81% of BESI participants reporting to be ‘very satisfied’ or ‘somewhat satisfied’ with the program.
2. Ratings for ‘service provided’ – whether by BC Hydro personnel, contractors or suppliers/distributors – continued to receive high ratings across all groups, with the exception of ‘service provided by BC Hydro personnel’ among the BESI group. ‘Knowing how/who to contact at BC Hydro’ and ‘clarity of communication’ were the next mostly highly rated elements for custom and SIP participants, the most likely of the groups to have a Key Account Manager.
3. Participants in SEM-Cohorts 4 and 5 reported moderately high levels of satisfaction with their participation in the SEM Cohort program with 78% reporting to be ‘very satisfied’ (56%) or ‘somewhat satisfied’ (22%). All of the individual aspects of the cohort offer received very high ratings, with aspects related to the energy coaches receiving particularly high scores.

SEM Trends and Outcomes

1. Energy managers played an important role in program participation. Among program participants that had a BC Hydro Key Account Manager, two-thirds of the sites had an energy manager or an energy coach, and these energy managers and coaches were associated with 90% of the energy savings from capital projects. Strategic energy management is related to greater project activity and energy savings. Project tracking data indicates that sites with an energy manager and an SEM savings claim completed almost three times as many projects as sites with an energy manager but no SEM savings claim.
2. SEM-Cohort survey respondents found the SEM-Cohort program helped them to identify and implement energy savings opportunities. They found the various program activities to be useful, particularly check-ins with their energy coaches.

3. Large industrial customers, both transmission and distribution, that participated in LEM-I reported engaging in more energy management activities than did non-participants of similar size. Smaller customers turned off equipment when not needed as their main energy management activity.

4. There are few processes embedded at sites to sustain SEM practices going forward without BC Hydro supports.

Gross Electrical Savings from Capital Projects

1. Between F2018 and F2021, 521 capital projects at 387 unique sites were implemented through the LEM-I custom incentives, program enabled, new plant design, self-serve incentives (SIP) and prescriptive incentives (BESI) program offers. Capital projects consisted of lighting, compressed air, process, and other end uses respectively representing 26%, 7%, 37% and 30% of savings.

2. The review of transmission customers' project energy savings reported through the Transmission Service Rate administrative process increased the overall sample coverage of verified energy savings from 28% to 51%.

3. The gross realization rate of energy savings from capital projects was 94%, indicating that the energy conservation measures largely performed as expected. The most common reasons identified through post-implementation review and M&V for why measures did not perform as expected were related to changes in operating conditions.

Net Electrical Savings from Capital Projects

1. The net-to-gross ratio for capital projects was 83% based on an overall level of free ridership of 24%, participant spillover of 5%, and non-participant spillover of 2%.

2. Evaluated net energy savings from capital projects were 200.1 GWh from F2018 to F2021.

Additional Energy Savings for SEM-IEM participants

1. Sixteen organizations with 26 sites met the LEM-I program criteria for reporting additional energy savings from SEM-IEM. SEM-IEM reported savings were based on the inclusion of sites that met pre-determined criteria established by the program administrator and inclusion of sites was reviewed every year.

2. Additional SEM savings without a sustainment plan were assigned a one-year persistence in accordance with the BC Hydro Persistence Standard. During the evaluation period, 65% of the participant sites and 71% of expected savings were from repeat SEM-IEM participants indicating that SEM is embedded into the participant's organization and savings sustained across multiple fiscal years. However, the effective useful life of SEM-IEM savings could not be evaluated due to the number and mix of new and repeat participants in the yearly SEM-IEM savings claim.

3. The additional savings from SEM-IEM were evaluated at 17 GWh per year in F2018, 20 GWh per year in F2019, 43 GWh per year in F2020, and 80 GWh per year in F2021. Evaluated net energy savings from SEM-IEM achieved a realization rate of 26% in F2018, 30% in F2019, 61% in F2020 and 81% in F2021 based on the deemed 2% reduction of annual site energy consumption.

4. A site-specific baseline period was not provided in the project file of the deemed SEM-IEM savings claim. Therefore, the SEM-IEM savings were evaluated as incremental savings relative to the baseline period of F2016 but only for fiscal years with reported SEM-IEM savings.

5. Sites for which deemed SEM-IEM savings were reported exhibited an average yearly reduction in energy consumption of 0.4% per year, from 0.5% in F2018 to 1.6% in F2021. These results are above and beyond savings achieved through reported capital projects. The analysis required supporting information on routine and non-routine events which was not consistently available.

6. The combined savings from capital projects and additional savings from SEM-IEM of participants in this evaluation period were estimated to represent a 5% reduction in site energy consumption by F2021 with two-thirds of the combined savings achieved from capital projects.

Additional Energy Savings for SEM-Cohort participants

1. Ten organizations from Cohort #2, nine organizations from Cohort #3, two organizations from Cohort #1 and two organizations from Cohort #4 for a total of 26 sites participated in the SEM-Cohort initiative between F2018 and F2021.

2. The additional savings from SEM-Cohort were evaluated at 5 GWh per year in F2018, 8 GWh per year in F2019, 8 GWh per year in F2020 and 12 GWh per year in F2021. The evaluation included all reporting periods after the baseline and found savings in F2018 and F2019 above what was reported.

3. In F2021 the SEM-Cohort achieved a realization rate of 67% of expected savings from primarily the third and fourth year of participation in the cohorts.

4. Persistence of SEM-Cohort savings was sustained over multiple fiscal years with 83% of reported savings from repeat projects in F2021.

5. The combined savings from capital projects and additional savings from SEM-Cohort participation were estimated to represent an 8% reduction in site energy consumption, with about one-third coming from capital projects and two-thirds from additional savings achieved through the SEM-Cohort initiative.

Total Net Energy and Peak Capacity Savings

1. Evaluated net energy savings for LEM-I were 71.1 GWh per year in F2018, 76.2 GWh per year in F2019, 103.0 GWh per year in F2020, and 145.1 GWh per year in F2021.

2. Net peak capacity savings were estimated at 8.4 MW in F2018, 9.0 MW in F2019, 12.5 MW in F2020, and 17.9 MW in F2021, based on applying the average peak-to-energy factor of 0.117 MW per GWh for transmission rate class customers and 0.136 MW per GWh for industrial distribution rate class customers.

3. The average weighted persistence of all capital measures (i.e., the length of time that the savings are reported by the program) was 10.1 years during the evaluation period. When including savings from SEM participants, the average weighted persistence of all savings reported was 4.9 years.

BC Hydro's Leaders in Energy Management – Industrial program achieved 59% to 82% of reported savings annually during fiscal years F2018 to F2021 including capital projects and additional savings from strategic energy management. Industrial customers generally have high levels of satisfaction with the program.

Recommendations

The following five recommendations flow from the results of this evaluation. Recommendation 1, 2 and 3 are for LEM-I program management and Recommendation 4 and 5 are for Evaluation.

1. Link the annual engineering reviews of energy savings reported through the Transmission Service Rate administrative process with LEM-I program tracking to refine the energy savings estimates earlier in reporting (i.e., before evaluation).
2. Improve tracking of energy impacts from non-routine events for SEM participants (IEM and SEM-Cohort) to help mitigate uncertainty in the SEM evaluation method.
3. Program administrator to specify the baseline period for SEM-IEM participants for evaluation to estimate additional savings from SEM incremental to the baseline. Consider alignment with the baseline period of the site's energy monitoring and tracking model.
4. Consider estimating site-specific capacity savings for SEM participants using hourly data in the next LEM-I evaluation.
5. Continue to explore the processes, procedures, and documentation that support SEM savings during and after BC Hydro engagement.

3.5 Conclusions

BC Hydro's Leaders in Energy Management – Industrial program achieved 59% to 82% of reported savings annually during fiscal years F2018 to F2021 including capital projects and additional savings from strategic energy management. Industrial customers generally have high levels of satisfaction with the program.

4 Summative Evaluation of the Thermo-Mechanical Pulp Initiative: F2015 to F2021

4.1 Introduction

This report presents the results of an evaluation of the BC Hydro Thermo-Mechanical Pulp (TMP) Initiative for fiscal years F2015 to F2021 (April 1, 2014 to March 31, 2021). The initiative was a one-time offer available to all seven BC Hydro thermo-mechanical pulping customers to complete electrical energy-efficiency upgrades to facilities.[6]

One objective of the TMP initiative was to help pulp and paper producers, who faced economic pressures, to save electricity and reduced their operating costs, thereby helping them to remain globally competitive, and supporting thousands of jobs across the province. At that time, these facilities consumed over 5,000 GWh of electricity per year – roughly 10% of BC Hydro's total electricity sales.

The initiative had a target budget of $100 million for incentives. In the end, three mills entered into an agreement with BC Hydro to complete an approved capital project to receive an incentive, and all projects were expected to undergo annual review and verification of energy savings. The projects implemented through the TMP initiative provided thermo-mechanical pulp mills in BC with an opportunity to complete upgrades which would help companies to maintain economically viable operations, offset expected rate increases, and reduce the electrical energy input per unit of production.

At the time of this evaluation only one of the three projects had completed post-implementation measurement and verification (M&V) activities.[7] Therefore, this is a summative evaluation[8] focusing on lessons learned and the effectiveness of the program in achieving its intended outcomes.

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6 The TMP initiative was implemented pursuant to the Government of B.C.'s Direction to the BCUC Respecting the Authority's TMP Program. This direction requires the BCUC to allow BC Hydro to recover up to $100 million in costs incurred to carry out the program.

7 Results of verified savings for all three projects are expected to be available in F2023 and will supersede the reported savings from post-implementation review. Verified savings from annual M&V will be reported thereafter.

8 A summative evaluation is outcome focused and examines an intervention's impact or efficacy through examination of program design and management. It is most often undertaken at the end of a program or project.

4.2 Approach

The table below presents the evaluation objectives and associated research questions that guided the evaluation.

Table 4.1 Evaluation Objectives and Research Questions

Evaluation Objective	Research Questions
1. Identify the successes and challenges encountered in the design and implementation of the TMP initiative	To what extent did the actual TMP initiative align with what was originally planned? What were the key challenges or issues from a design perspective? What were the business drivers for participating in the TMP initiative? Were there any unanticipated barriers to participation? Are there any best practices and lessons learned for BC Hydro to consider in developing initiatives of similar size and scope in different sectors?
2. Examine the extent to which expected outcomes were realized	What energy conservation measures were investigated through energy studies? What energy conservation measures were implemented using TMP project incentives? Are the energy conservation measures implemented achieving the expected magnitude of savings? To what extent were the energy conservation measures used to improve energy productivity (e.g., yield, quality, production rate, product type, new products)? What were the non-energy impacts of the TMP projects? Are there any significant energy related cross effects that occurred through the interaction of the TMP projects and waste heat recovery?
3. Qualitatively explore any market effects or sector changes influenced by the TMP initiative	Is there evidence of economic sustainability of companies that received TMP project incentives in terms of reduced site viability risk or evidence of company intentions to invest further in mills that participated in the TMP project incentives? How did the University of British Columbia research program on energy reduction in mechanical pulping contribute to energy efficiency projects and market adoption of emerging energy efficiency technologies in BC? Have any additional large capital energy efficiency projects been identified as a result of the TMP initiative? In what ways did the TMP initiative help to advance technical knowledge and skills within the mechanical pulping industry?

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

Table 4.2 Evaluation Objectives, Data and Methods

Evaluation Objective	Data Sources	Methods
1. Identify the successes and challenges encountered in the design and implementation of the TMP initiative	Initiative documentation Interviews with program managers, Key Account Managers Interviews with participants and non-participants	• Qualitative analysis
2. Examine the extent to which expected outcomes were realized	Administrative program and project tracking data Interviews with participants	• Qualitative analysis • Project data review and summary
3. Qualitatively explore any market effects or sector changes influenced by the TMP initiative	Interviews with participants	• Qualitative analysis

4.3 Results

Objective 1: Identify the successes and challenges encountered in the design and implementation of the TMP initiative

The main drivers for companies to participate in the initiative were that it allowed them to upgrade the technology at the mill to be more efficient and reduce energy costs. The initiative also enabled them to validate the applicability of new technology and think on a bigger scale about cost structure and competitiveness.

Funding ranged from $5 million to $25 million per project. However, both BC Hydro staff and participants mentioned that the funding cap of 75% of total project costs, which was part of the initiative design, was a financial constraint considering the participants' limited ability to contribute to the cost of upgrades given their financial issues and the short window of time in which implementation had to occur. Putting together these large capital projects in a tight timeframe was difficult, given the time required to identify a suitable project for the initiative, complete engineering studies, and make a substantial investment decision in an environment where it was difficult to predict long term market needs for mechanical pulp and paper products. BC Hydro staff commented that having more time to explore design options or ideas with suppliers before launching the initiative could have helped to understand technology accessibility and delivery timelines.

One interviewee who did not pursue a TMP incentive application said BC Hydro was very cooperative in attempting to make their application work, but ultimately the company was risk averse and decided not to proceed with the initiative given the poor paper market at the time.

When asked what could have been done better, one participant mentioned that BC Hydro's fiscal year (which ends in March) is not aligned with their company's fiscal year (which runs the calendar year), which forced them into a shorter lead time to plan bigger projects. Similarly, BC Hydro staff felt that large-scale, transformative projects, like those targeted by the TMP initiative, need sufficient time up front to plan and strategize as the impact will be long term. Another BC Hydro staff member mentioned that for some mills the TMP initiative may have been "too little, too late" as some of the facilities were just too old to be upgraded, noting that two of the originally targeted mills were permanently closed before project incentives were committed.

Communications about eligibility and incentives were clear and well laid out according to participants. Any questions were usually quickly answered. They also felt that the similarity of the TMP initiative delivery model to other BC Hydro incentive programs made it easier to manage. BC Hydro staff felt the initiative rollout could have been smoother and that having a defined project change approval process in advance would have been helpful.

Objective 2: Examine the extent to which expected outcomes were realized

The outcomes of the TMP initiative can be traced through the evolution of project related activity along five steps, from preliminary assessments to energy study applications, through to project implementation and completion of measurement and verification activities. In some cases, additional capital projects were also installed outside the TMP initiative project to improve the overall energy performance of the mill.

All seven TMP mills submitted applications for energy studies. These applications covered 17 projects totalling proposed energy savings of over 1,000 GWh per year. However, many projects did not proceed through all steps for various reasons and only three projects were implemented for total expected energy savings of 170 GWh per year. Reasons and barriers to implementation included the closure of two TMP mills and limited access to financing to complete projects at another two of the mills. Table 4.3 below summarizes the evolution of expected energy savings and proposed project costs as projects went through the five steps of the TMP initiative.

The targeted outcome of the $100 million in capital incentives was 300 GWh per year of energy savings. This was exceeded two- to threefold in terms of activity generated in Step 1 and Step 2 as can be seen in Table 4.3. The six projects that submitted applications for capital incentives in Step 3 also exceeded the initiative target. However, three projects withdrew their incentive application before an incentive agreement was signed, one due to an anticipated mill closure and two due to financing issues as the projects required a substantial investment on the part of the mills. As a result, only three projects were implemented in Step 4 of the TMP initiative, achieving approximately 57% of the expected outcome with incentives totalling $47 million.

Table 4.3 Expected energy savings and proposed project cost per step of the TMP initiative

	Number of projects	Total proposed Energy Savings (GWh/year)	Total proposed Project Costs ($ million)	Simple Payback Pre-Incentive[1] (years)	Simple Payback Post-Incentive[1] (years)
Step 1: Projects with application for energy study	17	1015	$364	5.4	
Step 2: Projects with energy study completed	11	808	$289	5.4	
Step 3: Projects with application for capital incentive	6	344	$143	6.3	2.1
Step 4: Projects with implementation	3	170	$71	6.3	2.2
Step 5: Projects with M&V completed in F2021	1	-- [2]	--	--	--
Additional capital projects enabled through the TMP initiative and with compounded effects	3	30	$12	6.2	2.6

[1] Simple payback was estimated with assumed average unit electricity cost of 6.6 cents per kilowatt-hour.
[2] Details not disclosed due to customer confidentiality

Further analysis of simple payback found individual project payback ranged from over two years to almost 10 years for an average simple payback of 5.4 years pre-incentive. Simple payback of projects with application for capital incentive ranged from 2.7 years to 9 years for an average simple payback of 6.3 years pre-incentive, while post-incentive payback ranged from 1.2 years to 5 years for an average simple payback of 2.2 years.

Participants indicated that the TMP initiative helped them improve energy efficiency and save costs, and that they were meeting their project targets. The competing goals of reducing energy consumption versus increasing mill productivity and revenue were also discussed in interviews. Participants generally were in the TMP initiative to conserve energy; one participant explained that the paper market in general is declining so there is no incentive to expand production.

The participants mentioned several non-energy impacts of the TMP initiative projects, both positive and negative. Positive effects included:

- the use of new technologies provided energy management tools which helped to better understand the relationship of energy and properties of core processes and new products that can be manufactured using mechanical pulp;
- new online quality analyzers enabled tracking pulp properties in real time and gave operators more insight and better control over the process; and,
- drop in condenser load which resulted in less cooling water required and quieter operation, thus improving working conditions in the mill.

On the negative side, participants reported impacts on product quality. One participant noted that some product lines they used to manufacture were affected and could not be produced to the same specifications. Another indicated that slightly lower pulp quality was expected and was generally found to be manageable after the project, but added that under certain conditions, they produce more off-grade pulp and are challenged in this respect. Another comment was that new processes or significant process modifications have a learning curve for operations staff, whose understanding is based on older processes, and it takes a while for them to adapt.

Objective 3: Qualitatively explore any market effects or sector changes influenced by the TMP initiative

Based on the comments from participants and BC Hydro staff, the TMP initiative did provide some degree of economic stability to the mills. At the time of the TMP initiative, BC Hydro staff expected that one or more of the participating mills might have had to close based on assessments conducted with industry experts for annual updates to the load forecast, although predicting the future of mills by anticipating market shifts is notoriously difficult. The fact that participating sites had to cover a significant portion of project costs and did invest in those as well as other projects certainly supports the idea that they believed in the economic viability of the sites. It was also thought likely that future energy efficiency projects may appear in mills that did not participate in the TMP Initiative.

Looking at the broader picture in sector changes influenced by BC Hydro, interviewees were asked to comment on the impact of a research program that BC Hydro financially supports at the University of British Columbia Pulp and Paper Centre -- Energy Reduction in Mechanical Pulping (ERMP)[9]. This industry consortium is now in its third phase with 16 partners and is known to be the largest research program in

9 Home Page | Energy Reduction in Mechanical Pulping (ubc.ca).

the world on mechanical pulping. It has made a positive contribution to the market adoption of emerging energy efficient technologies and the required technical expertise in B.C. The research also assists in the testing of new processes, the optimization of process variables and fibre properties, and conducting pilot trials with low consistency refiners and screening technology. This helped TMP participants in determining the right project fit for their mills.

4.4 Findings and Recommendations

1. BC Hydro's early consultation and interaction with industrial customers created the needed flexibility to address unique customer needs and barriers with the TMP initiative projects. For example, in addition to energy efficiency projects, turbine generator projects were made eligible after it became evident that there was potential for this type of conservation measure in four of the TMP mills.
2. Identification of energy savings opportunities at the beginning of the TMP initiative generated substantial interest and awareness among all the targeted customers. Seventeen projects were identified at the seven target mills, and six mills made an application for a TMP project incentive.
3. Implementing large capital projects such as those targeted by the TMP initiative is a lengthy and complex process. Some projects required close to two years between completion of energy study and the TMP incentive agreement due to customer decision making and project planning. At present, six years after the introduction of the TMP initiative, only one project has verified savings.
4. The TMP initiative increased awareness about energy efficiency and provided learning opportunities for mill staff. The TMP initiative led to transformative process changes at two of the three participating mills, with implications on mill operation and end-product quality that were ultimately managed.
5. The primary intent of participants was to conserve energy and reduce energy costs. Reduction in energy use intensity through higher production rates was a secondary consideration in this industry, as it continues to experience major market shifts and contraction.
6. On average the TMP incentives only covered 65% of the $71 million in project costs and the three implemented projects still required a substantial investment on the part of the mills. Other projects investigated through the initiative were not completed because they competed with other business initiatives for internal resources and capital.
7. Measurement and verification results were only available for one of the three TMP initiative projects at the time of this evaluation. Preliminary evaluation review of the three projects indicated that the verified energy savings will likely be as expected.

Lessons Learned

The following are the main lessons learned from the TMP initiative and should be considered when implementing similar initiatives in the future.

1. Large capital projects require long timelines for scope definition, planning, and implementation. Allowing participants plenty of time to accommodate their complex decision-making processes is particularly important for large capital project development and implementation.

2. Industry consultation and involvement early in the planning and design of the initiative, to understand what would best meet the needs of both BC Hydro and participants in terms of funding process and desired project outcomes, can lead to innovative ideas for program design.

The availability of expertise through an existing industry consortium of academia, utilities, suppliers, and industry partners was a valuable asset to address some of the barriers associated with the adoption of new energy efficient technologies.

4.5 Conclusions

The TMP initiative exceeded its expected outcome in generating TMP customer interest in energy efficiency projects but had limited success with bringing more projects to implementation due to customers' financial constraints and the perceived risk of committing to large-scale, transformative projects with long-term implications in an industry affected by continuing market changes.

5 Transmission Service Rate (TSR) Impact Evaluation: F2017 to F2020

5.1 Introduction

The Transmission Service Rate (TSR) was introduced on April 1, 2006 to large industrial customers that receive electricity supply at transmission voltage (60 kV or higher). This group of customers, about 150 sites, is dominated by industrial facilities and makes up about 25% of BC Hydro's overall energy sales.

A previous evaluation of the TSR was conducted in 2020, covering the period from F2012 to F2016. It evaluated the energy conservation impacts in response to the rate's two-step structure, as well as customer awareness, understanding, and support for the TSR rate. This evaluation adopts a similar scope and covers the period from April 2016 through March 2020 (Fiscal years F2017-F2020).

Under Rate Schedule 1823 Energy Rate B (RS1823B) - the default rate for these customers - electricity consumption is charged at a two-tiered rate for energy, plus a flat rate for demand. A customer-specific consumption baseline load (Energy CBL) is used to separate annual energy consumption into a lower-priced block of energy (Tier 1 energy) and a higher-priced block of energy (Tier 2 energy). The Tier 1 rate is applied to annual energy consumption up to 90% of the CBL. The rest of the consumption is billed at the higher-priced Tier 2 rate. A flat rate structure for energy is also provided under RS1823 Energy Rate A (RS1823A) for TSR customers who do not have a sufficient consumption history to permit the determination of a CBL (such as new customers), or whose facilities are undergoing significant changes that require sufficient operating history to establish a new CBL.

The CBL is based on the customer's historical energy consumption and is subject to annual review and periodic adjustments up and/or down in accordance with BC Hydro's Tariff Supplement 74 (TS 74) and with the approval of the British Columbia Utilities Commission. A CBL can also be reset (up or down) if the adjusted annual energy consumption falls below 90% of the CBL or exceeds 110% of the CBL. Customers are also eligible to apply for "energy bill adjustments" which, despite the name, do not change their energy bill but rather identify the specific events that contributed to a reduction in annual energy consumption. Common events include customer-funded DSM, incremental self-generation, force majeure, load curtailments, transmission system outages, and non-recurring downtime. This ensures that the CBL continues to serve as an appropriate baseline for normal operations and that the TSR encourages electricity conservation while not penalising business expansions. For example, under specified conditions, customer-funded DSM projects and/or incremental self-generation can result in an energy bill credit equivalent to the verified annual energy savings of the project. This credit is added to actual RS1823 energy consumption for the purpose of the annual CBL reset determination. A customer can thus conserve and/or reduce energy below the 90% of CBL threshold, but still avoid a CBL reset by receiving credit for their DSM efforts (provided that adjusted energy purchases are above the 90% of CBL threshold).

The stepped rate structure is designed for energy conservation as it creates a higher marginal price signal for TSR customers to encourage them to pursue energy efficiency gains and achieve energy conservation. This evaluation examines three major categories of customer-funded conservation impacts attributed to the TSR:

1. **TSR Reported DSM**. These are customer-funded DSM projects that are reported to BC Hydro through TSR filings for energy bill adjustments. These projects do not receive any other financial incentives from BC Hydro. Their energy saving impacts are considered to be influenced by the TSR incentive structure and are not claimed by any other BC Hydro DSM programs.

2. **Incremental self-generation**. Customer-funded projects that increase self-generation of energy and displace energy purchases from BC Hydro can also be reported for energy bill adjustments under the TSR. Energy savings attributed to the TSR is the portion of self-generation in excess of an established generation baseline and any contracted amounts sold to BC Hydro through electricity purchase agreements (EPA).
3. **Unreported DSM**. In addition, TSR customers may initiate other customer-funded DSM initiatives for which the energy impact is not accounted for under TSR reported DSM, incremental self-generation, or BC Hydro's conservation programs. These unreported DSM savings are also part of the evaluation scope.

5.2 Approach

The evaluation objectives and research questions are shown in Table 5.1

Table 5.1 Evaluation objectives and research questions

Evaluation objective	Research questions
1. Customer experience	• What is the general feedback from customers about their experience with the TSR?
2. Energy savings from TSR reported DSM	• What were annual incremental estimated gross energy savings from customer-funded energy conservation measures that were reported to BC Hydro through the annual CBL review process and not claimed as program-enabled savings under an industrial conservation and energy management program such as Leaders in Energy Management - Industrial? • What were annual incremental evaluated net energy and peak demand savings by fiscal year? • What does available data suggest about the persistence of savings?
3. Energy savings from TSR incremental self-generation	• What were adjusted gross reductions in energy purchases from BC Hydro (energy and demand) from incremental self-generation in response to the TSR by fiscal year?
4. Energy savings from unreported DSM	• What were annual incremental evaluated net energy savings from energy conservation measures that were not reported to BC Hydro but enabled by the TSR?
5. Total energy and capacity savings	• What was the total evaluated net reduction in energy purchases from BC Hydro (and associated capacity savings) by fiscal year?

The evaluation objectives, data sources, and methods are summarized in Table 5.2.

Table 5.2 Evaluation objectives, data and methods

Evaluation Objective	Data Sources	Methods
1. Customer experience	• F2017 to F2020 Leaders in Energy Management-T Participant Surveys (n=18)	• Cross tabulations of survey responses
2. Energy savings from TSR reported DSM	• Project files (n=5) • CBL Statements • PSP-T (F2012-F2014)/LEM-T (F2015-F2017) impact evaluation	• Engineering calculations • Gross realization rate • Free ridership estimation
3. Energy savings from TSR incremental self-generation	• List of sites reporting self-generation (n=11) • Customer metering data • CBL Statements	• Engineering calculations • Cross tabulation
4. Energy savings from unreported DSM	• BC Hydro's monthly billing data for TSR customers from F2017 to F2020 • Statistics Canada economic data for employment in the non-durable goods sector • TSR energy price history (RS1823B) • Consumer Price Index from BC Statistics Agency	• Economic analysis of billing data • Energy savings calculations based on price impact estimates
5. Total energy and capacity savings	• Results from objectives 2,3 and 4 • Peak-to-energy factor for industrial rate class	• Engineering calculations

5.3 Results

Results for Objective 1: Customer experience

The main source used to assess customer experience was an online survey of Leaders in Energy Management-Transmission (LEM-T) program participants. While this survey is used primarily to inform program evaluation, some questions pertained to experience with the TSR. Among LEM-T participants that had completed a program enabled project (i.e., a customer-funded DSM project that did not directly receive an incentive, but that may have received funding for the energy study or other BC Hydro support) during the evaluation period, 72% of program survey respondents (n=18) reported that the financial benefits through the TSR had been either very (39%) or somewhat (33%) influential on the decision to implement the energy-efficient measure. A total of 50% reported that the project would have met their organization's financial criteria even without the benefit from the TSR, while 17% reported that it would not have met their financial criteria, but likely would have gone ahead in some form. A further 28% reported that the project would not have gone ahead at all without support from the program.

Results for Objective 2: Energy savings from TSR reported DSM

Gross energy savings for TSR reported DSM are the change in energy consumption that resulted directly from customer-funded DSM projects and were not otherwise claimed as DSM program savings. This evaluation period covered five projects, all of which were for new plant design energy conservation measures. They were reported to BC Hydro for energy bill adjustments (and CBL administration) but not attributed to BC Hydro DSM programs. The evaluated gross energy savings are based on the project's most recent and best available estimate of energy savings in each fiscal year. Under the TSR, these projects result in an annual energy bill adjustment on the customer's CBL statement. Project performance is often tied to operating conditions, and in the present case all projects (five in total) had annual post-implementation engineering reviews. Therefore, the energy bill adjustment for a given fiscal year was considered the best available estimate of energy savings. The evaluation found an average gross realization rate of 99% when compared to the initial review of energy savings used for the reported gross savings which indicates that the year-over-year savings variability was on average aligned with the evaluated gross energy savings.

Evaluated net energy savings between F2017 and F2020 were calculated using the gross savings of each project multiplied by the evaluated net-to-gross ratio and are shown in Table 5.3 Energy savings are presented as incremental savings achieved during the evaluation period and expressed as an annual rate of savings (run rate savings).

Table 5.3 Evaluated gross and evaluated net energy savings from TSR reported DSM

Evaluation Period	Number of projects	Evaluated Gross Energy Savings (GWh/year)	Evaluated Net-to-Gross Ratio	Evaluated Net Energy Savings (GWh/year)
TOTAL (F2017-F2020)	**5**	**368.1**	**0.50**	**182.3**

Results for Objective 3: Energy savings from TSR incremental self-generation

The energy savings from incremental self-generation were obtained from CBL statements which provide results that have been verified by BC Hydro Contract Management as part of the TSR reporting requirements. Eligibility to report incremental self-generation energy in response to the TSR was limited to customers who were on the stepped rate (RS1823B) for the fiscal year when the energy generation occurred. Peak capacity savings were estimated by applying the peak-to-energy factor of 0.117 MW per GWh for the transmission rate class only to the incremental self-generation energy of customer sites that did not have an EPA with BC Hydro. For customer sites with an EPA, the incremental self-generation recognized as DSM is not delivered steadily and capacity savings cannot be ascribed to this particular form of excess generation energy. The total incremental self-generation and the associated capacity savings are given by fiscal year in the table on the next page.

Table 5.4 Evaluated net energy and capacity savings from TSR incremental self-generation

Fiscal Year	Evaluated Net Energy Savings (GWh/year)	Evaluated Net Capacity Savings (MW)
F2017	107	11
F2018	57	5
F2019	92	0
F2020	115	5
Average per Year (F2017-F2020)	**93**	**5**

Results for Objective 4: Energy savings from unreported DSM

Unreported DSM savings refer to energy savings that are induced by the stepped rate structure but not accounted for under TSR reported DSM, incremental self-generation, or BC Hydro's conservation programs. Unreported DSM savings were estimated through econometric modelling, by building regression models that relate changes in TSR customer's energy consumption to changes in energy prices and economic activity. Two different econometric model specifications were examined in this evaluation, and both produced negative estimates for unreported DSM savings, thus providing no evidence for the existence of such savings. Therefore, the unreported DSM savings were evaluated as zero.

Results for Objective 5: Total energy and capacity savings

For the evaluation period from F2017 to F2020, total net energy savings under the TSR were evaluated at 275 GWh per year, and total net capacity savings were evaluated at 26 MW. The evaluated net energy savings represent 79% of reported savings.

5.4 Findings and Recommendations

Findings and recommendations are presented below.

Customer Experience

1. Among Leaders in Energy Management-Transmission participants that completed a program enabled project, 72% reported that the financial benefits through the TSR had been 'very influential' or 'somewhat influential' on their organization's decision to implement the energy-efficient measure.

Energy Savings from TSR reported DSM

1. The evaluated gross energy savings of TSR reported DSM for F2017 to F2020 were estimated at 368 GWh per year, with a gross realization rate of 99%.

2. The evaluated net energy savings from TSR reported DSM for F2017-F2020 were estimated at 182 GWh per year. The net-to-gross ratio of TSR reported DSM projects was found to be 50%. Free ridership of 54% was estimated based on evaluation review of the TSR reported DSM projects using free ridership scores and criteria from industrial program evaluations of similar projects. Participant spillover of 4% was estimated from conservation measures installed but not recognized for CBL administration.

3. Evaluated net energy savings from TSR reported DSM projects achieved 75% of reported savings. The variance between reported and evaluated savings was primarily due to the difference between the deemed and evaluated net-to-gross ratio for TSR reported DSM for new plant design energy conservation measures. The average expected persistence of TSR reported DSM projects was found to be 10.6 years.

Energy Savings from TSR incremental self-generation

1. Annual average energy savings from TSR incremental self-generation were estimated at 93 GWh per year and achieved on average 97% of reported savings. Incremental self-generation for customers without an Electricity Purchase Agreement was found to have capacity savings, whereas, incremental self-generation for customers with an Electricity Purchase Agreement had no associated capacity savings.

2. The variance between reported and evaluated energy savings from TSR incremental self-generation is primarily due to the removal of self-generation energy from two load displacement projects that had also been reported to the BC Hydro Leaders in Energy Management program. A secondary source of variance was the refinement of energy estimates that occurred through the CBL review process, as these updates were not carried over to the energy savings for DSM reporting.

3. The persistence of energy savings from TSR incremental self-generation was one year, i.e., the fiscal year where the savings occurred. Due to the highly variable output and unpredictable fluctuations in savings from self-generation, they were subject to a rigorous annual verification process.

Energy Savings from TSR unreported DSM

1. Analysis of TSR RS1823B customers’ energy consumption through econometric modelling did not provide evidence for unreported DSM savings during the evaluation period and no savings were ascribed to TSR Unreported DSM in this evaluation.

Total Electricity Savings from TSR

1. For the evaluation period from F2017 to F2020, total net energy savings under the TSR are evaluated at 275 GWh per year, and total net capacity savings are evaluated at 26 MW. Evaluated net energy savings achieved 79% of reported savings.

Recommendations

The following recommendations flow from the findings of this evaluation.

1. Consider applying the evaluated Net-to-Gross ratio of 0.50 from this evaluation to future savings claimed for TSR reported DSM if the projects fall in the category of new plant design.

2. Remove savings from TSR incremental self-generation for sites with a DSM program-based load displacement agreement and without Electricity Purchase Agreement (EPA) as these were reported through the program.

3. Adjust TSR unreported DSM savings to zero for the evaluation period and consider discontinuing future claims for such savings.

5.5 Conclusions

Total net energy savings under the Transmission Service Rate were evaluated at 275 GWh per year in the period from F2017 to F2020, representing 79% of reported savings. The associated capacity savings were evaluated at 26 MW.

6 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.

SUMMATIVE EVALUATION OF THE THERMO-MECHANICAL PULP INITIATIVE: F2015-F2021

July 22, 2022

Prepared by:

BC Hydro Conservation and Energy Management Evaluation

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EXECUTIVE SUMMARY

Introduction

This report presents the results of an evaluation of the BC Hydro Thermo-Mechanical Pulp (TMP) Initiative for fiscal years F2015 to F2021 (April 1, 2014 to March 31, 2021). The TMP initiative was a one-time offer available to all seven BC Hydro thermo-mechanical pulping customers to complete electrical energy-efficiency upgrades to facilities. The initiative was implemented pursuant to the Government of B.C.'s Direction to the BCUC Respecting the Authority's TMP Program. This direction requires the BCUC to allow BC Hydro to recover up to $100 million in costs incurred to carry out the program.

One objective of the TMP initiative was to help pulp and paper producers, who faced economic pressures, to save electricity and reduce their operating costs, thereby helping them to remain globally competitive, and supporting thousands of jobs across the province. At that time, these facilities consumed over 5,000 GWh of electricity per year – roughly 10 percent of BC Hydro's total electricity sales.

The initiative had a target budget of $100 million for incentives. In the end, three mills entered into an agreement with BC Hydro to complete an approved capital project to receive an incentive, and all projects were expected to undergo annual review and verification of energy savings. The projects implemented through the TMP initiative provided thermo-mechanical pulp mills in BC with an opportunity to complete upgrades which would help companies to maintain economically viable operations, offset expected rate increases, and reduce the electrical energy input per unit of production.

At the time of this evaluation only one of the three projects had completed post-implementation measurement and verification (M&V) activities.[1] Therefore, this is a summative evaluation[2] focusing on lessons learned and the effectiveness of the program in achieving its intended outcomes.

[1] Results of verified savings for all three projects are expected to be available in F2023 and will supersede the reported savings from post-implementation review. Verified savings from annual M&V will be reported thereafter.

[2] A summative evaluation is outcome focused and examines an intervention's impact or efficacy through examination of program design and management. It is most often undertaken at the end of a program or project.

Approach

The following table presents the evaluation objectives and associated research questions that guided the evaluation.

Table ES.1 Evaluation Objectives and Research Questions

Evaluation Objective	Research Questions
1. Identify the successes and challenges encountered in the design and implementation of the TMP initiative	To what extent did the actual TMP initiative align with what was originally planned? What were the key challenges or issues from a design perspective? What were the business drivers for participating in the TMP initiative? Were there any unanticipated barriers to participation? Are there any best practices and lessons learned for BC Hydro to consider in developing initiatives of similar size and scope in different sectors?
2. Examine the extent to which expected outcomes were realized	What energy conservation measures were investigated through energy studies? What energy conservation measures were implemented using TMP project incentives? Are the energy conservation measures implemented achieving the expected magnitude of savings? To what extent were the energy conservation measures used to improve energy productivity (e.g., yield, quality, production rate, product type, new products)? What were the non-energy impacts of the TMP projects? Are there any significant energy related cross effects that occurred through the interaction of the TMP projects and waste heat recovery?
3. Qualitatively explore any market effects or sector changes influenced by the TMP initiative	Is there evidence of economic sustainability of companies that received TMP project incentives in terms of reduced site viability risk or evidence of company intentions to invest further in mills that participated in the TMP project incentives? How did the University of British Columbia research program on energy reduction in mechanical pulping contribute to energy efficiency projects and market adoption of emerging energy efficiency technologies in BC? Have any additional large capital energy efficiency projects been identified as a result of the TMP initiative? In what ways did the TMP initiative help to advance technical knowledge and skills within the mechanical pulping industry?

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

Table ES.2 Evaluation Objectives, Data and Methods

Evaluation Objective	Data Sources	Methods
1. Identify the successes and challenges encountered in the design and implementation of the TMP initiative	Initiative documentation Interviews with program managers, Key Account Managers Interviews with participants and non-participants	• Qualitative analysis
2. Examine the extent to which expected outcomes were realized	Administrative program and project tracking data Interviews with participants	• Qualitative analysis • Project data review and summary
3. Qualitatively explore any market effects or sector changes influenced by the TMP initiative	Interviews with participants	• Qualitative analysis

Results

Objective 1: Identify the successes and challenges in the design and implementation of the TMP initiative

The main drivers for companies to participate in the initiative were that it allowed them to upgrade the technology at the mill to be more efficient and reduce energy costs. The initiative also enabled them to validate the applicability of new technology and think on a bigger scale about cost structure and competitiveness.

Funding ranged from $5 million to $25 million per project. However, both BC Hydro staff and participants mentioned that the funding cap of 75 percent of total project costs, which was part of the initiative design, was a financial constraint considering the participants' limited ability to contribute to the cost of upgrades given their financial issues and the short window of time in which implementation had to occur. Putting together these large capital projects in a tight timeframe was difficult, given the time required to identify a suitable project for the initiative, complete engineering studies, and make a substantial investment decision in an environment where it was difficult to predict long term market needs for mechanical pulp and paper products. BC Hydro staff commented that having more time to explore design options or ideas with suppliers before launching the initiative could have helped to understand technology accessibility and delivery timelines.

One interviewee who did not pursue a TMP incentive application said BC Hydro was very cooperative in attempting to make their application work, but ultimately the company was risk averse and decided not to proceed with the initiative given the poor paper market at the time.

When asked what could have been done better, one participant mentioned that BC Hydro's fiscal year (which ends in March) is not aligned with their company's fiscal year (which runs the calendar year), which forced them into a shorter lead time to plan bigger projects. Similarly, BC Hydro staff felt that large-scale, transformative projects, like those targeted by the TMP initiative, need sufficient time up front to plan and strategize as the impact will be long term. Another BC Hydro staff member mentioned that for some mills the TMP initiative may have been "too little, too late" as some of the facilities were just too old to be upgraded, noting that two of the originally targeted mills were permanently closed before project incentives were committed.

Communications about eligibility and incentives were clear and well laid out according to participants. Any questions were usually quickly answered. They also felt that the similarity of the TMP initiative delivery model to other BC Hydro incentive programs made it easier to manage. BC Hydro staff felt the initiative rollout could have been smoother and that having a defined project change approval process in advance would have been helpful.

Objective 2: Examine the extent to which expected outcomes were realized

The outcomes of the TMP initiative can be traced through the evolution of project related activity along five steps, from preliminary assessments to energy study applications, through to project implementation and completion of measurement and verification activities. In some cases, additional capital projects were also installed outside the TMP initiative project to improve the overall energy performance of the mill.

All seven TMP mills submitted applications for energy studies. These applications covered 17 projects totalling proposed energy savings of over 1,000 GWh per year. However, many projects did not proceed through all steps for various reasons and only three projects were implemented for total expected energy savings of 170 GWh per year. Reasons and barriers to implementation included the closure of two TMP mills and limited access to financing to complete projects at another two of the mills. Table ES.3 below summarizes the evolution of expected energy savings and proposed project costs as projects went through the five steps of the TMP initiative.

The targeted outcome of the $100 million in capital incentives was 300 GWh per year of energy savings. This was exceeded two- to threefold in terms of activity generated in Step 1 and Step 2 as can be seen in Table ES.3. The six projects that submitted applications for capital incentives in Step 3 also exceeded the initiative target. However, three projects withdrew their incentive application before an incentive agreement was signed, one due to an anticipated mill closure and two due to financing issues as the projects required a substantial investment on the part of the mills. As a result, only three projects were implemented in Step 4 of the TMP initiative, achieving approximately 57 percent of the expected outcome with incentives totalling $47 million.

Table ES.3 Expected energy savings and proposed project cost per step of the TMP initiative

	Number of projects	Total proposed Energy Savings (GWh/yr)	Total proposed Project Costs ($ million)	Simple Payback Pre-Incentive[1] (years)	Simple Payback Post-Incentive[1] (years)
Step 1: Projects with application for energy study	17	1015	$364	5.4	
Step 2: Projects with energy study completed	11	808	$289	5.4	
Step 3: Projects with application for capital incentive	6	344	$143	6.3	2.1
Step 4: Projects with implementation	3	170	$71	6.3	2.2
Step 5: Projects with M&V completed in F2021	1	-- [2]	--	--	--
Additional capital projects enabled through the TMP initiative and with compounded effects	3	30	$12	6.2	2.6

[1] Simple payback was estimated with assumed average unit electricity cost of 6.6 cents per kilowatt-hour.
[2] Details not disclosed due to customer confidentiality

Further analysis of simple payback found individual project payback ranged from over two years to almost 10 years for an average simple payback of 5.4 years pre-incentive. Simple payback of projects with application for capital incentive ranged from 2.7 years to 9 years for an average simple payback of 6.3 years pre-incentive, while post-incentive payback ranged from 1.2 years to 5 years for an average simple payback of 2.2 years.

Participants indicated that the TMP initiative helped them improve energy efficiency and save costs, and that they were meeting their project targets. The competing goals of reducing energy consumption versus increasing mill productivity and revenue were also discussed in interviews. Participants generally were in the TMP initiative to conserve energy; one participant explained that the paper market in general is declining so there is no incentive to expand production.

The participants mentioned several non-energy impacts of the TMP initiative projects, both positive and negative. Positive effects included:

- the use of new technologies provided energy management tools which helped to better understand the relationship of energy and properties of core processes and new products that can be manufactured using mechanical pulp;
- new online quality analyzers enabled tracking pulp properties in real time and gave operators more insight and better control over the process; and,
- drop in condenser load which resulted in less cooling water required and quieter operation, thus improving working conditions in the mill.

On the negative side, participants reported impacts on product quality. One participant noted that some product lines they used to manufacture were affected and could not be produced to the same specifications. Another indicated that slightly lower pulp quality was expected and was generally found to be manageable after the project, but added that under certain conditions, they produce more off-grade pulp and are challenged in this respect. Another comment was that new processes or significant process modifications have a learning curve for operations staff, whose understanding is based on older processes, and it takes a while for them to adapt.

Objective 3: Qualitatively explore any market effects or sector changes influenced by the TMP initiative

Based on the comments from participants and BC Hydro staff, the TMP initiative did provide some degree of economic stability to the mills. At the time of the TMP initiative, BC Hydro staff expected that one or more of the participating mills might have had to close based on assessments conducted with industry experts for annual updates to the load forecast, although predicting the future of mills by anticipating market shifts is notoriously difficult. The fact that participating sites had to cover a significant portion of project costs and did invest in those as well as other projects certainly supports the idea that they believed in the economic viability of the sites. It was also thought likely that future energy efficiency projects may appear in mills that did not participate in the TMP Initiative.

Looking at the broader picture in sector changes influenced by BC Hydro, interviewees were asked to comment on the impact of a research program that BC Hydro financially supports at the University of British Columbia Pulp and Paper Centre -- Energy Reduction in Mechanical Pulping (ERMP)[3]. This industry consortium is now in its third phase with 16 partners and is known to be the largest research program in the world on mechanical pulping. It has made a positive contribution to the market adoption of emerging energy efficient technologies and the required technical expertise in B.C. The research also assists in the testing of new processes, the optimization of process variables and fibre properties, and conducting pilot trials with low consistency refiners and screening technology. This helped TMP participants in determining the right project fit for their mills.

Findings and Lessons Learned

Findings

1) BC Hydro's early consultation and interaction with industrial customers created the needed flexibility to address unique customer needs and barriers with the TMP initiative projects. For example, in addition to energy efficiency projects, turbine generator projects were made eligible after it became evident that there was potential for this type of conservation measure in four of the TMP mills.
2) Identification of energy savings opportunities at the beginning of the TMP initiative generated substantial interest and awareness among all the targeted customers. Seventeen projects were identified at the seven target mills, and six mills made an application for a TMP project incentive.
3) Implementing large capital projects such as those targeted by the TMP initiative is a lengthy and complex process. Some projects required close to two years between completion of the energy study and the TMP incentive agreement due to customer decision making and project planning. At present, six years after the introduction of the TMP initiative, only one project has verified savings.
4) The TMP initiative increased awareness about energy efficiency and provided learning opportunities for mill staff. The TMP initiative led to transformative process changes at two of the three participating mills, with implications on mill operation and end-product quality that were ultimately managed.
5) The primary intent of participants was to conserve energy and reduce energy costs. Reduction in energy use intensity through higher production rates was a secondary consideration in this industry, as it continues to experience major market shifts and contraction.
6) On average the TMP incentives only covered 65 percent of the $71 million in project costs and the three implemented projects still required a substantial investment on the part of the mills. Other projects investigated through the initiative were not completed because they competed with other business initiatives for internal resources and capital.
7) Measurement and verification results were only available for one of the three TMP initiative projects at the time of this evaluation. Preliminary evaluation review of the three projects indicated that the verified energy savings will likely be as expected.

[3] Home Page | Energy Reduction in Mechanical Pulping (ubc.ca)

Lessons Learned

The following are the main lessons learned from the TMP initiative and should be considered when implementing similar initiatives in the future.

1) Large capital projects require long timelines for scope definition, planning and implementation. Allowing participants plenty of time to accommodate their complex decision-making processes is particularly important for large capital project development and implementation.
2) Industry consultation and involvement early in the planning and design of the initiative, to understand what would best meet the needs of both BC Hydro and participants in terms of funding process and desired project outcomes, can lead to innovative ideas for program design.
3) The availability of expertise through an existing industry consortium of academia, utilities, suppliers, and industry partners was a valuable asset to address some of the barriers associated with the adoption of new energy efficient technologies.

Conclusions

The TMP initiative exceeded its expected outcome in generating TMP customer interest in energy efficiency projects but had limited success with bringing more projects to implementation due to customers' financial constraints and the perceived risk of committing to large-scale, transformative projects with long-term implications in an industry affected by continuing market changes.

1.0 INTRODUCTION

1.1 Evaluation Scope

This report presents the results of a summative evaluation[4] of the BC Hydro Thermo-Mechanical Pulp (TMP) Initiative covering fiscal years F2015 to F2021 (April 2014 to March 2021). The TMP initiative was a limited, one-time offer available to BC Hydro thermo-mechanical pulp customers. The initiative was implemented pursuant to the Government of B.C.'s Direction to the BCUC Respecting the Authority's TMP Program. This direction requires the BCUC to allow BC Hydro to recover up to $100 million in costs incurred to carry out the program. The TMP initiative falls in a special category of industrial programs, defined in the *BC Hydro DSM Evaluation Strategy* as programs where 100% of projects are subjected to measurement and verification (M&V). In those instances, the BC Hydro strategy calls for an evaluation within six years and targeting gross savings only. This summative evaluation examines the design and outcomes of the TMP initiative.

1.2 Organization of the Report

Section 1 covers the evaluation scope, the organization of the report and the initiative description. Section 2 discusses the approach to the evaluation, including evaluation objectives, methodology review, data sources, and methods. The results, organized by evaluation objectives, are presented in Section 3. Findings and lessons learned are discussed in Section 4, and Section 5 provides conclusions.

1.3 Initiative Description

The TMP initiative provided BC Hydro's industrial customers producing thermo-mechanical pulp[5] with capital funding to complete electrical energy efficiency upgrades to facilities. Thermo-mechanical pulping is a very energy intensive process often with electricity costs that account for as much as 30% of the mill's operating budgets. These upgrades were meant to allow companies to maintain viable operations by offsetting the impact of electricity rate increases. The initiative was available to seven customer sites and all projects were expected to undergo annual review and verification of energy savings. One objective of the TMP initiative was to help pulp and paper producers, who faced economic pressures, to save electricity and reduce their operating costs, thereby helping them to remain globally competitive, and supporting thousands of jobs across the province. Unlike other demand side management (DSM) initiatives or programs offered by BC Hydro, the TMP initiative did not focus only on projects that reduced overall energy consumption, but also allowed upgrades that reduced the electrical energy input per unit of production. The TMP initiative was a limited time offer launched in July 2014 with an expected project application close by October 2015. The project application close date was later extended by two years to October 2017.

TMP project incentives were awarded to companies with projects that would increase the electrical energy efficiency of a site and result in reduced electrical load or reduced energy-use intensity (EUI) relative to the baseline amount. Customers could submit multiple project proposals and could receive funding for studies and incentives to implement capital projects as long as the projects passed all of BC Hydro's standard cost tests. An expenditure approval request was developed for each project which required approval by the BC Hydro Board of Directors.

Seven TMP mills were identified as potential participants. These mills had approximately 600 MW of installed power in mechanical pulp refiners. At that time, these facilities consumed over 5,000 GWh of electricity per year

[4] A summative evaluation is outcome focused and examines an intervention's impact or efficacy through examination of program design and management. It most often undertaken at the end of a program or project.

[5] A description of thermomechanical pulping process can be found in Sandberg, Christer, Hill, Jan and Jackson, Michael. On the development of the refiner mechanical pulping process – a review. *Nordic Pulp & Paper Research Journal*, vol. 35, no. 1, 2020, pp. 1-17. https://doi.org/10.1515/npprj-2019-0083

– roughly 10% of BC Hydro's total electricity sales. The initiative had a target budget of $100 million for incentives, and the initial incentive allocation was based on the installed refiner motor power which has a direct relationship with a site's pulp production capacity and energy use. TMP customers interested in entering into an agreement for an incentive had to agree to completing pre- and post-project energy baseline assessments for each grade of pulp/paper produced at each participating mill location in B.C. The benchmark was required in the calculation of the project's energy savings and capital incentive. Each project incentive was calculated based on the lesser of a) the site's allocated funding based on installed refiner power, b) 75% of eligible incremental project cost, or c) an incentive cap based on the levelized incentive rate of $45 per MWh of energy saved. In the end, three mills entered into an agreement with BC Hydro to complete an approved capital project to receive an incentive.

2.0 EVALUATION APPROACH

2.1 Evaluation Objectives

At the time of this evaluation only one of the three projects had undergone measurement and verification. Results for the other two projects are expected to be available in F2023 and reviewed and reported annually thereafter. Therefore, the evaluation could not report energy savings outcomes for the TMP initiative and this summative evaluation was undertaken to examine other expected outcomes.

The objectives and research questions for this evaluation are summarized below.

Table 2.1. Evaluation Objectives and Research Questions

Evaluation Objective	Research Questions
1. Identify the successes and challenges encountered in the design and implementation of the TMP initiative	To what extent did the actual TMP initiative align with what was originally planned? What were the key challenges or issues from a design perspective? What were the business drivers for participating in the TMP initiative? Were there any unanticipated barriers to participation? Are there any best practices and lessons learned for BC Hydro to consider in developing initiatives of similar size and scope in different sectors?
2. Examine the extent to which expected outcomes were realized	What energy conservation measures were investigated through energy studies? What energy conservation measures were implemented using TMP project incentives? Are the energy conservation measures implemented achieving the expected magnitude of savings? To what extent were the energy conservation measures used to improve energy productivity (e.g., yield, quality, production rate, product type, new products)? What were the non-energy impacts of the TMP projects? Are there any significant energy related cross effects that occurred through the interaction of the TMP projects and waste heat recovery?
3. Qualitatively explore any market effects or sector changes influenced by the TMP initiative	Is there evidence of economic sustainability of companies that received TMP project incentives in terms of reduced site viability risk or evidence of company intentions to invest further in mills that participated in the TMP project incentives? How did the University of British Columbia research program on energy reduction in mechanical pulping contribute to energy efficiency projects and market adoption of emerging energy efficiency technologies in BC? Have any additional large capital energy efficiency projects been identified as a result of the TMP initiative? In what ways did the TMP initiative help to advance technical knowledge and skills within the mechanical pulping industry?

2.2 Methodology

The objectives, data sources and methods used for this evaluation are summarized in Table 2.2. A more detailed description of the data sources and analytic approach follows the table.

Table 2.2. Evaluation Objectives, Data Sources and Methods

Evaluation Objective	Data Sources	Methods
1. Identify the successes and challenges encountered in the design and implementation of the TMP initiative	• Initiative documentation • Interviews with program managers, Key Account Managers • Interviews with participants and non-participants	• Qualitative analysis
2. Examine the extent to which expected outcomes were realized	• Administrative program and project tracking data • Interviews with participants	• Qualitative analysis • Project data review and summary
3. Qualitatively explore any market effects or sector changes influenced by the TMP initiative	• Interviews with participants	• Qualitative analysis

2.2.1 Data and Methods for Interview-based Research (Objectives 1, 2, 3)

A total of eight semi-structured in-depth interviews were completed for this evaluation. A third-party contractor conducted four one-on-one interviews with Energy Managers or Project Leads from the pulp industry organizations involved with BC Hydro's TMP initiative. These interviews were also attended by a Specialist Engineer from the evaluation team to deal with any technical topics that arose in the interviews. The interviewees consisted of three representatives from the three companies that participated in the initiative and one company that qualified but did not participate in the TMP initiative. As well, four BC Hydro staff members who were involved with designing and implementing the initiative were interviewed, including two from BC Hydro Industrial Marketing and two Key Account Managers.[6]

The interviews ranged from about 30 minutes to one hour and were conducted in November and December 2020. BC Hydro developed the question guides, which can be found in Appendix B.

2.2.2 Data and Methods for Objective 2: Examine the extent to which expected outcomes were realized

In addition to interview-based research, initiative documentation and project data for each of the seven TMP mills were examined for related activity in each of five steps of project progression, from proposed savings to verified savings. The five steps identified included:

- Step 1: Identification of projects based on preliminary assessment of proposed project scope and energy savings with application for funding of an energy efficiency feasibility study.
- Step 2: Investigation and energy efficiency feasibility study completed by third-party consultants with cost-benefit analysis of various options and scenarios.
- Step 3: Application for capital incentive based on selection of project from energy study with BC Hydro engineering review of expected energy savings and project cost estimate.
- Step 4: Project implementation with post-implementation review of energy savings and project costs by BC Hydro, including incentive payments as per agreement.

[6] Key Account Managers manage BC Hydro's relationship with its largest industrial, commercial, institutional and government accounts.

- Step 5: Annual review with measurement and verification of energy savings, including consideration of interconnected and compounded effects from additional capital projects for TMP process improvement but installed outside of the TMP initiative.

The TMP initiative allowed two types of projects: TMP process improvement projects and turbine-generator projects at the TMP mill. A total of 17 projects were identified in Step 1 with all seven mills completing at least one energy study. Additional details on project related activity in each step is provided in Section 3 of this report.

The evaluation of gross energy savings, one of the key expected outcomes of the TMP initiative, was planned to be based on M&V analyses conducted on an annual basis. However, as mentioned previously, annual M&V results were available for only one project in this evaluation period. The other two projects suffered delays in installation and commissioning, thus delaying M&V work, and the M&V analysis was further complicated by the interconnected and compounded effects of other capital projects outside the TMP initiative. Since M&V results were not available, the evaluation of gross energy savings was removed from the scope of this evaluation. In any case, energy savings reported for all projects in the TMP initiative will be based on annual M&V results as soon as these become available, since reported savings are regularly updated to reflect best available estimates.

3.0 RESULTS

3.1 Results for Objective 1: Identify the successes and challenges encountered in the design and implementation of the TMP initiative

The provincial government together with BC Hydro announced the TMP initiative in July 2014 to help mechanical pulp producers remain globally competitive, support jobs across the province and reduce electricity costs while keeping electricity rates low for all customers over the long-term. As such, BC Hydro staff saw the main business driver of the TMP initiative as being a way to assist the TMP industry customers to support investments in more energy efficient equipment and transform their business processes in helping to improve the competitiveness and viability of B.C.'s TMP mills.

Participants had similar views citing the following as the main drivers behind their respective company's involvement in the initiative:

- upgrading the technology at the mill and allowing the company to be more efficient and conserve energy, including the opportunity to validate the applicability of new technology;
- providing an incentive to think on a bigger scale about cost structure and competitiveness of the mill; and
- reducing energy costs, in view of steadily rising electricity rates that have eroded the competitiveness of the BC industry.

Both BC Hydro staff and participants mentioned financial constraints of the TMP initiative. Funds for each of the seven prospective participants were allocated based on installed refining power. Funding was limited to 75% of total project costs and ranged from $5 million to $25 million per project. This funding cap was a major constraint considering the participant's limited ability to contribute to the cost of upgrades given their financial issues and the short window in which implementation had to occur.

Participants and BC Hydro staff mentioned a number of challenges to participating in the TMP initiative, including the relatively tight timelines. For BC Hydro staff, there was a sense of urgency in developing this initiative to counteract some of the negative pressure experienced by the industry at the time. The TMP initiative needed to be implemented fairly quickly but delivering an initiative that the industry could use was challenging given the financial state of the industry and issues around credit and access to capital beyond the TMP incentive. Despite this sense of urgency, the approval of specific projects was delayed, in part, because of a change in BC Hydro's internal approval processes. The initial plan was to submit a business case for the full TMP initiative for approval by the BC Hydro Board of Directors. This was subsequently changed to project-level approval through the BC Hydro expenditure authorization request procedure. Project approval was also delayed by participants. Putting together these large projects in a tight timeframe was difficult for the mills, given the time required to identify a suitable project for the initiative, having to wait for the results of engineering studies before deciding whether to proceed, and difficulty in predicting long term market needs for pulp and paper products.

The participants stated that BC Hydro addressed the challenges in several ways such as by helping fund studies and trials that were used to design new processes or bundling the TMP funding with other BC Hydro funding initiatives to assist with scaling the capital project to the customer's needs. Removing the typical BC Hydro requirement to have security upfront when providing a financial incentive eliminated a major hurdle for at least one participant. The TMP initiative was designed with financial penalties if a project did not operate as expected, such that financial security was embedded as a commercial liability as opposed to forcing the proponent to post that commercial commitment up front at a significant cost. The interviewee who did not pursue a TMP incentive application said BC Hydro was very cooperative in attempting to make their application work, but ultimately the company was risk averse and decided not to proceed with the initiative given the poor paper market at the time.

When asked what could have been done better, the common thread among participants and BC Hydro staff was the timing of when the TMP initiative elements would be in place. One participant mentioned that BC Hydro's fiscal year (which ends in March) is not aligned with their fiscal year (which runs the calendar year), which forced them into a shorter lead time to plan bigger projects. Another participant talked about the difficulty in deciding on a project that transforms the TMP process and the potential long-term risk in committing to one because of the transitioning paper market. Similarly, BC Hydro staff felt that transformative projects, like those targeted by the TMP initiative, need sufficient time up front to plan and strategize as the impact will be long term. Another BC Hydro staff member mentioned time in the sense of the TMP initiative perhaps being "too little, too late" as some of the facilities were just too old to be upgraded. In fact, two of the seven TMP mills originally targeted were permanently closed during the TMP initiative and before project incentives were committed.

From the participants' standpoint, BC Hydro did a number of things that went well when delivering the TMP initiative:

- Communications about eligibility and incentives were clear and well laid out. There was ongoing in-person and telephone updates from BC Hydro Key Account Managers. Any questions from participants were usually quickly answered.
- The TMP initiative design was very similar to other BC Hydro incentive programs so participants were already familiar with how to manage the initiative.
- Not having the financial security requirement for eligibility was also seen as a positive, with more flexibility on the incentive payment schedule from BC Hydro. For example, one participant received quarterly incentive payments from BC Hydro instead of a few large incentive payments at project completion milestones.

In terms of things to consider when developing initiatives of similar size and scope in the future, BC Hydro staff pointed out:

- Engaging customers and obtaining feedback into initiative design for large incentives is important, especially in determining what would best meet the needs of both BC Hydro and participants in terms of funding process and desired project outcomes. One staff member noted the progressive incentive payments built into the initiative was an innovative and unique way to help mitigate financial risks on large projects.
- Looking at other markets and jurisdictions for examples of efficiency, to see what they do and how they might be doing it better, was another suggestion for best practice. In this context, European mills were seen as the example to follow.
- Having more time to explore more initiative design options or ideas with suppliers before launching could have been beneficial to examine technology accessibility and delivery timelines.
- To assist customers to transform their business viability, it was perceived that funding needs to be larger to enable the leap from projects that improve energy efficiency for current products to transformative projects that alter processes and open markets for new products.
- Initiative rollout could have been smoother through better planning and flexibility; one staff member commented that having a defined project change approval process in advance would have been helpful.

3.2 Results for Objective 2: Examine the extent to which expected outcomes were realized

The outcomes of the TMP initiative can be traced through the evolution of project related activity along the five steps from preliminary assessments and prioritization of many project ideas to implementation of a few projects. In some cases, additional capital projects were also installed outside the TMP initiative main project to improve the overall energy performance of the mill.

The level of activity for each step is shown in Table 3.1 by mill and in Table 3.2 by type of project. Step 1 involved all seven participating TMP mills and 17 applications for energy studies were submitted. Six participants had two or more projects identified for the TMP initiative. Eleven energy studies were completed in Step 2 and four participants completed two energy studies each at their mills.

Table 3.1. Number of Projects by Mill and through the Steps of the TMP Initiative

Mill	Step 1: Number of projects with application for energy study	Step 2: Number of projects with energy study completed	Step 3: Number of projects with application for capital incentive	Step 4: Number of projects with implementation
A	4 (3 withdrawn)	1	1	1
B	2	2	1	1
C	2	2	1	1
D	2	2	1 (withdrawn)	-
E	4 (2 withdrawn)	2	1 (withdrawn)	-
F	2 (1 withdrawn)	1	-	-
G	1	1	1 (withdrawn)	-
Total	**17**	**11**	**6**	**3**

Table 3.2 also provides the distribution of projects between TMP process improvement and TMP turbine generator projects along with the total proposed energy savings. TMP process improvement projects included energy savings from refining line modernization with low consistency refiners, pulp fractionation and screening technologies, and chemical treatment of wood chips or pulp during processing. TMP turbine generator projects included optimization of steam and energy balance to improve heat recovery for self-generation at the TMP mill without incremental fossil fuel, thereby reducing energy purchases from BC Hydro. Three mills considered both a TMP process improvement and turbine generator project in the energy study phase. Turbine generator projects were fewer in number but typically had higher proposed energy savings on a per project basis.

Projects with application for energy study were submitted totalling proposed energy savings of over 1,000 GWh per year. For projects with completed energy studies, proposed energy savings ranged from 33 to 124 GWh per year, averaging 73 GWh per year. Many projects did not proceed through all steps for various reasons and only three projects were implemented for total expected energy savings of 170 GWh per year in the TMP initiative. Reasons and barriers to implementation included the closure of two TMP mills and limited access to financing to complete projects at another two of the mills. It should be noted that BC Hydro staff did not expect all mills to implement projects, recognizing that the TMP initiative could not address all the potential barriers to participation for each targeted facility and that some of them may have been facing unique market challenges.

Table 3.2. Number of Projects and Expected Energy Savings through the Steps of the TMP Initiative

	Number of participating TMP mills	Number of TMP process improvement projects [A]	Number of TMP turbine generator projects [B]	Total number of TMP projects [A]+[B]	Total proposed Energy Savings (GWh/yr)
Step 1: Projects with application for energy study	7	12	5[1]	17	1,015[2]
Step 2: Projects with energy study completed	7	6	5[1]	11	808
Step 3: Projects with application for capital incentive	6	3	3	6	344
Step 4: Projects with implementation	3	2	1	3	170
Step 5: Projects with M&V completed in F2021	1	0	1	1	n/a[3]
Additional capital projects enabled through the TMP initiative and with compounded effects	2	3	0	3	30

[1] Four energy studies were funded by BC Hydro and one was customer funded.
[2] The energy savings for projects identified in Step 1 have much higher uncertainty than energy savings estimated in Step 4.
[3] Project savings with M&V are not disclosed due to customer confidentiality as only one project had M&V completed.

Projects with energy studies were unique and, in general, their proposed energy savings were additive for mills that conducted more than one energy study. However, there were exceptions and some TMP process improvement projects had significant interconnection and compound effects across projects at the same mill. Three such projects received incentives through the Leaders in Energy Management-Industrial (LEM-I) program[7] outside of the TMP initiative and were installed at two of the three mills that participated in the TMP initiative. These additional projects included advanced refiner control, new low consistency refiners for reject refining and new mainline pulp screens. These projects were expected to generate an additional 30 GWh per year of savings by improving overall performance of the TMP initiative project. However, because of the integrated nature of the systems involved, M&V could only estimate the energy savings and combined impact from all projects at the same mill. Therefore, M&V results were not available for all three of the TMP initiative projects at the time of this evaluation. The one project with M&V results found an average gross realization rate of 100 percent across multiple years, and preliminary M&V analysis of the other two projects indicated that the verified energy savings will likely be as expected.

Table 3.3, below, summarizes the progression of expected energy savings and proposed project costs through the steps of the TMP initiative. The targeted outcome of the TMP investment of $100 million in capital incentives was 300 GWh per year of energy savings. This was exceeded two- to threefold in terms of activity generated in Step 1 and Step 2. The six projects that submitted applications for capital incentives in Step 3 also exceeded the initiative target. However, three projects withdrew their incentive application before an incentive agreement was signed, one due to an anticipated mill closure and two due to financing issues as the projects required a substantial investment on the part of the mills. As a result, only three projects were implemented in Step 4, achieving approximately 57 percent of the targeted energy savings of the TMP initiative. A review of the projects implemented found that the TMP incentives covered $47 million of the total proposed project cost of $71 million due to the incentive caps (i.e., the lower of 75 percent of eligible project costs or $45 per MWh levelized cost of energy saved). This represents an average of 65 percent of project costs.

Further analysis of simple payback found individual project payback ranged from over 2 years to almost 10 years for an average simple payback of 5.4 years pre-incentive. The proposed simple payback of projects with

[7] LEM-I (previously, the Leaders in Energy Management-Industrial Transmission, or LEM-T, program) is the demand side management program for BC Hydro's industrial customers.

application for capital incentive ranged from 2.7 years to 9 years for an average simple payback of 6.3 years pre-incentive, and from 1.2 years to 5 years for an average simple payback of 2.2 years post-incentive.

There was a 22 percent increase in simple payback for the six projects that reached Step 3 as they progressed from energy study to incentive application. This was primarily due to refinement of estimates and a reduction of the expected energy savings to a more conservative figure for contracted energy savings in the incentive agreement. The increase in project cost between Step 2 and Step 3 was estimated to be 5 percent. For projects that were eventually implemented, changes in project cost from incentive application to reconciled during post implementation review in Step 4 were within 1 percent.

Table 3.3. Expected Energy Savings and Proposed Project Cost Per Step of the TMP Initiative

	Number of projects	Total proposed Energy Savings (GWh/yr)	Total proposed Project Costs ($ million)	Simple Payback Pre-Incentive[1] (years)	Simple Payback Post-Incentive[1] (years)
Step 1: Projects with application for energy study	17	1015	$364	5.4	
Step 2: Projects with energy study completed	11	808	$289	5.4	
Step 3: Projects with application for capital incentive	6	344	$143	6.3	2.2
Step 4: Projects with implementation	3	170	$71	6.3	2.3
Step 5: Projects with M&V completed in F2021	1	n/a[2]	n/a	n/a	n/a
Additional capital projects enabled through the TMP initiative and with compounded effects	3	30	$12	6.2	2.8

[1] Simple payback was estimated with assumed average unit electricity cost of 6.6 cents per kilowatt-hour.
[2] Details not disclosed due to customer confidentiality

The average time experienced through the steps of the TMP initiative is illustrated in Table 3.4 by incremental and total time. The total time taken is calculated from the TMP initiative launch in July 2014. On average the time to complete the energy study was 0.6 years (7 months) and the time to install and implement the TMP project was 1.3 years (15 months). The average total time to complete the TMP projects was 4.6 years compared to the expected time of 3.2 years from the TMP initiative plan. The difference in the actual time required is primarily due to the periods of customer planning and scoping of the energy study (before Step 1) and the refinement of the project cost and benefits between completion of the energy study in Step 2 and application for capital incentive in Step 3. An additional 2.1 year period was needed between project completion and final incentive payment to allow for project commissioning and optimization.

Table 3.4. Expected and Actual time through the Steps of the TMP Initiative

	Number of projects	Average incremental period (years)	Actual total time (years)	Expected total time (years)
TMP initiative launch (July 2014)			Start	Start
Step 1: Time to application for energy study	10	0.8	0.8	0.1
Step 2: Time to complete energy study	10	0.6	1.4	
Step 3: Time to application for capital incentive	2	1.9	3.3	1.2
Step 4: Time to install project	3	1.3	4.6	3.2
Step 5: Time to final incentive payment	3	2.1	6.7	

In summary, Table 3.5 provides a description of projects that were implemented through the TMP initiative, along with the associated persistence of energy savings for these projects.

Table 3.5. Project Description and Project Persistence of Installed Projects by Mill

Mill Identifier	Project description	Persistence (years)	Installation Date
Mill A	New turbine generator and improved TMP heat recovery for additional generation with no incremental fuel	20	Nov. 2015
Mill B	Mechanical pulp refiner modernization - Mainline Fractionation and Low Consistency Reject Refining Project. Additionally, in F2022, installed advanced refiner controls and instrumentation for advanced quality control.	15	Oct. 2018
Mill C	Mechanical pulp refiner modernization - Project involved directing all production to single line with multi-stage refining to benefit from the production rate effect. Additionally, in F2019, installed low consistency refiners in rejects refining system and modified pulp screening systems with program incentives.	15	Dec. 2018

During the evaluation period from F2015 to F2021, the three participants were also impacted by a 32 percent rate increase. Considering the cumulative impact of the electricity rate increases from F2015 to F2021 as additional customer cost, the average simple payback of the three projects completed at participating mills was calculated at 9.2 years without the TMP project incentives and reduced to 4.6 years with the TMP project incentives. As a result, the TMP initiative helped offset the increased electricity costs through operational efficiencies.

Participants indicated that the TMP initiative had indeed helped them improve energy efficiency (and had even contributed to reducing natural gas consumption) and save costs, and they are also meeting their project targets. However, this can come at the expense of product quality, with one of the participants saying that new processes with lower energy intensity also reduced the quality of their end products, requiring them to adjust and pivot to slightly different products in response.

The competing goals of reducing energy consumption versus increasing mill productivity and revenue were also discussed in interviews. Participants generally were in the TMP initiative to conserve energy; one participant brought up that the paper market in general is declining anyway.

There was mixed response to the question of whether any significant interactions between production and waste heat recovery occurred as a result of TMP initiative projects. One participant said that reducing refining energy by implementing the TMP initiative project naturally reduced waste heat that they normally recovered as low-pressure process steam and hot water, resulting in more natural gas consumption to maintain process temperature. This shift was anticipated based on modelling performed before the project was installed but ended up larger than expected.

On the other hand, another participant found that the interaction between production and waste heat recovery resulted in natural gas savings. Older steam-capturing equipment was replaced, which improved heat recovery and, in turn, offloaded their boiler and reduced natural gas consumption. However, they felt the mill is operating not quite at target and had anticipated recovering higher pressure steam than they ended up doing.

The participants mentioned several non-energy impacts of the TMP initiative projects, both positive and negative. Positive effects included:

- the use of new technologies provided energy management tools which helped to better understand the relationship of energy and properties of core processes and new products that can be manufactured using mechanical pulp;
- new online quality analyzers enabled tracking pulp properties in real time and gave operators more insight and better control over the process; and,

- drop in condenser load which resulted in less cooling water required and quieter operation, thus improving working conditions in the mill.

On the negative side, participants reported impacts on product quality. One participant noted that some product lines they used to manufacture were affected and could not be produced to the same specifications. Another indicated that slightly lower pulp quality was expected and was generally found to be manageable after the project, but added that under certain conditions, they produce more off-grade pulp and are challenged in this respect. Another comment was that new processes or significant process modifications have a learning curve for operations staff, whose understanding is based on older processes, and it takes a while for them to adapt.

3.3 Results for Objective 3: Qualitatively explore any market effects or sector changes influenced by the TMP initiative

Based on the comments from participants and BC Hydro staff, the TMP initiative did provide some degree of economic stability to the mills. One participant commented that the project had a "positive influence on economics and financial performance". Another indicated that the project allowed them to improve the cost structure and made capital available for other projects. A further comment was that these projects would not have happened without the program, which is credible considering that all participating sites were part of large organizations where capital investment decisions are made at the corporate level and projects across the organization compete for funding. At the time of the TMP initiative, BC Hydro staff expected that one or more of the participating mills might have had to close based on assessments conducted with industry experts for annual updates to the load forecast, although predicting the future of mills by anticipating market shifts is notoriously difficult.

The fact that participating sites had to cover a significant portion of project costs and did invest in those projects certainly supports the idea that they believed in the economic viability of the sites. Several instances of further investments in the facilities were also reported by participants, including a new roof at one mill, a fibre quality analyzer and controls upgrade at another, and general improvements in mill operations.

In terms of identifying additional large capital energy efficiency projects as a result of participating in the TMP initiative, two of the participants discussed process improvements being considered or studied. One said they were developing process improvements related to instrumentation and the integration of fibre quality analyzers in their process control strategy. Another participant mentioned pushing the low consistency refining concept further. They installed low consistency refiners through a TMP initiative project and offset some of the energy consumed in high consistency refiners, and thought they could add more low consistency refiners so that they can turn their high consistency refiners off and save more energy. This participant also mentioned having an online pulp quality analyzer, which they saw as a tool to enable advanced refiner control that would minimize energy while maintaining product quality within a defined window. The third participant, whose TMP initiative project was to install a new steam turbine generator, said they were working on optimizing boiler operation and reducing the need to burn fossil fuel to sustain combustion. This participant was also contemplating steam conservation projects as a next step.

BC Hydro staff said they could probably tie several follow-up projects to this: "There were a lot of ideas generated, external parties doing audits to find these projects." It was also thought likely that some of these additional projects may appear in mills that did not participate.

Looking at the broader picture in sector changes influenced by BC Hydro, interviewees were asked to comment on the impact of a research program that BC Hydro sponsors at the University of British Columbia (UBC). Since 2007, the UBC Pulp and Paper Centre has had a research program on Energy Reduction in Mechanical Pulping (ERMP)[8] that brings together a unique technical team of mechanical pulp producers, associated industry

[8] Home Page | Energy Reduction in Mechanical Pulping (ubc.ca)

suppliers, research institutes, university researchers, utilities, and governments to develop and demonstrate the technical potential to reduce energy consumption and to explore the use of low energy mechanical pulp products beyond their current use. This industry consortium is now in its third phase with 16 partners and is known to be the largest research program in the world on mechanical pulping. BC Hydro and five TMP mills in BC are partners in this consortium.

Overall, the UBC research program appears to have made a positive contribution to the market adoption of emerging energy efficient technologies and the required technical expertise in B.C. The UBC program has brought highly qualified professionals and resources to the consortium partners' respective companies. The research conducted at UBC also assists in the testing of new processes, the optimization of process variables and fibre properties, and conducting pilot trials with low consistency refiners and screening technology. This helped TMP participants in determining the right project fit for their mills.

BC Hydro staff concurred with what the participants said about the UBC program, adding that the mills have a close relationship with the university's Pulp and Paper Centre. They mentioned the research studies being done on screen rotors and low consistency refiners, saying that the applied research is a test bed for trials with specific wood types and pulp grades. This provides mills with some certainty before they decide to invest in changes. UBC also conducts fibre analyses which have been important for participants to understand how fibre characteristics change with processing technologies and energy inputs.

The participants and BC Hydro staff identified a few different ways in which the TMP initiative helped build new technical capacity among staff within companies including:

- Acquiring greater technical knowledge;
- Having opportunities to attend international conferences to learn from peers;
- Learning how to execute a large capital project (and developing skills and knowledge in other employees filling in for those involved with the capital project);
- Information and knowledge sharing among different mills involved with the TMP initiative; and,
- Learning first-hand through experience the reality of how their steam systems work, with the actual detailed heat and material balance exposing a number of issues.

From the non-participant's point-of-view, being involved with the TMP initiative highlighted the "importance of power savings and the cost of power, more than anything", and raised awareness of energy use at the mill. Despite not participating in the TMP initiative, the mill continues to have an Energy Manager and set energy priorities as well as pursue BC Hydro funded energy studies.

BC Hydro staff felt the TMP initiative has built new but limited technical capacity in the province, although there are still very few pulp and paper subject matter experts in B.C.: "You can get lots of electrical engineers who know pumps and stuff but in terms of paper and pulp making, there aren't very many."

Participants also felt major suppliers to the mechanical pulping industry, such as those from Europe and Asia, have made a positive contribution to the market adoption of emerging energy efficient technologies and the required technical expertise in B.C. One participant said they have improved access to design and development of key process components used in their company's operation, helping fine tune deficiencies when implementing a capital project. Another mentioned that they bring in experience from their operations located around the world to provide insights on what works, what they can and cannot guarantee, what doesn't work, and help guide an approach around some process options and opportunities and changes. The third participant added that the two suppliers they work with are very supportive of the UBC program; their company provides wood chips to UBC research and one of the suppliers donates access and time to their pilot-plant to obtain mill-specific energy performance data on different scenarios. The third participant indicated that at the time of exploring project ideas for the TMP initiative, they invited the two primary TMP equipment suppliers for discussions and brainstorming, and then got proposals from both sides. This participant recognized that both suppliers are very supportive of the UBC work, and one of the suppliers donated pilot plant time to gather pilot-scale data on some of the different process scenarios they were exploring.

3.4 Limitations of Results

Verified energy savings through measurement and verification were not available for all projects at the time of the evaluation. Hence the impact of the TMP initiative in terms of energy savings could not be evaluated. However, measurement and verification is underway for all projects based on hourly energy consumption and related process data. Verified energy savings will be reported in the BC Hydro administrative database once available and will be updated annually.

Evaluation results are heavily reliant on anecdotal evidence provided in interviews conducted in late 2020, which is well after the initiative launch in 2014. The passage of time could have influenced interviewee responses. Staff changes at the mills and mill closures also created constraints in data collection. In addition, because the initiative was targeted at a select group of customers, the total numbers of participants and non-participants were very small. Therefore, some experiences may not be reflected in the evaluation results, particularly those of non-participating sites.

The inability to measure the impact of the TMP initiative on the economic stability of the mills is a limitation of this evaluation. Data on the financial performance of the TMP mills was not available and therefore, the only available indicator of economic viability was the mill's retained electrical load over time. However, the baseline scenario – what would have happened to the electrical energy consumption in the absence of the TMP initiative – is largely speculative.

4.0 FINDINGS AND RECOMMENDATIONS

4.1 Findings

1) BC Hydro's early consultation and interaction with industrial customers created the needed flexibility to address unique customer needs and barriers with the TMP initiative projects. For example, in addition to energy efficiency projects, turbine generator projects were made eligible after it became evident that there was potential for this type of conservation measure in four of the TMP mills.
2) Identification of energy savings opportunities at the beginning of the TMP initiative generated substantial interest and awareness among all the targeted customers. Seventeen projects were identified at the seven target mills, and six mills made an application for a TMP project incentive.
3) Implementing large capital projects such as those targeted by the TMP initiative is a lengthy and complex process. Some projects required close to two years between completion of energy study and the TMP incentive agreement due to customer decision making and project planning. At present, six years after the introduction of the TMP initiative, only one project has verified savings.
4) The TMP initiative increased awareness about energy efficiency and provided learning opportunities for mill staff. The TMP initiative led to transformative process changes at two of the three participating mills, with implications on mill operation and end-product quality that were ultimately managed.
5) The primary intent of participants was to conserve energy and reduce energy costs. Reduction in energy use intensity through higher production rates was a secondary consideration in this industry, as it continues to experience major market shifts and contraction.
6) On average the TMP incentives only covered 65 percent of the $71 million in project costs and the three implemented projects still required a substantial investment on the part of the mills. Other projects investigated through the initiative were not completed because they competed with other business initiatives for internal resources and capital.
7) Measurement and verification results were only available for one of the three TMP initiative projects at the time of this evaluation. Preliminary evaluation review of the three projects indicated that the verified energy savings will likely be as expected.

4.2 Lessons Learned

The following are the main lessons learned from the TMP initiative and should be considered when implementing similar initiatives in the future.

1) Large capital projects require long timelines for scope definition, planning, and implementation. Allowing participants plenty of time to accommodate their complex decision-making processes is particularly important for large capital project development and implementation.
2) Industry consultation and involvement early in the planning and design of the initiative, to understand what would best meet the needs of both BC Hydro and participants in terms of funding process and desired project outcomes, can lead to innovative ideas for program design.
3) The availability of expertise through an existing industry consortium of academia, utilities, suppliers, and industry partners was a valuable asset to address some of the barriers associated with the adoption of new energy efficient technologies.

5.0 CONCLUSIONS

The TMP initiative exceeded its expected outcome in generating TMP customer interest in energy efficiency projects but had limited success with bringing more projects to implementation due to customers' financial constraints and the perceived risk of committing to large-scale, transformative projects with long-term implications in an industry affected by continuing market changes.

EVALUATION OVERSIGHT COMMITTEE SIGN-OFF

BC Hydro's Evaluation Oversight Committee is made up of DSM stakeholders from various parts of the company and is mandated to ensure that BC Hydro's DSM evaluations are objective, unbiased and of sufficient quality.

The *Summative Evaluation of the Thermo-Mechanical Pulp Initiative: F2015-F2021* meets the following criteria for approval by the Evaluation Oversight Committee:

- The evaluation complied with the defined scope.
- The evaluation methodology is appropriate given the available resources at the time of the evaluation.
- The evaluation results are reasonable given the available data and resources at the time of the evaluation.

__________________________________ July 22, 2022

Serina Grahn, Finance Manager, Business Services — Date

Evaluation Oversight Committee Chair

ABBREVIATIONS AND GLOSSARY

Consistency (low consistency/high consistency): the solid content of a pulp slurry, expressed as a percentage by mass (mass of dry pulp divided by total mass of dry pulp and water).

Demand: Demand refers to the amount of electricity that is consumed at any instant in time, measured in watts.

Energy-Use Intensity (EUI): A measure of annual electricity energy consumption per unit of production.

Mainline fractionation: The separation of pulp produced from mainline refiners into fractions with different fibre characteristics for the purpose of applying separate mechanical treatment to these different fractions. In a typical TMP mill, pulp is first produced on refining lines referred to as mainline, and subsequently screened to separate long wood fibres that need further treatment. This long fibre fraction is referred to as rejects and it receives further treatment in reject refiners.

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

Thermo-mechanical pulping (TMP): An industrial process in which wood chips are reduced to pulp through mechanical action in steam-pressurized rotating machines known as refiners, to produce wood pulp for a variety of paper products.

APPENDIX A ADVISOR MEMOS ON EVALUATION REPORT

Advisor Memo on Evaluation Report

Date: July 25, 2022
To: BC Hydro
From: Carol Yin

Re: Summative Evaluation of the Thermo-Mechanical Pulp Initiative: F2015-F2021

1. **What is your assessment of the quality of the evaluation approach (i.e., data sources and methods) relative to the evaluation scope and objectives? If you identify any shortcomings, what is your assessment of the implications for the evaluation results?**

Given the small sample size, the evaluation team made the appropriate choice of using in-depth interviews with program managers, participants and a non-participant.

2. **What is your assessment of the quality of the input data? If you identify any shortcomings, what is your assessment of the implications for the evaluation results?**

The input data came from program documents and in-depth interviews. The thorough documentation of program challenges shows that interviewees were open with their input. The inclusion of the non-participant also benefitted the evaluation by allowing a more comprehensive understanding of the TMP initiative strengths and challenges.

3. **What is your assessment of the quality of the analytical methods? If you identify any shortcomings, what is your assessment of their potential risk for the validity of the evaluation results?**

The analytical method showed the convergence of opinions and facts on the Initiative's challenges, drawing from interview results program the program managers, the participants, and a non-participant, and from industry experts.

4. **How does the methodology compare to common industry practice for evaluations of similar initiatives?**

The use of in-depth interviews with subject matter experts is standard practice in evaluation; the inclusion of the non-participant is a "best practice" that is becoming more neglected, so it is commendable that BC Hydro included one.

5. **What are your suggestions for future evaluations of similar DSM programs?**

I have no suggestions for improvements in future evaluations: the report shows the evaluation team is well aware of the study limitations, which are largely due to the unique parameters and the context of the TMP Initiative.

6. **Do you have any other comments that you would like to make?**

The report's frank discussion and feedback from the participants and non-participant really demonstrates the extent to which BC Hydro was seen as a partner in addressing the challenges facing the industry.

Advisor Memo on Evaluation Report

Date July 23, 2022
To: BC Hydro
From: Rafael Friedmann
EOC Evaluation Advisor
Oakland, California

Re: Summative Evaluation of the TMP Initiative: F2015-F2021

1. ***What is your assessment of the quality of the research design? If you identify any shortcomings, what is your assessment of their potential risk for the validity of the evaluation results?***

   Comprehensive, appropriate and mostly cost-effective effort for this multi-year engagement. Correctly focused on a qualitative, summative research effort, given the long lead times and available data and program termination.

2. **What is your assessment of the quality of the input data? If you identify any shortcomings, what is your assessment of their potential risk for the validity of the evaluation results?**

   Data from a variety of sources (program tracking, customer surveys, literature) is adequate.
   Customer surveys were limited as often happens with the few, very large customers, due to few participants, personnel turnover and attrition in the complex decision-making participation process.

3. **What is your assessment of the quality of the analytical methods? If you identify any shortcomings, what is your assessment of their potential risk for the validity of the evaluation results?**

   Methods used are well established for this qualitative and summative effort.
   Commend the evaluation team for including non-participant survey as well.

4. **How does the methodology compare to common industry practice for evaluations of similar initiatives?**

   Very similar to other efforts evaluating interventions with major industrials.
   Long lead times, production changes, attrition and confidentiality concerns, make savings reporting very difficult.

5. **Suggestion for future evaluations**

   Consider doing yearly interviews of participants and non-participants to capture important data before memories fade or personnel changes occur.
   Yearly interviews of potential customers and/or of KAMs, will provide feedback to program implementers in a timelier and more useful fashion for program design adjustments.

6. **Any other comments**

   Very well written and easy to follow report.
   Commend the evaluation team for offering useful summative report that may be helpful when developing similar initiatives in the future.

APPENDIX B INTERVIEW QUESTIONS

Participants (the 3 TMP mills that implemented/are implementing a project)

Initiative Design and Implementation

1. What were the main business drivers for your company/site to participate in the TMP initiative? In what ways did the initiative meet your company's needs?

2. Were there any challenges to participating in the initiative as intended? If yes, how did BC Hydro address these challenges?

3. What worked well in terms of the way in which BC Hydro designed and delivered the TMP initiative to fund large capital energy efficiency projects from your company's perspective (e.g., communications, timing, eligibility, processes/procedures)?

4. Was there anything in the way the initiative was designed or implemented that could have been done better?

Productivity and Consumption

5. To what extent did the TMP energy efficiency project reduce operating costs and/or improve revenues (i.e., was there an energy savings trade-off for improved yield, quality, production rate, product type, new products)?

6. Were there any significant interactions between production and waste heat recovery as a result of the TMP project?

7. What were the non-energy impacts of the TMP project (positive or negative; intended or unintended)?

Market Effects and Sector Changes

8. Has your company identified any additional process-improvement energy efficiency projects as a result of participating in the TMP initiative (e.g., controls, technology), outside the TMP project?

9. Did the TMP project have an influence on the economic stability of your company overall or at the mill site? Did the TMP project create an opportunity for further investment in the mills in energy or non-energy related areas?

10. In what ways did the TMP initiative help to build new technical knowledge or skills among staff within the company? Within the TMP sector (within BC, nationally, internationally)? Did the TMP initiative influence knowledge gains or retention within the sector in BC?

11. How has the UBC research program and associated industry consortium on energy reduction in mechanical pulping contributed to market adoption of emerging energy efficient technologies and the required technical expertise in BC? How did this affect the efficiency projects implemented under the TMP initiative?

12. How have major suppliers to the mechanical pulping industry contributed to market adoption of emerging energy efficient technologies and the required technical expertise in BC? How did this affect the efficiency projects implemented under the TMP initiative?

Non-participants (TMP mills that did not participate)

1. Back in 2014 BC Hydro announced an initiative to fund large capital energy efficiency projects at TMP mills in BC. Your company/site was identified as a potential candidate to receive funding under the BC Hydro's TMP initiative. Did your company consider doing a project at this site under this initiative?

   If yes:

   a. What was the nature of the intended project?

   b. What were the main business drivers for your company/site considered with respect to undertaking that project?

2. What were the challenges to participating in the initiative and undertaking an eligible project? Which of these was the main cause of not going ahead with a project?

3. Has your company identified or undertaken any other large capital energy efficiency projects? If yes, what kinds of projects were those and what are the expected outcomes?

4. Did the TMP initiative help to build capacity among vendors, professional services, and technical staff in the industry. Did the TMP initiative influence on knowledge retention within the sector in BC?

TMP Interviews – Internal staff (program managers and KAMs)

<u>Design and Implementation</u>

1. Please describe the drivers behind the TMP initiative and any relevant parameters that influenced its design and implementation. Were any of these parameters particularly constraining?

2. What were the key challenges or issues in implementing the TMP initiative? How were these addressed?

3. What were the main business drivers for companies to participate in the TMP initiative?

4. What were the barriers faced by companies that participated in the initiative and those that did not? Why did some of the targeted companies not participate?

5. Based on your experience in the initiative design and implementation are there any best practices and lessons learned that BC Hydro should consider in developing initiatives of similar size and scope in the same or other sectors in the future?

Market Effects

6. Have any additional process improvement energy efficiency projects been identified in the pulp and paper sector as a result of the TMP initiative, outside of TMP projects?

7. Is there evidence that the TMP project investment helped to retain the economic viability of the mills and/or attract additional business investment into the mills?

8. Did the TMP initiative help to build capacity among vendors, professional services, and technical staff in the industry. Did the TMP initiative influence on knowledge retention within the sector in BC?

9. How has the UBC research program on energy reduction in mechanical pulping contributed to energy efficiency projects and market adoption of emerging energy efficient technologies in BC?

10. How have major suppliers to the mechanical pulping industry contributed to market adoption of emerging energy efficient technologies and the required technical expertise in BC? How did this affect the efficiency projects implemented under the TMP initiative?

Transmission Service Rate (TSR) Impact Evaluation: F2017-F2020

March 10, 2023

Prepared by:

BC Hydro Conservation and Energy Management Evaluation

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Introduction

The Transmission Service Rate (TSR) was introduced on April 1, 2006 to large industrial customers that receive electricity supply at transmission voltage (60 kV or higher). This group of customers, about 150 sites, is dominated by industrial facilities and makes up about 25 percent of BC Hydro's overall energy sales.

A previous evaluation of the TSR was conducted in 2020, covering the period from F2012 to F2016. It evaluated the energy conservation impacts in response to the rate's two-step structure, as well as customer awareness, understanding, and support for the TSR rate. This evaluation adopts a similar scope and covers the period from April 2016 through March 2020 (Fiscal years F2017-F2020).

Under Rate Schedule 1823 Energy Rate B (RS1823B) - the default rate for these customers - electricity consumption is charged at a two-tiered rate for energy, plus a flat rate for demand. A customer-specific consumption baseline load (Energy CBL) is used to separate annual energy consumption into a lower-priced block of energy (Tier 1 energy) and a higher-priced block of energy (Tier 2 energy). The Tier 1 rate is applied to annual energy consumption up to 90 percent of the CBL. The rest of the consumption is billed at the higher-priced Tier 2 rate. A flat rate structure for energy is also provided under RS1823 Energy Rate A (RS1823A) for TSR customers who do not have a sufficient consumption history to permit the determination of a CBL (such as new customers), or whose facilities are undergoing significant changes that require sufficient operating history to establish a new CBL.

The CBL is based on the customer's historical energy consumption and is subject to annual review and periodic adjustments up and/or down in accordance with BC Hydro's Tariff Supplement 74 (TS 74) and with the approval of the British Columbia Utilities Commission. A CBL can also be reset (up or down) if the adjusted annual energy consumption falls below 90 percent of the CBL or exceeds 110 percent of the CBL. Customers are also eligible to apply for "energy bill adjustments" which, despite the name, do not change their energy bill but rather identify the specific events that contributed to a reduction in annual energy consumption. Common events include customer-funded DSM, incremental self-generation, force majeure, load curtailments, transmission system outages, and non-recurring downtime. This ensures that the CBL continues to serve as an appropriate baseline for normal operations and that the TSR encourages electricity conservation while not penalising business expansions. For example, under specified conditions, customer-funded DSM projects and/or incremental self-generation can result in an energy bill credit equivalent to the verified annual energy savings of the project. This credit is added to actual RS1823 energy consumption for the purpose of the annual CBL reset determination. A customer can thus conserve and/or reduce energy below the 90 percent of CBL threshold, but still avoid a CBL reset by receiving credit for their DSM efforts (provided that adjusted energy purchases are above the 90 percent of CBL threshold).

The stepped rate structure is designed for energy conservation as it creates a higher marginal price signal for TSR customers to encourage them to pursue energy efficiency gains and achieve energy conservation. This evaluation examines three major categories of customer-funded conservation impacts attributed to the TSR:

1) **TSR Reported DSM.** These are customer-funded DSM projects that are reported to BC Hydro through TSR filings for energy bill adjustments. These projects do not receive any other financial incentives from BC Hydro. Their energy saving impacts are considered to be influenced by the TSR incentive structure and are not claimed by any other BC Hydro DSM programs.

2) **Incremental self-generation.** Customer-funded projects that increase self-generation of energy and displace energy purchases from BC Hydro can also be reported for energy bill adjustments under the TSR. Energy savings attributed to the TSR is the portion of self-generation in excess of an established generation baseline and any contracted amounts sold to BC Hydro through electricity purchase agreements (EPA).

3) **Unreported DSM**. In addition, TSR customers may initiate other customer-funded DSM initiatives for which the energy impact is not accounted for under TSR reported DSM, incremental self-generation, or BC Hydro's conservation programs. These unreported DSM savings are also part of the evaluation scope.

Approach

The evaluation objectives and research questions are shown in Table ES.1.

Table ES.1 Evaluation objectives and research questions

Evaluation objective	Research questions
1. Customer experience	• What is the general feedback from customers about their experience with the TSR?
2. Energy savings from TSR reported DSM	• What were annual incremental estimated gross energy savings from customer-funded energy conservation measures that were reported to BC Hydro through the annual CBL review process and not claimed as program-enabled savings under an industrial conservation and energy management program such as Leaders in Energy Management - Industrial? • What were annual incremental evaluated net energy and peak demand savings by fiscal year? • What does available data suggest about the persistence of savings?
3. Energy savings from TSR incremental self-generation	• What were adjusted gross reductions in energy purchases from BC Hydro (energy and demand) from incremental self-generation in response to the TSR by fiscal year?
4. Energy savings from unreported DSM	• What were annual incremental evaluated net energy savings from energy conservation measures that were not reported to BC Hydro but enabled by the TSR?
5. Total energy and capacity savings	• What was the total evaluated net reduction in energy purchases from BC Hydro (and associated capacity savings) by fiscal year?

The evaluation objectives, data sources, and methods are summarized in Table ES.2.**Error! Reference source not found.**

Table ES.2 Evaluation objectives, data and methods

Evaluation Objective	Data Sources	Methods
1. Customer experience	• F2017 to F2020 Leaders in Energy Management-T Participant Surveys (n=18)	• Cross tabulations of survey responses
2. Energy savings from TSR reported DSM	• Project files (n=5) • CBL Statements • PSP-T (F2012-F2014)/LEM-T (F2015-F2017) impact evaluation	• Engineering calculations • Gross realization rate • Free ridership estimation
3. Energy savings from TSR incremental self-generation	• List of sites reporting self-generation (n=11) • Customer metering data • CBL Statements	• Engineering calculations • Cross tabulation
4. Energy savings from unreported DSM	• BC Hydro's monthly billing data for TSR customers from F2017 to F2020 • Statistics Canada economic data for employment in the non-durable goods sector • TSR energy price history (RS1823B) • Consumer Price Index from BC Statistics Agency	• Economic analysis of billing data • Energy savings calculations based on price impact estimates
5. Total energy and capacity savings	• Results from objectives 2,3 and 4 • Peak-to-energy factor for industrial rate class	• Engineering calculations

Results

Results for Objective 1: Customer experience

The main source used to assess customer experience was an online survey of Leaders in Energy Management-Transmission (LEM-T) program participants. While this survey is used primarily to inform program evaluation, some questions pertained to experience with the TSR. Among LEM-T participants that had completed a program enabled project (i.e., a customer-funded DSM project that did not directly receive an incentive, but that may have received funding for the energy study or other BC Hydro support) during the evaluation period, 72 percent of program survey respondents (n=18) reported that the financial benefits through the TSR had been either very (39%) or somewhat (33%) influential on the decision to implement the energy-efficient measure. A total of 50 percent reported that the project would have met their organization's financial criteria even without the benefit from the TSR, while 17 percent reported that it would not have met their financial criteria, but likely would have gone ahead in some form. A further 28 percent reported that the project would not have gone ahead at all without support from the program.

Results for Objective 2: Energy savings from TSR reported DSM

Gross energy savings for TSR reported DSM are the change in energy consumption that resulted directly from customer-funded DSM projects and were not otherwise claimed as DSM program savings. This evaluation period covered five projects, all of which were for new plant design energy conservation measures. They were reported to BC Hydro for energy bill adjustments (and CBL administration) but not attributed to BC Hydro DSM programs. The evaluated gross energy savings are based on the project's most recent and best available estimate of energy savings in each fiscal year. Under the TSR, these projects result in an annual energy bill adjustment on the customer's CBL statement. Project performance is often tied to operating conditions, and in the present case all projects (five in total) had annual post-implementation engineering reviews. Therefore, the energy bill adjustment for a given fiscal year was considered the best available estimate of energy savings. The evaluation found an average gross realization rate of 99 percent when compared to the initial review of energy savings used for the reported gross savings which indicates that the year-over-year savings variability was on average aligned with the evaluated gross energy savings.

Evaluated net energy savings between F2017 and F2020 were calculated using the gross savings of each project multiplied by the evaluated net-to-gross ratio and are shown in Table ES.3. Energy savings are presented as incremental savings achieved during the evaluation period and expressed as an annual rate of savings (run rate savings).

Table ES.3 Evaluated gross and evaluated net energy savings from TSR reported DSM

Evaluation Period	Number of projects	Evaluated Gross Energy Savings (GWh/yr)	Evaluated Net-to-Gross Ratio	Evaluated Net Energy Savings (GWh/yr)
TOTAL (F2017-F2020)	**5**	**368.1**	**0.50**	**182.3**

Results for Objective 3: Energy savings from TSR incremental self-generation

The energy savings from incremental self-generation were obtained from CBL statements which provide results that have been verified by BC Hydro Contract Management as part of the TSR reporting requirements. Eligibility to report incremental self-generation energy in response to the TSR was limited to customers who were on the stepped rate (RS1823B) for the fiscal year when the energy generation occurred. Peak capacity savings were estimated by applying the peak-to-energy factor of 0.117 MW per GWh for the transmission rate class only to the incremental self-generation energy of customer sites that did not have an EPA with BC Hydro. For customer sites with an EPA, the incremental self-generation recognized as DSM is not delivered steadily and capacity savings cannot be ascribed to this particular form of excess generation energy. The total incremental self-generation and the associated capacity savings are given by fiscal year in the table below.

Table ES.4 Evaluated net energy and capacity savings from TSR incremental self-generation

Fiscal Year	Evaluated Net Energy Savings (GWh/yr)	Evaluated Net Capacity Savings (MW)
F2017	107	11
F2018	57	5
F2019	92	0
F2020	115	5
Average per Year (F2017-F2020)	**93**	**5**

Results for Objective 4: Energy savings from unreported DSM

Unreported DSM savings refer to energy savings that are induced by the stepped rate structure but not accounted for under TSR reported DSM, incremental self-generation, or BC Hydro's conservation programs. Unreported DSM savings were estimated through econometric modelling, by building regression models that relate changes in TSR customer's energy consumption to changes in energy prices and economic activity. Two different econometric model specifications were examined in this evaluation, and both produced negative estimates for unreported DSM savings, thus providing no evidence for the existence of such savings. Therefore, the unreported DSM savings were evaluated as zero.

Results for Objective 5: Total energy and capacity savings

For the evaluation period from F2017 to F2020, total net energy savings under the TSR were evaluated at 275 GWh per year, and total net capacity savings were evaluated at 26 MW. The evaluated net energy savings represent 79 percent of reported savings.

Findings and Recommendations

Findings and recommendations are presented below.

Customer Experience

1. Among Leaders in Energy Management-Transmission participants that completed a program enabled project, 72 percent reported that the financial benefits through the TSR had been ‘very influential’ or ‘somewhat influential’ on their organization’s decision to implement the energy-efficient measure.

Energy Savings from TSR reported DSM

2. The evaluated gross energy savings of TSR reported DSM for F2017 to F2020 were estimated at 368 GWh per year, with a gross realization rate of 99%.
3. The evaluated net energy savings from TSR reported DSM for F2017-F2020 were estimated at 182 GWh per year. The net-to-gross ratio of TSR reported DSM projects was found to be 50 percent. Free ridership of 54 percent was estimated based on evaluation review of the TSR reported DSM projects using free ridership scores and criteria from industrial program evaluations of similar projects. Participant spillover of 4 percent was estimated from conservation measures installed but not recognized for CBL administration.
4. Evaluated net energy savings from TSR reported DSM projects achieved 75 percent of reported savings. The variance between reported and evaluated savings was primarily due to the difference between the deemed and evaluated net-to-gross ratio for TSR reported DSM for new plant design energy conservation measures. The average expected persistence of TSR reported DSM projects was found to be 10.6 years.

Energy Savings from TSR incremental self-generation

5. Annual average energy savings from TSR incremental self-generation were estimated at 93 GWh per year and achieved on average 97 percent of reported savings. Incremental self-generation for customers without an Electricity Purchase Agreement was found to have capacity savings, whereas, incremental self-generation for customers with an Electricity Purchase Agreement had no associated capacity savings.

6. The variance between reported and evaluated energy savings from TSR incremental self-generation is primarily due to the removal of self-generation energy from two load displacement projects that had also been reported to the BC Hydro Leaders in Energy Management program. A secondary source of variance was the refinement of energy estimates that occurred through the CBL review process, as these updates were not carried over to the energy savings for DSM reporting.

7. The persistence of energy savings from TSR incremental self-generation was one year, i.e., the fiscal year where the savings occurred. Due to the highly variable output and unpredictable fluctuations in savings from self-generation, they were subject to a rigorous annual verification process.

Energy Savings from TSR unreported DSM

8. Analysis of TSR RS1823B customers' energy consumption through econometric modelling did not provide evidence for unreported DSM savings during the evaluation period and no savings were ascribed to TSR Unreported DSM in this evaluation.

Total Electricity Savings from TSR

9. For the evaluation period from F2017 to F2020, total net energy savings under the TSR are evaluated at 275 GWh per year, and total net capacity savings are evaluated at 26 MW. Evaluated net energy savings achieved 79 percent of reported savings.

Recommendations

The following recommendations flow from the findings of this evaluation.

1. Consider applying the evaluated Net-to-Gross ratio of 0.50 from this evaluation to future savings claimed for TSR reported DSM if the projects fall in the category of new plant design.
2. Remove savings from TSR incremental self-generation for sites with a DSM program-based load displacement agreement and without Energy Purchase Agreement (EPA) as these were reported through the program.
3. Adjust TSR unreported DSM savings to zero for the evaluation period and consider discontinuing future claims for such savings.

Conclusions

Total net energy savings under the Transmission Service Rate were evaluated at 275 GWh per year in the period from F2017 to F2020, representing 79 percent of reported savings. The associated capacity savings were evaluated at 26 MW.

1.0 INTRODUCTION

The Transmission Service Rate (TSR) was introduced on April 1, 2006 to large industrial customers that receive electricity supply at transmission voltage (60 kV or higher). This group of customers, about 150 sites, is dominated by industrial facilities and makes up about 25 percent of BC Hydro's overall energy sales. The default rate for these customers thus became a two-tiered rate where energy is billed at a lower rate (the Tier 1 rate) for the first block of annual energy consumption and a higher rate (the Tier 2 rate) for the balance of their energy consumption. The rate was designed for energy conservation, as it creates a higher marginal price signal for energy and provides an incentive structure for customers to reduce annual energy consumption. This evaluation examines conservation impacts that are claimed as demand side management (DSM) savings under this rate structure.

1.1 Evaluation Scope

The previous evaluation of the TSR was conducted in 2020, covering the period from F2012 to F2016[1]. It evaluated the energy conservation impacts in response to the rate's two-step structure, as well as customer awareness, understanding, and support for the TSR rate. This evaluation adopts a similar scope and investigates energy conservation impacts associated with TSR reported DSM, TSR reported incremental self-generation, and TSR unreported DSM activities[2] separately. The customer experience with the rate was also explored. The evaluation covers the period from April 2016 through March 2020 (Fiscal years F2017-F2020).

Starting in 2016, BC Hydro introduced a freshet rate (Rate Schedule 1892[3]) which is an optional and advantageous rate for TSR customers during the freshet period (June and July) of each year to encourage customers to absorb BC Hydro's seasonal energy surplus. This rate is only applied to extra energy consumption measured above TSR customer's baseline consumption to ensure it has no impact on energy consumption charged under the TSR rate. The evaluation of the freshet rate was conducted separately and is not covered in this report.

1.2 Organization of the Report

Section 1 of this report covers the evaluation scope, the organization of the report and a more detailed description of the TSR rate. Section 2 discusses the approach to the evaluation, including evaluation objectives, methodology review, data sources, and methods. Section 3 provides the results organized by the evaluation objectives. Section 4 provides the findings and recommendations, and Section 5 provides the conclusions. Additional supporting material is included in the appendices.

1.3 Initiative Description

The Transmission Service Rate, defined under Rate Schedule RS1823[3], is the default rate for BC Hydro customers who receive service at transmission voltage of 60 kV and above. Under Rate Schedule RS1823 Energy Rate B (RS1823B), energy supplied to customers is charged at a two-tiered rate for energy, plus a flat rate for demand. A customer-specific consumption baseline load (Energy CBL) is used to separate annual energy consumption into a lower-priced block of energy (Tier 1 energy) and a higher-priced block of energy (Tier 2 energy). The Tier 1 rate is applied to annual energy consumption up to 90 percent of the CBL. The rest of the consumption is billed at the Tier 2 rate. Since customers are billed on a monthly

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[1] BC Hydro Transmission Service Stepped Rate (TSR) Impact Evaluation: F2012-F2016.

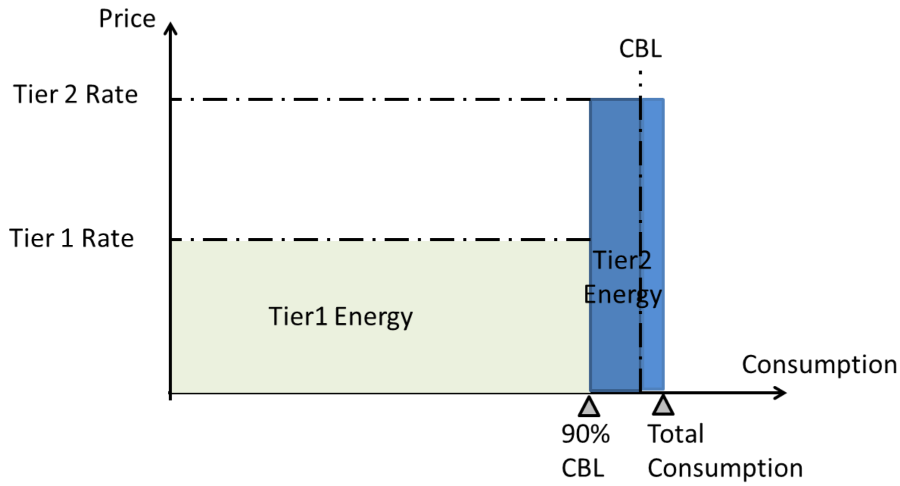
[2] See Glossary for definition of the different DSM components.

[3] See Electric Tariff (bchydro.com)

basis, Tier 2 energy charges tend to appear only on the last one or two bills of the fiscal year. Figure 1.1 illustrates this stepped rate and the different quantities of energy charged at Tier 1 and Tier 2 rates.

The Tier 1 and Tier 2 rates apply to the entire customer rate class, and a customer's individual CBL determines how much energy is billed at Tier 1 during the fiscal year before they start being billed for Tier 2 consumption. The Tier 2 rate was initially set to reflect BC Hydro's long run marginal cost of energy, and the Tier 1 rate was initially set such that the TSR would remain revenue neutral compared to the flat rate structure that was in place for this customer class at the time.

Figure 1.1 TSR Energy consumption charged at Tier 1 and Tier 2 rates



A flat rate structure for energy is also provided under RS1823 Energy Rate A (RS1823A) for TSR customers who do not have a sufficient consumption history to permit the determination of a CBL, such as new customers, or those whose facilities are undergoing significant changes that require sufficient operating history to establish a new CBL. Under RS1823A, customers are billed at a flat "blended" rate[4] for energy consumption until a CBL can be determined, at which point the customer starts to be billed under the stepped rate schedule, RS1823B.

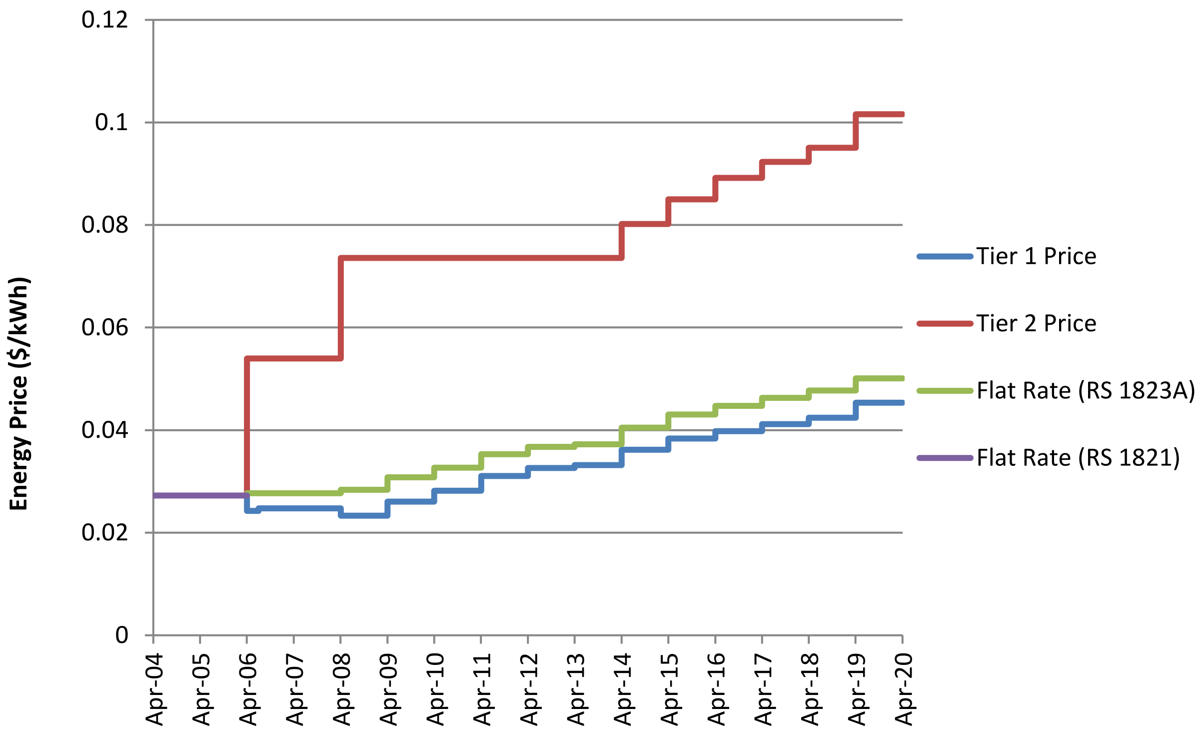
The CBL is based on the customer's historical energy consumption and is subject to annual review and adjustments, with the approval of the British Columbia Utilities Commission. When the stepped rate was first introduced, CBLs were determined based on energy consumption in calendar year 2005. New customers are now initially billed for energy under the flat rate (RS1823A) until sufficient energy consumption history exists to determine a CBL. The Electric Tariff Supplement No. 74 (TS 74) sets out the criteria for energy CBL determination, adjustment, and reset. The CBL can be adjusted up or down through a detailed system of debits and credits to account for changes such as capacity expansions or equipment shutdown. A key principle set out in TS 74 is that a CBL can be reset (up or down) if the annual energy consumption falls below 90 percent of the CBL or exceeds 110 percent of the CBL. Importantly though, the criteria for a CBL reset is based on an adjusted annual energy consumption that accounts for the impact of customer-funded DSM projects and other qualifying events. Customer-funded DSM projects result in an energy bill credit equivalent to the verified energy savings of the project. This credit is added to the actual RS1823 energy consumption for the purpose of annual CBL reset determination. A customer can thus conserve energy and reduce energy purchases below the 90 percent of CBL threshold but still avoid a CBL reset by receiving credit for their DSM efforts. These adjustment

[4] The blended rate (RS1823A) is set to be equal to 90% of the Tier 1 rate plus 10% of the Tier 2 rate.

mechanisms ensure that the CBL continues to serve as an appropriate baseline and that the TSR encourages energy conservation while not penalizing economic growth.

Figure 1.2 shows the evolution of energy prices for industrial customers since 2004, including the two tiers of RS1823B, the flat rate under RS1823A, and the flat rate (RS1821) that preceded the introduction of the stepped rate.

Figure 1.2 Evolution of energy prices for industrial customers (F2003-F2020)



The stepped rate, through its price signals and adjustable consumption baseline, was intended to encourage conservation actions and participation in BC Hydro's industrial energy efficiency programs by improving the payback on conservation investments. Likewise, the presence of BC Hydro industrial energy efficiency programs and educational initiatives was expected to elevate customers' awareness and understanding of the TSR and enhance their response to the rate's price signals. The logic model presented in Figure 1.3 illustrates how the TSR works toward energy conservation by dividing the initiative into its main elements or inputs, and examining the logic chain for each element, its output and the outcomes generated in short, intermediate and long term.

The CBL Determination Guidelines contained in TS 74 define DSM as "capital projects relating to energy efficiency, energy conservation and load displacement". TS 74 distinguishes between two main categories of DSM: BC Hydro funded DSM and customer-funded DSM. BC Hydro funded DSM generates savings that are reported under DSM programs and evaluated with these programs. Some customer-funded DSM is reported as program savings if some influence[5] from the program can be demonstrated. These savings are referred to as "program-enabled". They are evaluated as part of program impact evaluations and were not included in this evaluation. This evaluation is focused on savings credited to the TSR, which were generated exclusively by customer-funded DSM. For the analysis presented in this

[5] This influence can be a program-funded energy study or sponsored energy manager.

evaluation, the broad category of customer-funded DSM is broken down into sub-categories as shown in Figure 1.4. Shaded boxes in the figure identify the savings covered by this evaluation.

The first distinction is between customer-funded DSM projects that are reported to BC Hydro (for rate administration purposes or because they were enabled through DSM program activities), and projects that remain unreported. The distinction is necessary because this evaluation is concerned with both categories of savings, but their analysis requires different approaches.

Figure 1.3 Logic model

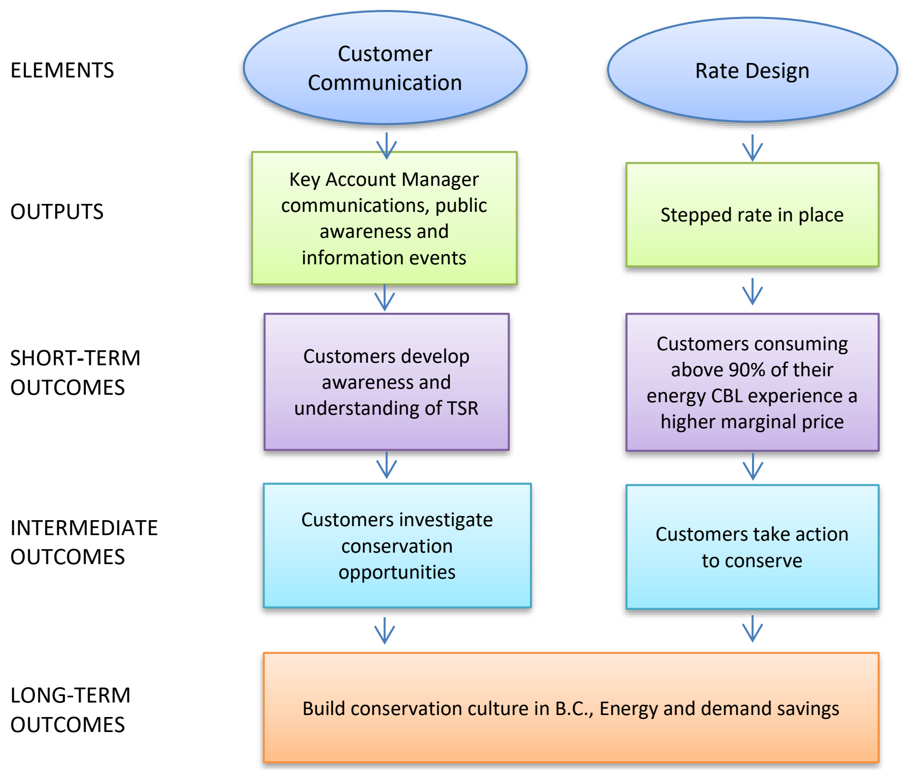
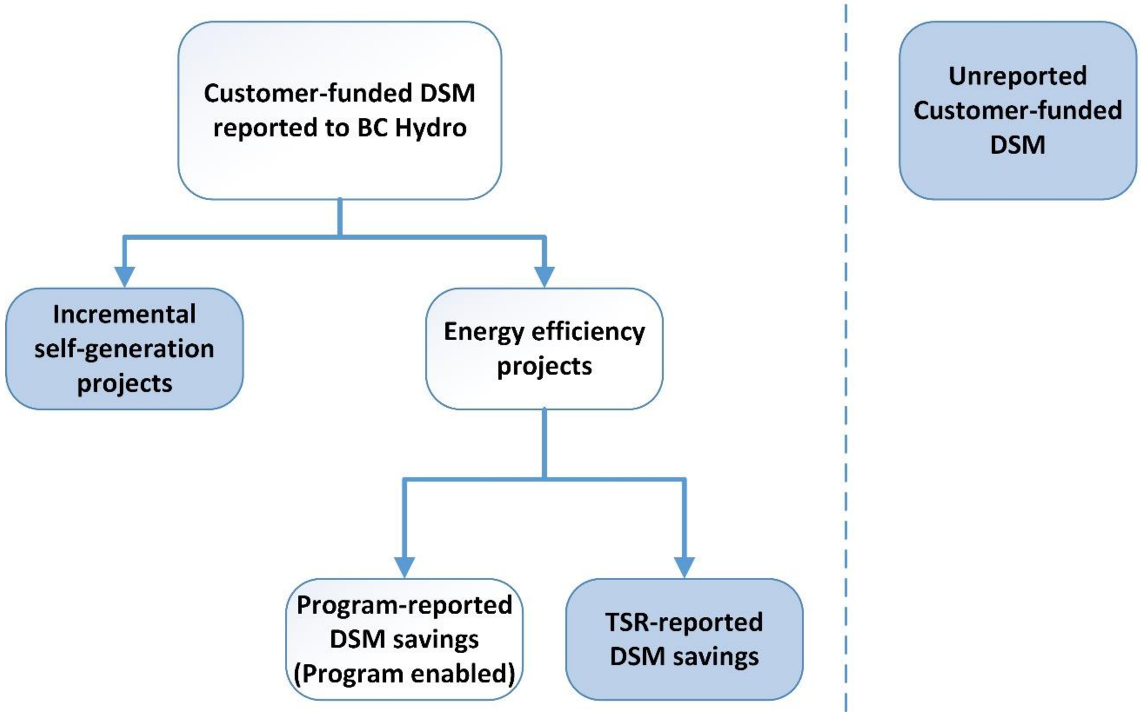


Figure 1.4 Categories of customer-funded DSM



Customer-funded DSM reported to BC Hydro includes energy savings from energy conservation, efficiency and incremental self-generation projects that were funded and installed by the customer. Most of these projects were reported to BC Hydro as part of the annual CBL review process required under the TSR and they are verified by BC Hydro to be operational. As shown in Figure 1.4, a distinction is made in this evaluation between conventional energy efficiency projects and projects that focus on incremental self-generation. This is again for methodological reasons. Energy savings from reported energy efficiency projects and incremental self-generation projects are included in the Customer's annual Energy CBL Statement that is filed with the Utilities Commission for review and approval. All customer-funded and reported DSM is considered to occur in response to the stepped rate and BC Hydro enabling activities working in combination. Figure 1.4 also shows that some savings from customer-funded energy efficiency projects were included as program-reported DSM savings. This occurs because savings are considered program enabled if sufficient program influence from a program can be demonstrated. While customers also receive energy bill adjustments under the TSR for these savings, the savings are not counted by BC Hydro as TSR-reported savings because they are reported as program savings. Note that TS 74 does not consider BC Hydro's internal reporting allocation/attribution, and all eligible customer-funded DSM projects are eligible for treatment as energy bill adjustments.

Unreported DSM is an estimate of residual energy savings from energy conservation and efficiency actions that were funded and installed by the customer but were neither reported to nor verified by BC Hydro. There is no treatment under TS 74 for Unreported DSM since no projects have been reported or defined. Unreported DSM is determined at a portfolio level and is assumed to occur in response to the stepped rate in combination with BC Hydro enabling activities. More details on this category of savings and the methods used to estimate them are provided in Section 2.3.4.

2.0 EVALUATION APPROACH

2.1 Evaluation Objectives

The evaluation objectives, data sources and methods used for this evaluation are summarized in the table below. The methodology for each evaluation objective is described in more detail in this section.

Table 2.1 Evaluation objectives and research questions

Evaluation Objective	Research Questions
1. Customer experience	• What is the general feedback from customers about their experience with the TSR?
2. Energy savings from TSR reported DSM	• What were annual incremental estimated gross energy savings from customer-funded energy conservation measures that were reported to BC Hydro through the annual CBL review process and not claimed as program-enabled savings under an industrial conservation and energy management program such as Leaders in Energy Management - Industrial? • What were annual incremental evaluated net energy and peak demand savings by fiscal year? • What does available data suggest about the persistence of savings?
3. Energy savings from TSR incremental self-generation	• What were adjusted gross reductions in energy purchases from BC Hydro (energy and demand) from incremental self-generation in response to the TSR by fiscal year?
4. Energy savings from unreported DSM	• What were annual incremental evaluated net energy savings from energy conservation measures that were not reported to BC Hydro but enabled by the TSR?
5. Total energy and capacity savings	• What was the total evaluated net reduction in energy purchases from BC Hydro (and associated capacity savings) by fiscal year?

2.2 Methodology Review

The Uniform Methods Project, one of the most recent and comprehensive energy efficiency evaluation guidelines produced by the office of Energy Efficiency and Renewable Energy under the U.S. Department of Energy, does not specify the protocols and methods for evaluating rate-induced energy saving. There is considerable literature on the evaluation of electricity rates, with methods that include econometric analysis to quantify elasticity of consumption and experimental design to measure impact through billing analysis. No recommended rate impact evaluation methodology could be identified for BC Hydro's large industrial customers charged at the Transmission Service Rate as it is a unique rate design with a stepped rate structure incorporating both an inclining block and a rewarding mechanism for energy saving initiatives. TSR customers are high energy users and energy costs constitute a significant part of their operating costs. Generally large in size and unique in business nature, these TSR customers operate in different markets and on different scales, which are all factors that affect their energy consumption. The heterogeneous characteristics and profile of industrial customers make them hard to compare to each other and the jurisdiction-specific composition of industrial customers further complicates the task of conducting comparison studies in order to evaluate rate impacts.

Econometric modelling of industrial energy consumption for estimating industrial rate elasticity is the generally adopted approach to estimate industrial electricity rate impacts. The industrial rate elasticity has been estimated in several research studies for different countries and markets. A list of the methods as well as the study results are provided and summarized in Appendix D.3. The results of these studies, in terms of elasticity estimates, vary over a wide range and tend to be specific to industrial sectors and jurisdictions. Therefore, they only serve as reference for this evaluation and only provide some indicative values of elasticities. These studies have internal validity, but their external validity is questionable. Some studies have focused on a specific industrial sector but are not representative of the entire transmission service rate customer class. A recent study by Csereklyei[6] (2020) on the European Union electricity market shows that the short-run elasticity estimates of the industrial sector ranges between -0.08 and -0.1, while long-run elasticity falls in the range between -0.75 and -1.01. Liddle and Hasanov (2021) estimated that the price elasticity of electricity for industrial customer is on average about -0.25 for 35 high income countries (most are OECD countries).

Some impact evaluations of energy conservation programs directed at industrial customers, though not specifically related to electricity pricing, are based on engineering review and measurement and verification results. Warren and Membrino[7] (2015) discuss the general approach of evaluating conservation impacts through an engineering analysis of system efficiency improvements in the context of plant production changes.

The last BC Hydro TSR evaluation adopted a mixed engineering and econometric methodology to evaluate savings associated with the stepped rate. TSR reported DSM conservation impacts and incremental self-generation by TSR customers were evaluated based on engineering estimates and measurement and verification results. Deemed savings claimed as "unreported DSM" were evaluated through an econometric model that led to an estimate of total energy savings impact achieved by the TSR. Several engineering adjustments were then made to this overall impact to arrive at an estimate of unreported DSM. The estimate was presented as a range and carried significant uncertainty, but it provided credibility to the relatively small deemed savings that were claimed for this component of the rate impact. As explained in the next section, this evaluation follows a similar approach.

2.3 Methodology

The objectives, data sources and methods used for this evaluation are summarized in Table 2.2. A more detailed description of the data sources and analytic approach follows the table.

[6] Csereklyei, Z. (2020). "Price and income elasticities of residential and industrial electricity demand in the European Union." Energy Policy 137: 111079.

[7] Warren, K. and Membrino C. (2015), "Standard Approach to Non-Standard Industrial Projects", IEPEC 2015.

Table 2.2 Evaluation objectives, data sources and methods

Evaluation Objective	Data Sources	Methods
1. Customer experience	• F2017 to F2020 Leaders in Energy Management-T Participant Surveys (n=18)	• Cross tabulations of survey responses
2. Energy savings from TSR reported DSM	• Project files (n=5) • CBL Statements • PSP-T/LEM-T (F2012-F2017) impact evaluations	• Engineering calculations • Gross realization rate • Free ridership estimation
3. Energy savings from incremental self-generation	• CBL Statements for sites reporting self-generation (n=11) • Project files for sites reporting savings through BC Hydro Load Displacement program (n=2)	• Engineering calculations • Cross tabulation
4. Energy savings from unreported DSM	• BC Hydro's monthly billing data for TSR customers from F2012 to F2020 • Statistics Canada economic data for employment in the non-durable goods sector • TSR energy price history • Consumer Price Index from BC Statistics Agency	• Econometric analysis of billing data • Energy savings calculations based on price impact estimates
5. Total energy and capacity savings	• Results from Objectives 2, 3, and 4 • Peak-to-energy factor for industrial rate class	• Engineering calculations

2.3.1 Data and Methods for Objective 1: Customer experience

The main source used to assess customer experience was an online survey of Leaders in Energy Management program participants, conducted in multiple waves over the evaluation period. While this survey is used primarily to inform program evaluation, some questions pertained to experience with the TSR. Specifically, customers that had completed a program enabled project (i.e., a customer-funded project for which no direct incentive was paid by BC Hydro, but for which the customer received a financial benefit through the TSR, as well as other support, such as funding for an energy study) were queried about the influence of any financial benefit through the TSR on their decision to complete the project. Over the evaluation period, responses were received for a total of 18 program enabled projects completed by transmission customers. The relevant questions from the questionnaire are included in Appendix E.

Given that all TSR customers were invited to participate in ongoing consultation workshops to review and discuss proposed changes to the TSR and that the vast majority have a Key Account Manager, they have direct channels to provide feedback to BC Hydro on the rate on an ongoing basis. As such, no further data collection specific to this evaluation was conducted.

2.3.2 Data and Methods for Objective 2: Energy savings from TSR reported DSM

The analysis of energy savings from TSR reported DSM in this evaluation is generally consistent with recent industry standard practice for commercial and industrial custom projects and new construction programs in that it makes use of the most common evaluation methods. It involves an estimation of the gross realization rate and a net-to-gross ratio of energy efficiency projects. This evaluation also considers provisions specific to the TSR, such as the CBL Determination Guidelines[8], which set specific conditions for how and when energy savings can be claimed under the rate structure.

The same evaluation methods used for program enabled projects completed by transmission customers as part of BC Hydro's conservation programs[9] apply to TSR reported DSM projects. In both cases, the energy efficiency projects are customer-funded and the customer benefits financially through reduced energy costs. The primary difference is how these energy savings are reported by BC Hydro. Program enabled projects need to demonstrate program influence for savings to be attributed to the program, whereas TSR reported DSM projects that result in energy bill adjustments under the TSR simply need to meet the criteria set out in TS 74. Both types of projects undergo rigorous internal review by BC Hydro.

TSR reported DSM projects were considered to be influenced by the financial mechanism of the rate structure and reported to BC Hydro for CBL administration, and savings for these projects were not attributed to any DSM program. In some cases, these TSR reported DSM projects may have had some program influence through project enabling activities such as an energy study or energy manager, but the customers were unable to meet all the criteria for attribution to the program (e.g., through a program enabled energy savings report). Therefore, energy savings for TSR reported DSM projects were exclusively attributed and reported to the TSR.

The evaluation considered energy savings from the date of project installation, regardless of whether the customer was on rate schedule RS1823A or RS1823B. This recognizes the fact that the rate structure influences customer actions even when they are on the flat rate in anticipation of the treatment they will receive when they transition to the stepped rate. In contrast, for projects implemented while customers were on the flat rate, energy savings were tracked by BC Hydro as TSR reported DSM only after the customer moved to the RS1823B stepped rate structure. Customers can submit a request to BC Hydro for recognition of customer-funded DSM projects up to 18 months after the project's in-service date. This may result in the project's reported energy savings being attributed to a different fiscal year than the year of installation.

Evaluated Gross Energy Savings

Energy savings from TSR reported DSM are estimated and confirmed through a project cycle that includes several steps. The project cycles of BC Hydro programs and TSR reported DSM were almost identical. If an energy study was conducted, it provided the initial engineering estimate of a project's predicted energy savings based on a technical application of engineering principles and forecast assumptions of production and energy performance. However, if no predictive energy savings estimate was found, the initial engineering estimate of a project's energy savings was based on the application for recognition of customer-funded DSM project submitted after project implementation. The next step for all five projects was a refinement of the energy savings estimates through a post-implementation engineering review that occurred after the project was completed. This review confirmed equipment installation and operation through a physical site inspection or customer submission of project records and photos. Some projects also underwent annual post-implementation engineering reviews as their annual energy performance was closely tied to varying operating conditions. The post-implementation review often considered actual production and actual energy use as well as performance data. A subset of projects also underwent an impact study with annual review to further refine prior engineering estimates, which involved measurement and verification (M&V) consistent with the International Performance Measurement and Verification Protocol[10] (IPMVP). M&V typically involved pre- and post-

[8] BC Hydro Electric Tariff Supplement No. 74

[9] BC Hydro Power Smart Partner – Transmission Program Evaluation (F2012-F2014), 2016

[10] IPMVP - Efficiency Valuation Organization (EVO) (evo-world.org)

implementation measurements of actual energy use and variables that have a significant impact on energy consumption, such as production. When and how a project had M&V conducted by an independent third party depended on a criterion determined by tariff rules[11].

A review by Evaluation was also completed for all projects to produce an estimate of the annual rate of energy savings (also known as run rate savings). The results were then compared to the estimates of the acquired energy savings used for CBL Statements and energy bill adjustment purposes. The following table shows the number of projects with expected savings by fiscal year.

Table 2.3. Number of TSR reported DSM projects with expected savings by fiscal year

Fiscal Year	Number of projects installed	Number of energy conservation measures	Expected Savings (GWh/yr)
F2017	0	0	-
F2018	3	23	328.8
F2019	1	12	28.9
F2020	1	8	15.0

Evaluated gross savings were obtained from the best available estimate of energy savings from the CBL annual review records. All five TSR reported DSM projects underwent an annual engineering review with impact study starting in F2019. Expected savings were obtained from the energy savings reported to the TSR following the year of installation. The gross realization rate is the ratio of evaluated gross savings over expected savings and reflects the overall performance of all TSR reported DSM projects during the evaluation period. The following equation was used to calculate the gross realization rate using all TSR reported DSM projects (i):

Equation 1

$$Gross\ Realization\ Rate\ (GRR)_{F17-F20} = \frac{\sum_{i=1}^{n} Evaluated\ Gross\ Energy\ Savings_i}{\sum_{i=1}^{n} Expected\ Energy\ Savings_i}$$

Evaluated Net Energy Savings

The treatment of TSR reported DSM projects under the TSR rate structure for the purpose of CBL adjustment and annual review does not require any information that demonstrates the influence of the conservation rate on the decision to implement a project. From that perspective, estimates of energy savings from CBL statements clearly represent gross savings that require an adjustment if an estimate of evaluated net energy savings is needed for the purpose of DSM reporting. Gross energy savings did not account for factors external to the TSR rate structure that could impact energy savings. Gross savings may include energy savings that are not attributable to the TSR or to the combined effect of program enabling activities and the TSR working together. Net savings typically adjust gross savings for free ridership and spillover. Net energy savings attributable to TSR reported DSM were determined through the following equation:

Equation 2

$$Evaluated\ Net\ Savings = Evaluated\ Gross\ Savings \times (1 - Free\ Rider\ Rate + Spillover)$$

A common method used to estimate free ridership for industrial and commercial programs involves analyzing the results of decision-maker surveys that ask a customer representative about the projects

[11] BC Hydro Electric Tariff Supplement No. 74 Customer Baseline Load Determination Guidelines

their organization implemented through the program. In the present case, the free ridership rate was determined by proxy, using free ridership estimates obtained through this method for previous program evaluations deemed to be relevant, combined with the use of case studies as described below.

Free Ridership

The evaluation considered the free ridership survey results from the BC Hydro DSM programs for transmission customers (LEM-Transmission F2015-F2017, PSP-Transmission F2012-F2014 and New Plant Design F2009-F2014) as representative of customer decision-making under the TSR. Therefore, program results were used as a proxy to estimate free ridership for TSR reported DSM projects in this evaluation period. DSM projects reported under the TSR were divided into three categories as shown in Table 2.4, based on an examination of each project file. All five TSR reported DSM projects in this evaluation period were of the New Plant Design type. Different free ridership scores were applied to each of these categories. DSM projects with a savings estimate based on an energy study were assigned a free ridership score of 0.1 based on the estimated free ridership for similar projects in the LEM-T, PSP-T and New Plant Design (NPD) programs. Projects without an energy study and for which the customer had no experience through a similar past projects were assigned a free ridership score of 0.6, also based on the estimates from the LEM-T, PSP-T and NPD programs for similar projects. Projects for which savings were estimated by an energy manager or based on a similar previous project by the customer were assigned a free ridership score of 0.35 based on the average of the previous two categories. The results were then combined into a single weighted free ridership score based on evaluated gross energy savings.

Table 2.4 Free ridership assessment of TSR reported DSM projects

Project Type and Grouping	Count of Projects	Free Ridership Score	Reference source of Free Ridership score applied
• All retrofit type projects • New Plant Design (NPD) or Plant Capacity Increase (PCI) projects for which savings were estimated based on an energy study	2	**0.10**	BC Hydro LEM-T (F15-F17), PSP-T (F12-F14) and NPD (F09-F14) evaluation of program enabled projects with energy savings prediction
• NPD or PCI projects with no energy study but for which savings were estimated by an energy manager or based on a similar previous project	0	**0.35**	Estimated as an average of the two free ridership scores of groupings above and below
• NPD or PCI projects with no energy study, no energy manager, or no similar previous project	3	**0.60**	BC Hydro LEM-T (F15-F17), PSP-T (F12-F14) and NPD (F09-F14) evaluation of program enabled projects without energy savings prediction

An alternative approach to estimate free ridership was to conduct case studies. The case study method recognizes that customers face several barriers to implementing energy conservation measures. The key barriers are awareness, acceptance, affordability, and availability. A range of influence tactics are used to address these barriers. The following table summarizes the barriers and tactics considered in the case study method.

Table 2.5 Case study method: project barriers and program or TSR influence tactics

Criteria	Project Barrier	Program (or Rate) Influence Tactic
Awareness	Lack of customer awareness of energy conservation opportunities	Promotion, training etc.
Acceptance	Lack of customer understanding of technical performance risks of energy conservation opportunities	Energy studies, demonstration projects, etc.
Affordability	Incremental cost of energy conservation projects	Incentives, or TSR bill savings
Availability	Lack of customer management commitment or staff resource availability during decision making	Energy Managers, BC Hydro Alliance, Key Account Managers, etc.

Through the case study method, individual projects are assessed to determine the specific barriers faced by a project and the degree to which BC Hydro actions addressed the barriers. Details on the case study method are described in Appendix C.1.

All five projects were selected for the case study method to test the validity of the two methods and support the free ridership estimate with multiple lines of evidence. A score of zero to three points was assigned to each barrier and influence tactic using guidelines for assessing and scoring each barrier and influence tactic. The guiding principle for scoring was 0 points for no evidence, 1 point for some evidence, 2 points for significant evidence and 3 points for substantial evidence. Scores were then converted to a measure of free ridership using an algorithm that is further described in Appendix C.1. In addition, business and market driver scores were estimated for new plant design program enabled projects to measure the degree of business alignment and market adoption of the equivalent service alternative and its non-energy benefits if applicable. Free ridership was calculated separately for each grouping as described above and then combined into a single weighted free ridership score based on evaluated gross energy savings.

Spillover

Spillover for TSR reported DSM projects was estimated based on supporting information found in the project file during evaluation review, which documented that additional energy conservation measures were installed at the customer site but were not recognized for energy bill adjustment or claimed as program DSM. Note that this TSR spillover is similar to program reported participant spillover in that it was evaluated only for the five participants with TSR reported DSM.

Persistence

The TSR reported DSM projects were evaluated for persistence using the BC Hydro DSM Standard on Effective Measure Life and Persistence[12]. Persistence is defined as the length of time the energy savings are expected to be attributable to the DSM activity and is used for DSM reporting purposes. Note that for CBL administration, project energy savings are assigned a duration[13] that may differ from the DSM persistence.

[12] BC Hydro DSM Standard Effective Measure Life and Persistence – Revision 10, June 2016.

[13] Duration of project energy savings for CBL administration is determined based on Attachment A in Tariff Supplement No. 74.

2.3.3 Data and Methods for Objective 3: Energy savings from TSR incremental self-generation

The analysis of energy savings from TSR incremental self-generation energy in this evaluation is based on the fact that it was considered customer-funded DSM that reduces the customer's energy purchases from BC Hydro. The treatment of incremental self-generation is unique to BC Hydro and the TSR in that it is limited to surplus self-generation energy in excess of any contracted customer based self-generation[14]. Hence, industry standard evaluation methods developed for combined heat and power programs[15] do not apply in this context, since incremental self-generation energy represents only a fraction of the output of the total self-generation energy system. The DSM impact depends on other contractual obligations and an established generation energy baseline. BC Hydro has worked to establish a "non-contracted" generation baseline (non-contracted GBL) for most customers with self-generation based on the actual gross metered output of each generator in a reference year. The non-contracted GBL represents generation output that is not under contract for off-site sales and is in effect the baseline generation output used by the customer to serve an equivalent portion of their historical plant load.

Some customers with self-generation sell a portion of their incremental generation output to off-site customers (mainly to BC Hydro and Powerex). In such cases, BC Hydro establishes a contracted GBL for the customer that represents the amount of generation output that must first be used to meet historical plant load requirements. Generation output that is incremental to the contracted GBL may then be sold under contract as "off-site sales", usually via an Electricity Purchase Agreement (EPA).

For customers without an EPA, gross generation energy in excess of the non-contracted GBL is considered incremental self-generation (DSM savings) under the TSR. For customers with an EPA, only the gross generation energy in excess of all contractual obligations (contracted GBL and EPA) is considered incremental self-generation under the TSR, and it is considered only if the customer nominated any potential incremental self-generation at the start of each billing year to be used as an offset to energy purchases under the TSR. In those cases, at the end of the billing year, the incremental self-generation resulted in an energy bill adjustment for the customer. Any excess generation energy that was not nominated under the TSR was sold to BC Hydro under the terms of the EPA. The reconciliation of metered energy flows and customer allocations was done by BC Hydro's Commercial Operations based on rules set out in Tariff Supplement No. 89 and on the terms and conditions of the EPA. This sets a GBL that can be annual, seasonal, monthly, or hourly depending on the specific contract.

This evaluation is focused on comparing the TSR tariff treatment of this incremental self-generation with BC Hydro's reporting practices for DSM projects relating to energy efficiency, energy conservation, and load displacement energy. The following steps were required in the evaluation:

1. Estimate the gross incremental self-generation by fiscal year based on CBL statements.
2. Estimate the gross incremental self-generation by fiscal year in response to the TSR and for DSM reporting purposes for the two categories of customers, with and without an EPA. Also check for reporting of incremental self-generation energy to parallel initiatives such as those participants with a load displacement agreement.
3. Assess the year-over-year change in incremental self-generation energy at customer sites without an EPA for evaluation objective 4 (Unreported DSM of RS1823B customers).

[14] BC Hydro Electric Tariff Supplement No. 89, Billing Formula for Customers That Sell Electricity to BC Hydro Pursuant to an Electricity Purchase Agreement with a Contracted GBL

[15] Uniform Methods Project, Chapter 23: Combined Heat and Power Evaluation Protocol, US Department of Energy, National Renewable Energy Laboratory.

The first step required the CBL statements for customer accounts with self-generation. Of the 13 participants with self-generation, 11 were pulp mills or wood product facilities, one was a wastewater treatment plant, and one was a gas processing facility. There were 11 unique accounts that reported incremental self-generation under the TSR at least once between F2017 and F2020, for a total of 24 records of annual reported incremental self-generation in response to the TSR.

The second step consisted of separating customers into accounts with or without energy delivered to BC Hydro under an EPA. This was necessary for the evaluation of peak demand savings. For customers without an EPA, all self-generated electricity directly reduces the electricity requirements at the site. Peak demand savings can be estimated by applying the average peak-to-energy factor of 0.117 MW per GWh for the transmission rate class. However, for customer sites with an EPA, the incremental self-generation recognized as DSM is by nature more sporadic, since they can allocate their excess energy in different ways. It becomes difficult to associate peak demand savings with this particular form of excess generation energy. No demand savings were accounted for from sites with an EPA that reported incremental self-generation. Of the 11 accounts reporting incremental self-generation, five were customers without an EPA and the other six had an EPA. In addition, two customers with incremental self-generation had parallel load displacement agreements under a BC Hydro DSM program. Although these two accounts were eligible for customer-funded incremental self-generation under the TSR, their incremental self-generation energy was already reported with the load displacement project.

The third and last step was required because the econometric model developed for objective 4 provided gross energy impact results in the form of year-over-year changes in energy consumption under RS1823B. Therefore, calculating unreported DSM savings using this approach required the year-over-year changes in incremental self-generation for customers on RS1823B as an input.

2.3.4 Data and Methods for Objective 4: Energy savings from unreported DSM

Unreported DSM savings refer to the energy savings that are induced by the stepped rate but not accounted for under TSR reported DSM, incremental self-generation, or BC Hydro's conservation programs. These savings may arise in part from the fact that a threshold exists for customer-funded DSM[16] to be recognized for CBL energy bill adjustments. Projects with savings below this threshold are not expected to be claimed and reported as DSM. Another possible reason why savings may go unreported is that customers only need to justify 90 percent of their CBL to avoid a reset, so there is no compelling reason for them to expend resources in claiming this marginal portion of energy savings. In the current evaluation period, these unreported DSM savings were claimed by BC Hydro in its annual DSM report to the Commission at a deemed rate of 10 GWh per year.

As in the previous evaluation of the TSR, unreported DSM savings were estimated through econometric modelling, by building a regression model that relates changes in TSR customer's energy consumption to changes in energy prices and economic activity. This methodology aims at isolating energy consumption changes induced by the TSR, where the stepped rate mechanism incentivises customers to reduce energy consumption through DSM, from changes that are due to fluctuations in economic activity. This method provides only a high-level estimate of unreported DSM savings and has limitations that are discussed in more details in Section 3.6. This method relies on BC Hydro's TSR customer billing data from F2012 to F2020 as well as data from Statistics Canada and BC Stats related to TSR customers business activities.

As mentioned earlier, BC Hydro has introduced the optional Freshet Rate schedule (RS1892) to TSR customers in 2016. This rate is designed to encourage TSR customers to take on extra generation capacity during the freshet period (typically in June and July every year). The Freshet Rate is a market

[16] The threshold is set at 0.3 GWh/yr for customer-funded DSM in TS 74.

rate determined by the Mid-Columbia (Mid-C) market price which is generally more favorable to customers than the TSR. It is only applied to additional energy consumption during the freshet period that exceeds a customer's baseline in high-load hours and low-load hours for each day in comparison to the baseline year (2015) consumption. The Freshet Rate was evaluated separately and load shifting events affecting the volume of TSR energy sales were found to be minimal[17]. Therefore, any energy consumption by TSR customers charged at the freshet rate is not included in the econometric analysis.

In the econometric analysis, the econometric model identifies the degree to which energy consumption changes are correlated with changes in TSR prices. More specifically, this correlation is expressed as price elasticities which denote the percentage change in energy consumption that corresponds to a one percent change in price. The gross energy impacts induced by the TSR are then calculated from these estimates of price elasticity[18] under RS1823B. Such impacts may encompass energy savings from different DSM initiatives, including all customer-funded DSM, BC Hydro's DSM programs, and Codes and Standards initiatives. With this in mind, unreported DSM savings were then calculated by deducting from the gross TSR impacts the energy savings from all these initiatives. An estimate of natural conservation savings that accounts for the counterfactual scenario of what would have happened in the absence of the TSR is also provided and deducted in the calculations of unreported TSR savings.

Under this analytical framework, significant research efforts were focused on econometric modelling due to the uniqueness and complexity of the TSR design. Particular attention was paid to three large DSM projects funded by BC Hydro and implemented under a special initiative targeting thermo-mechanical pulping (TMP) customers. These customers account for a large share of TSR energy consumption, and the three projects implemented under the TMP Initiative generated considerable savings. How to treat these projects in the econometric model and the calculation of gross TSR impacts was a source of debate. Consequently, two econometric models were developed to treat the TMP projects savings differently and analyse unreported DSM savings from different perspectives. This provided insights into how sensitive the econometric model was to the treatment of these large projects.

The method of evaluating unreported savings with the two econometric models is detailed below. The first model follows a general specification that reproduces the approach used in the last evaluation of the TSR, while the second one uses a modified specification pertaining to the treatment of TMP Initiative project savings. The two models are similar in specification and, for brevity, only the key model differences are discussed in the presentation of the second model. Additional analysis and discussion of econometric modelling are presented in Appendix D.3, including several alternative model specifications that were explored in this evaluation.

Econometric Model #1

Step 1. Estimate the TSR stepped rate elasticity through econometric analysis

This step employed an econometric model of monthly Tier 1 and Tier 2 consumption by customers under RS1823B to estimate the elasticity of Tier 1 and Tier 2 prices. Two key factors under consideration in the econometric analysis are electricity price and business factors that may influence electricity consumption. The econometric analysis uses statistical methods to estimate the relative influence of these factors and in turn determine what portion of the changes in electricity consumption can be attributed to each of them. The econometric model essentially provides an analytical framework to

[17] Freshet Rate Pilot Final Evaluation Report, BC Hydro, December 2018. Filed in compliance with B.C. Utilities Commission Orders No. G-17-16 and G-45-18.

[18] Price elasticities identified through this analysis should be interpreted with caution. As discussed further in this report, given the econometric model specification, they should not be interpreted specifically as responses to marginal price.

isolate the impact of electricity price changes on electricity consumption from other impacts by incorporating economic indicators into the electricity consumption model.

A key issue with such a model is to identify economic indicators that are representative of the business activities of the diverse group of customers that take service under RS1823B. Consistent and systematic business intelligence or data pertaining to the TSR customer group are hard to obtain and track. Therefore, high-level economic indicators are generally preferred to capture the overall impacts of diverse business activities over a long period of time. Employment and industrial outputs are two general and most representative economic indicators reflecting business conditions. Over a sufficiently long period these indicators should reflect TSR customers' business operations and thereby electricity consumption. They are available from public statistical sources and have been used in similar studies of electricity consumption. For example, Quesada-Pineda et al. (2016) [19] analyzed the electricity consumption in the wood products sector in the US using three factors affecting electricity consumption: 1) electricity price; 2) employment in the sector and; 3) plant size. Employment in the non-durable goods sector in B.C., sourced from Statistics Canada, was adopted as an indicator of changes in economic activity in the econometric model for this evaluation.

Another key consideration is to build a proper econometric model that reflects the specific TSR rate design. One particular element of this rate design is an adjustable rather than a fixed CBL, which accommodates TSR customers' production changes. Another key element is energy bill adjustments, which reward customers by maintaining their CBL in recognition of energy conservation impacts, even if they have completely displaced any Tier 2 energy consumption through energy conservation measures. The energy consumption data applied in the econometric model accounts for these elements by tracking Tier 1 and Tier 2 energy consumption separately. Customers are billed on a monthly basis at either the Tier 1 price or Tier 2 price based on energy purchases relative to the CBL. In any given month, the energy consumption of an industrial customer is billed at the Tier 1 price if the annual cumulative consumption to-date in the fiscal year is below 90 percent of the annual CBL. When consumption reaches and exceeds 90 percent of the annual CBL in a given month, the energy bill includes charges at both the Tier 1 and the Tier 2 prices. Finally, if the total energy consumption in a month is in excess of 90 percent of the annual CBL, the customer is billed at the Tier 2 price for the whole month. As such, at an aggregate level for TSR RS1823B customers, the monthly aggregated consumption can be divided into three categories: Tier 1 consumption only, Tier 2 consumption only, or both Tier 1 and Tier 2 consumption (which occurs in the month where annual cumulative consumption crosses the threshold of 90 percent of the CBL). Each category of consumption can be modelled using one of the three equations listed below, and together form a system of equations that describes the entire RS1823B monthly energy consumption. The system of equations can then be solved using linear regression analysis to estimate for the unknown parameters. The model reflects changes in both Tier 1 and Tier 2 energy consumption over the period analyzed.

Equation 3

$$\ln(Tier1\ Consumption_i) = \alpha + \beta \cdot \ln(Tier1\ Price_i) + \varphi \cdot Employment\_Non\_Durable_i + \mu$$

Equation 3 represents Tier 1 consumption in month *i* as a function of Tier 1 price and monthly employment in the non-durable goods producing sector in B.C.

Equation 4

$$\ln(Tier2\ Consumption_i) = \alpha + \theta \cdot \ln(Tier2\ Price_i) + \varphi \cdot Employment\_Non\_Durable_i + \mu$$

[19] Quesada-Pineda, H., Wiedenbeck, J. & Bond, B. (2016) "Analysis of electricity consumption: a study in the wood products industry", Energy Efficiency (2016) 9: 1193.

Equation 4 represents Tier 2 consumption in month *i* as a function of Tier 2 price and monthly employment in the non-durable goods producing sector in B.C.

Equation 5

$$\ln(Tier1\ and\ Tier2\ Consumption_i) = \alpha + \beta \cdot \ln(Tier1\ Price_i) + \theta \cdot \ln(Tier2\ Price_i) + \varphi \cdot Employment\_Non\_Durable_i + \mu$$

Equation 5 represents combined Tier 1 and Tier 2 consumption in month *i* as a function of Tier 1 price, Tier 2 price, and monthly employment in the non-durable goods producing sector in B.C.

In all three equations, the consumption variables and the price variables are in the natural logarithm form so that the parameters β and θ, associated with Tier 1 and Tier 2 prices in the regression analysis, represent the Tier 1 and Tier 2 price elasticities[20]. The parameter φ quantifies the relative weight of the employment variable, and μ is the error term.

Step 2. Estimate gross TSR energy impact based on the price elasticity estimates

As mentioned earlier, Tier 1 and Tier 2 price elasticities derived from Step 1 represent a measure of the sensitivity of energy consumption to a change in price. Mathematically, the definition of price elasticity can be expressed as:

Equation 6

$$Price\ Elasticity = \frac{\Delta(Energy\ Consumption)/Energy\ Consumption_{i-1}}{\left(Price_i - Price_{i-1)}\right)/Price_{i-1}}$$

As demonstrated in Appendix C.2, once the price elasticity is estimated, the price impact on consumption (*ΔEnergy Consumption*) can be calculated as follows:

Equation 7

$$\Delta Energy\ Consumption_i = (Energy\ Consumption_{i-1}) \cdot Price\ Elasticity \cdot ((Price_i - Price_{i-1)})/\ Price_{i-1})$$

where

i denotes the current year;

ΔEnergy Consumption is the change in energy consumption of period *i* over the previous period *i-1*;

$Energy\ Consumption_{i-1}$ is the total consumption in the previous period, and

$Price_i$ and $Price_{i-1}$ are the current and previous period's real price (discounted by the inflation rate), respectively.

The above approach can be applied to the three categories of TSR energy consumption represented by Equation 3, Equation 4, and Equation 5, which produces Equation 8, Equation 9, and Equation 10 as follows:

[20] Although these parameters are identified here as price elasticities, they should be interpreted with caution. Given the econometric model specification and the multiple DSM initiatives and energy savings streams affecting the consumption of TSR customers, these parameters capture some of the impacts of energy consumption for all these savings streams. In addition, they should not be interpreted strictly as a difference in response to marginal price.

Equation 8

$$Price\ impact\ on\ Tier1\ consumption_i = (Tier1\ Consumption_{i-1}) \cdot \beta \cdot (\Delta Tier1Price\ /\ Tier1\ Price_{i-1})$$

Where $\Delta Tier1Price$ is the change in price relative to the previous period, discounted by the inflation rate

Equation 9

$$Price\ impact\ on\ Tier2\ consumption_i = (Tier2\ Consumption_{i-1}) \cdot \theta \cdot (\Delta Tier2Price / Tier2\ Price_{i-1})$$

Equation 10

$$\begin{aligned} &Price\ impact\ on\ Tier1\ and\ Tier2\ consumption_i \\ &\quad = (Tier1\ and\ Tier\ 2\ Consumption_{i-1}) \cdot \beta \cdot (\Delta Tier1Price\ /\ Tier1\ Price_{i-1}) \\ &\quad + (Tier1\ and\ Tier\ 2\ Consumption_{i-1}) \cdot \theta \cdot (\Delta Tier2Price\ /\ Tier2\ Price_{i-1}) \end{aligned}$$

The Gross TSR energy impact on TSR customers is the sum of the three equations above:

Equation 11

$$\begin{aligned} &Gross\ TSR\ Energy\ Impact \\ &\quad = Price\ impact\ on\ Tier1\ consumption + Price\ impact\ on\ Tier2\ consumption \\ &\quad + Price\ impact\ on\ Tier1\ and\ Tier2\ consumption \end{aligned}$$

It is important to note that the elasticity estimates discussed here should not be interpreted as indicators of marginal price response, because the econometric model was not structured in a manner that would allow it to measure marginal price response. Elasticity estimates representing a marginal price response are often used to model the effect of changes in a rate structure. However, estimating marginal price response requires isolating customers specifically exposed to a high marginal price to see how they respond in comparison to those not exposed to the higher price. In the case of the TSR, this is not possible because every customer is exposed to the high marginal price of Tier 2 and each customer has an individual CBL which determines the amount of consumption to be charged at the Tier2 price. The only exceptions are sites billed under RS1823A (flat rate), but they are generally on this rate for only a limited time while the site faces major transitions. This makes them unsuitable for analysis as a comparison group. The elasticity estimates identified through the method described above represent an overall response to price changes, but the difference in Tier 1 and Tier 2 elasticities cannot be interpreted as a difference in marginal price response.

Step 3. Calculate Unreported DSM Savings

The elasticity results provide, in principle, a measure of TSR customers' response to price changes reflected by changes in energy consumption under schedule RS1823B. However, one must bear in mind that, in the TSR scheme, this measured price response may be confounded by other factors. For example, customers have the flexibility to decide, for any DSM project they implement, whether to take a financial incentive from a regular program or receive an energy bill adjustment under the TSR; both pathways produce the same change in energy consumption and would produce the same result in the regression model presented above. Past evaluations of the TSR have in fact demonstrated that the price variables in the regression model capture a significant portion of the program DSM impact that is embedded in the actual energy consumption[21]. Other factors, such as natural conservation brought about by general technological or production efficiency improvements, or energy savings related to codes and standards improvements are also embedded in the energy consumption and may produce similar effects. The estimates of price elasticity derived through this analysis may capture, at least in part, the influence of

[21] See BC Hydro Transmission Service Stepped Rate (TSR) Impact Evaluation: F2012-F2016 (p.28) and BC Hydro Process and Impact Evaluation of the Transmission Service Rate (TSR) – Milestone Evaluation Report F2011.

all these factors. This is because a portion of the change in consumption contributed by these factors can be correlated with changes in price, and the regression analysis will reflect this correlation in the price elasticity coefficients.

The general goal of this econometric modelling effort is to quantify TSR unreported DSM savings. The gross TSR energy impact calculated in Step 2 represents the impacts on consumption that are ascribed to price changes, as opposed to changes in economic activity, by the econometric model. As discussed above, this may include the impact of DSM measures (reported to BC Hydro or not), the impact of Codes and Standards changes, as well as the impact of natural conservation. Once the gross TSR energy impact is calculated, a conservative estimate of unreported DSM savings can be obtained by deducting energy savings from all these sources. Note that no deductions were made for TSR-Reported DSM because all projects falling in this category were implemented by customers that were on the flat rate and therefore not included in the econometric analysis.

The deductions are carried out according to the following list of steps:

Step 3.1 **Net savings from LEM-T or LEM-I program incentive DSM (net of free riders)**

Step 3.2 **Net savings from LEM-T or LEM-I program enabled DSM (net of free riders)**

Step 3.3 **LEM-T or LEM-I program spillover savings**: evaluated based on spillover impacts of DSM projects incentivized by BC Hydro for Transmission customers.

Step 3.4 **Savings from Thermo-Mechanical Pulp (TMP) Initiative:** during the evaluation period some TSR customers (pulp and paper mills) implemented major projects with BC Hydro's financial assistance under the TMP Initiative. The three customers which implemented TMP projects reported net energy saving of 138 GWh per year. These savings have not been the subject of an impact evaluation but preliminary M&V analysis has confirmed that projects were performing as expected.

Step 3.5 **Net savings from Strategic Energy Management (SEM):** SEM is a set of energy-reducing goals, principles, and practices emphasizing continuous improvements in energy performance or savings through energy management. Although SEM has long been supported by BC Hydro programs, BC Hydro did not report incremental energy savings relating specifically to SEM practices prior to F2017. For each fiscal year from F2017 to F2020 additional deemed energy savings for selected SEM participants were reported under the LEM-T or LEM-I program. Savings were reported based on a deemed two percent of the site energy consumption for all sites that met a pre-qualifying threshold of SEM practices[22]. In prior years, the TSR evaluation of F2012-F2016 provided an estimate of unreported savings which likely included unreported energy savings from DSM program activities such as strategic energy management.

Step 3.6 **Incremental self-generation energy:** this includes surplus customer-funded self-generated energy, in excess of any contracted customer based self-generation, that reduces energy purchases from BC Hydro and is recognized as customer-funded DSM. This is quantified in this evaluation under Objective 3. Note that since the impacts calculated with the econometric model represent year-over-year changes, it is the year-over-year change in incremental self-generation that needs to be deducted from the gross TSR energy impacts.

Step 3.7 **Codes and Standards savings:** these are incremental savings reported by BC Hydro in this evaluation period for advancements in codes and standards applicable to industrial

[22] Evaluation of SEM savings was only conducted for F17. SEM savings for the later years have not been evaluated yet.

production. These savings are mostly associated with a new standard for large industrial motors and a small portion of savings identified for general service lamps. These codes and standards impacts have not been evaluated[23] and the associated savings are taken as reported. Also, the portion of impacts attributable to TSR customers, as opposed to those receiving service at distribution voltage or under a flat rate, is unknown. For the purposes of this calculation, it is assumed that the codes and standards impact is in proportion to the share of energy consumption of stepped rate customers relative to the total energy consumption of the BC Hydro industrial rate class (about 64%).

Step 3.8 **Estimates of natural conservation:** this largely captures normal production efficiency improvements and technological advancement. It is incremental to the net energy savings achieved through BC Hydro's energy efficiency and conservation programs. Natural conservation is estimated by hypothesizing what would have happened under a flat rate scenario, which is a counterfactual case where there is no influence of the TSR. As this is a hypothetical scenario, there is a lack of a reliable and systematic way to evaluate the impact of natural conservation for industrial customers. In this evaluation, two approaches were adopted to estimate a range of magnitude for natural conservation. The first was to indirectly estimate natural conservation impacts by basing it on the magnitude of energy savings ascribed to free ridership of DSM programs sponsored by BC Hydro and TSR reported DSM. This estimate should represent a lower bound to total natural conservation, as natural conservation is also expected from other sources, such as TSR customers not participating in any DSM programs promoted by BC Hydro. The second approach to estimate the impact of natural conservation was to consider the flat rate scenario and apply a price elasticity assumption of -0.1, which BC Hydro uses for energy planning[24]. Natural conservation is then estimated by applying the price elasticity assumption to Equation 7 and the historical flat rate price changes.

The above methodology produces an estimate of unreported DSM savings by deducting the above items from the gross TSR energy impact. The estimate is thought to be conservative because the gross TSR energy impact might not have captured the entire savings of the items listed above. Nonetheless, most of them are deducted in full.

Econometric Modelling #2

The second econometric model differs from the first one in that the independent variable in the model, the energy consumption of TSR customers under RS1823B, was adjusted by adding the TMP Initiative project savings to it. This in essence simulates a counterfactual scenario where the TMP Initiative has no influence on customers energy consumption. which are relatively large in size compared to other DSM projects and largely driven by project incentives. This model produced estimates of Tier 1 and Tier 2 price elasticities that reflect no impact from TMP projects. When those deductions are made from the gross TSR energy impacts calculated based on the price elasticity estimates, as outlined in Step 3 model #1, TMP Initiative project savings (step 3.4) no longer need to be deducted to estimate unreported TSR savings.

To implement this second model, a monthly time series of TMP Initiative project savings was constructed based on the in-service date of the projects and the estimated annual run rate of savings. The three sites that implemented TMP Initiative projects did not incur any Tier 2 consumption during the evaluation

[23] An evaluation of General Service Lighting savings was completed in F2018 but its scope was limited to the residential sector and did not cover the portion of savings attributed to industrial customers.

[24] The elasticity value of -0.1 was adopted recently for energy planning purposes in accordance with recommendations stemming from a comprehensive review by DNV-GL (Memo – Price elasticity Findings and Recommendations, 9/6/2018).

period while these projects delivered energy savings. Therefore, monthly TMP savings were added back only where Tier 1 energy consumption was accounted for in the model. The second econometric model, as represented by Equations 12 to 14 below, is specified in a very similar way as the first model and only the independent variable is different.

Equation 12

$$\ln(Tier1\ Consumption_i + TMP\ Savings_i) = \alpha + \beta \cdot \ln(Tier1\ Price_i) + \varphi \cdot Employment\_Non\_Durable_i + \mu$$

Equation 13

$$\ln(Tier2\ Consumption_i) = \alpha + \theta \cdot \ln(Tier2\ Price_i) + \varphi \cdot Employment\_Non\_Durable_i + \mu$$

Equation 14

$$\ln(Tier1\ and\ Tier2\ Consumption_i + TMP\ Savings_i) = \alpha + \beta \cdot \ln(Tier1\ Price_i) + \theta \cdot \ln(Tier2\ Price_i) + \varphi \cdot Employment\_Non\_Durable_i + \mu$$

where all the terms are as previously defined and *TMP Savings$_i$* represents total TMP Initiative projects savings in month *i*.

Once the estimates of Tier 1 and Tier 2 price elasticity are obtained from the above econometric model, the gross TSR impact and unreported DSM savings can be calculated in the same way as described in Step 2 and Step 3 under "Econometric Model #1 ", with the notable exception that TMP Initiative savings no longer need to be deducted in Step 3.4.

2.3.5 Data and Methods for Objective 5: Total energy and capacity savings

The total energy savings attributed to the TSR are simply the sum of savings identified in this evaluation under objectives 2, 3, and 4. Capacity savings refer to the peak demand savings during BC Hydro's peak period, defined as the period from 5 p.m. to 7 p.m. during winter weekdays (in December and January). In this evaluation, peak demand savings were calculated when applicable by applying an average peak-to-energy factor that is derived from the transmission customers' rate class load shape.

2.4 Alternative Methodologies

Because BC Hydro's rate design provides an alternative flat rate (RS1823A) for industrial customers who are new or undergo production changes, an alternative method to evaluating TSR impacts could have been to use this group as a control. Customers under RS1823A have the opportunity to establish a consumption baseline that will be used when they move to the stepped rate (RS1823B). Most TSR customers billed under RS1823A stay on this rate schedule for 2 to 3 years. However, the majority are pulp and paper mills, sawmills or new plants that are not representative of the entire TSR customer class. In addition, many of these sites are undergoing transitions that affect the stability of their energy consumption. These factors make it difficult to discern and ascertain the impact of the stepped rate by comparing RS1823A and RS1823B customer billings.

In the previous evaluation, different econometric models were explored. In this evaluation, further research in this area was conducted and several alternative econometric models were explored to estimate price elasticity of the Tier 1 and Tier 2 rate. In particular, these models include specifications based on annual consumption, a specification where Tier 1 consumption is used as an independent variable, and specifications where the lagged impact of the flat rate (RS1823A) is included. The results of these models were less suitable as indicated by the diagnostic parameters. Details of these models are provided in Appendix D.2.

2.5 Threats to Validity

1 Energy savings generated through the implementation of DSM projects can vary due to operational changes over time and the changes in energy savings are not always tracked and may have been evaluated as run-rate savings based on a limited history of performance. This may cause true year-over-year savings to vary unknowingly. In addition, this poses a threat to validity in the method of calculating unreported DSM savings of TSR customers since the energy deductions were taken as a "static" value and not evaluated for each year in the evaluation period. This threat was mitigated by performing annual post-implementation review on larger projects subject to performance fluctuations.

2 Threats to the validity of the case study method to estimate free ridership include incomplete or inaccurate information in the project file. To mitigate this threat, the simplified case study method was applied to only three types of projects and groupings. The case study method is also subject to potential bias of the evaluator. This threat was managed by using survey results to complement the case studies.

3 Capacity savings were estimated by applying a peak-to-energy factor derived from BC Hydro's industrial transmission rate class load shape. This approach introduces uncertainty because it relies on the assumption that energy savings at the participating sites have the same annual load shape as the rate class load shape, but this may not be true for unique sites.

4 A true counterfactual case to the TSR (where industrial customers on a flat rate exist alongside TSR customers) does not exist, which makes it impossible to estimate what would truly happen in the absence of the rate. This evaluation adopted assumptions for the counterfactual case by borrowing estimates from other sources such as the free rider rate of the industrial DSM program and the flat rate elasticity assumption used for energy planning. How close these assumptions are to a true counterfactual case cannot be tested, which creates uncertainty on the validity of the conclusions drawn from the analysis.

3.0 RESULTS

3.1 Results for Objective 1: Customer experience

Through the ongoing program participant surveys, transmission customers that had completed a program enabled project through the Leaders in Energy Management-Transmission (LEM-T) program (n=18) were asked how influential the financial benefits through the TSR had been on their organization's decision to implement the energy-efficient measure. In total, 72 percent of customers indicated that it had been very (39%) or somewhat (33%) influential, while the remaining 28 percent indicated it had been not too influential (6%) or not influential at all (22%).

Table 3.1 Influence of the TSR on completing energy efficiency projects (F2017 to F2020 participants)

	Program Enabled Transmission Participants (n=18)
Very influential	39%
Somewhat influential	33%
Not too influential	6%
Not at all influential	22%

Leaders in Energy Management-Transmission participants who would have completed the project in some form even without support from the program (n=13) were also queried about whether or not the project would have met their organization's financial criteria around site investments without the financial benefits through the TSR. The results below have been fully based (n=18) to also include the 28 percent of respondents who had stated in a previous question that the project would not have gone ahead at all without support from the program. A total of 50 percent reported that their project would have met their organization's financial criteria without the benefit through the TSR and 17 percent reported that it would not have met their financial criteria. Note that the savings associated with these projects are credited to the Leaders in Energy Management program and are not included in this evaluation.

Table 3.2 Whether project would have met financial criteria without benefits through TSR (F2017 to F2020 participants)

	Program Enabled Transmission Participants (n=18)
Yes, it would have met our financial criteria	50%
No, it would NOT have met our financial criteria	17%
Had reported in a previous question that the project would not have gone ahead without support from the program	28%
Not applicable	6%

3.2 Results for Objective 2: Energy savings from TSR reported DSM

Gross energy savings of TSR reported DSM are the change in energy consumption that resulted directly from customer-funded but non-program enabled DSM projects. They were reported to BC Hydro for energy bill adjustments (and CBL administration) but not attributed to BC Hydro DSM programs. The evaluated gross energy savings are based on the project's most recent and best available estimate of energy savings in each fiscal year. Under the TSR, these projects resulted in an annual energy bill adjustment on the customer's CBL Statement. Project performance is often tied to operating conditions, and in the present case all of the five projects had annual post-implementation engineering reviews. Therefore, the energy bill adjustment for a given fiscal year was considered the best available estimate of energy savings. The evaluation found an average gross realization rate of 99 percent when compared to the initial review of energy savings used for the reported savings which indicates that the year-over-year savings variability was on average aligned with the evaluated gross energy savings.

Table 3.3 provides the expected and evaluated gross savings. Energy savings are presented as incremental savings achieved within the evaluation period and expressed as an annual rate of savings (also known as run rate savings).

Table 3.3. Expected and evaluated gross energy savings for TSR reported DSM

Period	Number of Projects	Expected (Reported) Gross Energy Savings (GWh/yr)	Gross Realization Rate	Evaluated Gross Energy Savings (GWh/yr)
TOTAL (F2017-F2020)	**5**	**372.7**	**0.99**	**368.1**

Net energy savings are the net change in energy consumption that is exclusively attributable to the TSR and reported by BC Hydro as DSM savings. The results of the net-to-gross ratio analysis are presented below. Free ridership was estimated separately for the three types of projects reported by the participants as described in Section 2.3.2 and Table 2.4. Free ridership in this context may also be thought of as natural conservation due to market forces beyond the influence of the TSR or BC Hydro's DSM initiatives. Free ridership of reported DSM projects reflects the idea that some of the savings would have been achieved without the influence of BC Hydro's DSM program or that of the TSR. As such, it represents natural conservation and naturally occurring adoption of technology that occurs due to technological improvements over time or optimization of production processes.

All five projects evaluated here were New Plant Design projects. The results of the case studies to estimate free ridership aligned with the findings of previous program evaluations and grouping by project type. Two of the five TSR reported DSM projects were found to have an associated energy study and received an estimated free ridership score of 10 percent. The three remaining projects had no energy savings prediction and received a free ridership score of 60 percent. The overall level of free ridership was estimated at 54 percent, driven by high free ridership among customer-funded new plant design projects without an energy savings prediction. Spillover was estimated at 4 percent from energy conservation measures that were installed at the same sites and identified during post implementation review but not included in the energy bill adjustment. Combined free ridership and spillover resulted in an overall net-to-gross ratio of 50 percent for TSR reported DSM projects.

Evaluated net energy savings between F2017 and F2020 were calculated using the gross savings of each project multiplied by the net-to-gross ratio and are shown in Table 3.4. Energy savings are presented as incremental savings achieved during the evaluation period and expressed as an annual rate of savings (run rate savings).

Table 3.4. Evaluated gross and net energy savings for TSR reported DSM

Period	Evaluated Gross Energy Savings (GWh/yr)	Net to Gross Ratio (NTGR)	Evaluated Net Energy Savings (GWh/yr)
TOTAL (F2017-F2020)	**368.1**	**0.50**	**182.3**

The weighted average persistence of the TSR reported DSM projects was found to be 10.6 years. Individual measure persistence ranged from 10 years for variable frequency drives to 30 years for energy efficient transformers and reduction of power losses in customer transmission or distribution lines.

All five TSR reported DSM projects were implemented while the subject sites were on the flat rate schedule (RS1823A) during the evaluation period from F2017 to F2020. They do not impact the calculation of unreported DSM savings in objective 4 for sites on the stepped rate schedule (RS1823B).

3.3 Results for Objective 3: Energy savings from TSR incremental self-generation

The energy savings from incremental self-generation were obtained from CBL statements which have been verified by BC Hydro Contract Management as part of the TSR reporting requirements. Only customers on the stepped rate (RS1823B) were eligible to report incremental self-generation energy in response to the TSR. As explained in Section 2.3.3, customers with incremental self-generation were grouped into two types of accounts, one with and the other without energy delivered to BC Hydro under an EPA. The number of customer sites involved and the incremental self-generation by grouping is given by fiscal year in the table below.

Table 3.5. Evaluated net Energy savings from TSR incremental self-generation

	TOTAL		GROUP 1 (without EPA)		GROUP 2 (with EPA)	
Fiscal Year	**Count of Sites**	**Evaluated TSR Incremental Self-generation (GWh/yr)**	**Count of Sites**	**Evaluated TSR Incremental Self-generation (GWh/yr)**	**Count of Sites**	**Evaluated TSR Incremental Self-generation (GWh/yr)**
F2017	5	107.3	2	90.7	3	16.7
F2018	5	56.5	1	39.9	4	16.5
F2019	5	92.2	0	0	5	92.2
F2020	5	115.1	2	44.8	3	70.3

Peak demand savings for incremental self-generation for customer sites without EPAs were estimated by applying the average peak-to-energy factor of 0.117 MW per GWh for the transmission rate class. These are presented in the table below. However, peak demand savings for incremental self-generation for customer sites with EPAs are considered nil. This is because incremental self-generation is by nature more sporadic for these customers, given the contractual arrangements. The conditions that lead to incremental self-generation sometimes imply a transitory stage where the customer load was well below normal. As such, it is not possible to ascribe capacity savings to this generated energy.

Table 3.6. Evaluated capacity savings from TSR incremental self-generation

Fiscal Year	GROUP 1 (without EPA) Capacity Savings for Incremental Self-generation (MW)	GROUP 2 (with EPA) Capacity Savings for Incremental Self-generation (MW)
F2017	10.6	0
F2018	4.7	0
F2019	0	0
F2020	5.2	0

Although the self-generation system improvements may last many years, the persistence of incremental self-generation is one year, i.e., the fiscal year where the savings occurred, because this energy is subject to unpredictable variations and is calculated and verified annually in accordance with contractual terms.

3.4 Results for Objective 4: Energy savings from unreported DSM

Objective 4 is to evaluate any energy savings attributable to the TSR but not reported by TSR customers through any energy conservation initiatives. The evaluation results for Objective 4 are based on the two econometric models discussed in Section 2.3.4 and are reported separately for the two models.

3.4.1 Results based on econometric model #1

The econometric analysis results that provide Tier 1 and Tier 2 price elasticities, the gross TSR energy impact, and unreported DSM savings are presented below, based on the three steps of calculations described in Section 2.3.4

Step 1. Estimate the TSR stepped rate elasticity based on econometric model #1

The econometric modelling results for Step 1 are listed in Table 3.7 below. The table shows the value of the parameters α, β, θ, and φ associated with the variables listed in Equation 3 to Equation 5 in Section 2.3.4, as obtained through the regression analysis. The resulting estimates of Tier 1 and Tier 2 price elasticity are -0.28 and -0.73, respectively, and these estimates are very close to the results reported in the previous TSR evaluation. (For comparison, reference electricity price estimates from different econometric analysis in different jurisdictions are provided in Appendix D.3)

Table 3.7 Parameter estimates from regression analysis, including Tier 1 and Tier 2 price elasticities

Variable	Parameter	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	α	22.02053	0.18610	118.32	<.0001
Ln(Tier 1 Price)	β	-0.28250	0.03944	-7.16	<.0001
Ln(Tier 2 Price)	θ	-0.71575	0.13091	-5.47	<.0001
Employment (Non-Durable)	φ	0.00000468	0.00000238	1.96	0.0522

The negative values of the Tier 1 and Tier 2 elasticity estimates indicate that rising Tier 1 and Tier 2 rates lead to reductions in Tier 1 and Tier 2 energy use, which can occur through a variety of measures that TSR customers are encouraged to pursue by the rate design.

Step 2. Estimate gross TSR energy impact based on the price elasticity estimates

The gross TSR energy impact (Equation 11 in Section 2.3.4) is the sum of the three components of energy impacts based on Equation 8, Equation 9 and Equation 10. In addition to the Tier 1 and Tier 2 price elasticities already presented above, two other sets of parameters are required to calculate the gross

TSR impact in the evaluation period: 1) energy consumption by industrial customers under RS1823B from F2016 to F2019 and; 2) Tier 1 and Tier 2 price changes. These are respectively listed in Table 3.8 and Table 3.9. The tables present the real price change (in percentage term) of the Tier 1 and Tier 2 rates, and the associated elasticity estimates in the same period.

Table 3.8 Aggregated consumption of industrial customers under RS1823B (in GWh) in the three predefined billing categories

Fiscal Year	Tier 1 Energy only	Tier 2 Energy only	Tier 1 and Tier 2 Energy
	A	B	C
F2016	9,510	220	347
F2017	9,663	147	326
F2018	9,646	180	416
F2019	9,594	303	395

Table 3.9 Percentage change in real price (measured in 2002$)[25] and elasticity of Tier 1 and Tier 2 prices

	Tier 1		Tier 2	
	Price Change	Elasticity	Price Change	Elasticity
Fiscal Year	D	E	F	G
F2017	3.3%	-0.28	4.4%	-0.73
F2018	1.1%	-0.28	1.1%	-0.73
F2019	0.5%	-0.28	0.5%	-0.73
F2020	5.7%	-0.28	5.7%	-0.73

Applying the elasticity results and data from the above two tables to Equation 8, Equation 9 and Equation 10 from Section 2.3.4 yields the gross TSR energy impacts listed below in Table 3.10. Estimates of the gross TSR energy impact, the sum of columns H, I, and J, vary from 17 GWh/yr to 188 GWh/yr over the fiscal years of the evaluation period. Total gross TSR energy impacts are estimated at 349 GWh/yr over the evaluation period. The year-over-year fluctuations of gross TSR impact are largely a result of fluctuations in the percentage changes in Tier 1 and Tier 2 prices. The impacts are also determined by price elasticity, which is an average estimate over the whole analysis period from F2012 to F2020 rather than an estimate for each specific year. As such, the evaluated energy impact in each year is an average figure and the year-over-year fluctuations should be interpreted with caution.

Table 3.10 Gross TSR energy impact (GWh/yr)

Fiscal Year	Tier 1 Energy Impact	Tier 2 Energy Impact	Tier 1 and Tier 2 Energy Impact	Gross TSR Energy Impact
	H=A*D*E†	I=B*F*G	J=C* (D*E+F*G)	K=H+I+J
F2017	88	7	14	109
F2018	30	1	4	35
F2019	14	1	2	17
F2020	153	12	22	188
Overall (F17-F20)	**286**	**21**	**43**	**349**

† Note: Letters A through G refer to columns in Tables 3.8 and 3.9 above.
Figures may not sum due to rounding.

[25] Statas Can uses the 2002 price level as the base for calculating the consumer price index.

Step 3. Calculate Unreported DSM Savings

As discussed in Section 2.3.4, the TSR unreported DSM savings are estimated as the gross TSR energy impact minus the energy savings from other known sources. The deductions were carried out in the following steps:

Step 3.1 Net savings from LEM-T/LEM-I program incentive DSM (net of free riders)
Step 3.2 Net savings from LEM-T/LEM-I program enabled DSM (net of free riders)
Step 3.3 LEM-T program spillover savings
Step 3.4 TMP initiative savings
Step 3.5 Net savings from strategic energy management claimed under the LEM-T program (average year-over-year change)
Step 3.6 Incremental self-generation energy (average year-over-year change)
Step 3.7 Codes and Standards savings, and
Step 3.8 Estimates of natural conservation

Step 3.1-3.3 Estimate for deduction of net savings and spillover savings from the LEM-T program

The BC Hydro program DSM savings are energy savings that were reported by BC Hydro with attribution to Conservation and Energy Management programs. The estimate was derived from a list of incentivized and customer-funded projects selected from the BC Hydro tracking database for the LEM-T and LEM-I programs for customers that were on RS1823B during project implementation between F2017 and F2020. Projects of customers on the flat rate (RS1823A) during project implementation were not included because the econometric model only analyzed changes in RS1823B energy consumption. Since savings for projects in F2018-F2020 have not been evaluated yet, the evaluated gross realization rate and free ridership rate from the most recent LEM-T F15-F17 evaluation were applied to these reported gross savings to estimate net savings. A spillover savings estimate of 13% from the most recent LEM-T F15-F17 evaluation was also applied to the reported gross energy savings. The free ridership estimates of these projects were also used in the estimate of natural conservation in Step 3.8. The number of projects and evaluated net energy savings by fiscal year are shown in the following table.

Table 3.11 Estimate of energy savings from BC Hydro LEM-T program DSM (GWh/yr)

Fiscal Year	Estimate of Net Savings from Incentivized DSM	Estimate of Net Savings from Program Enabled DSM	Estimate of Spillover savings
F2017	21	55	11
F2018*	11	33	6
F2019*	15	22	5
F2020*	4	9	2
OVERALL (F2017-F2020)	**51**	**119**	**24**

* Figures for F2018 to F2020 are based on the program estimates which are not evaluated yet.

Step 3.4 Estimate for deduction of TMP initiative savings from TSR gross impacts

Three customers included in the econometric analysis that quantified TSR gross impacts had implemented projects under the TMP initiative. These projects have reported net energy saving of 138 GWh per year but have not been evaluated yet. For each fiscal year in the evaluation period, energy savings to be deducted from gross TSR energy impacts are as listed in the following table.

Table 3.12 TMP initiative savings to be deducted from TSR gross impact

Fiscal Year	Deduction for TMP energy savings (GWh/yr)
F2017	52
F2018	54
F2019	32
F2020	0
Total	**138**

Step 3.5 Estimate for deduction of energy savings from Strategic Energy Management

Since F2017 the LEM-T and LEM-I programs have reported energy savings from strategic energy management for customers that met the SEM program eligibility criteria. Because these deemed savings are reported with a persistence of one year, a separate estimate of savings from SEM was required to deduct them from the gross TSR impact when estimating unreported DSM. This estimate is the year-over-year difference in annual net savings from strategic energy management at customer sites (under RS1823B) and is based on the net realization rate of 70 percent from the LEM-T F2015-F2017 evaluation for reported SEM savings. The values by fiscal year are given in the table below.

Table 3.13 Estimated year-over-year change in net energy savings from SEM

Fiscal Year	Count of sites on RS1823B and with reported savings from SEM	Reported Net Savings from SEM for estimate of unreported DSM (GWh/yr)	Year-over-year change in Net Savings from SEM for estimate of unreported DSM (GWh/yr)
F2017	16	24	24
F2018	10	45	21
F2019	12	48	3
F2020	8	38	-10
Overall F2017-F2020	**25 unique sites**	**39** (avg)	**38** (sum)

Step 3.6 Estimate for deduction of incremental self-generation energy

The estimate for deduction of incremental self-generation for the evaluation of unreported DSM consists in the year-over-year difference in annual incremental self-generation at customer sites (under RS1823B) without EPAs and is given in Table 3.14.

Table 3.14 evaluated year-over-year change in gross incremental self-generation

Fiscal Year	Count of sites with Incremental Self-generation for estimate of unreported DSM	Evaluated Gross Incremental Self-generation for estimate of unreported DSM (GWh/yr)	Year-over-year change in Gross Incremental Self-generation for estimate of unreported DSM (GWh/yr)
F2017	2	91	-13*
F2018	2	40	-51
F2019	2	0	-40
F2020	3	45	45

*Estimated as difference from F2016 incremental self-generation at customer sites for estimate of unreported DSM.

Step 3.7 Estimate for deduction of energy savings from Codes and Standards

Codes and Standards savings for the entire industrial sector are shown in the second column of Table 3.15. These values are estimates based on stock and flow models that have been used to account for Codes and Standards savings in BC Hydro's load forecast. For the calculation of unreported DSM savings, only the portion of those savings that is applicable to RS1823B consumption is relevant, and these values are shown in the third column of Table 3.15. This was estimated by multiplying the reported values by the estimated percentage of the industrial rate class consumption due to transmission accounts (79 percent) and by the share of TSR consumption billed under RS1823B (77 to 83 percent, depending on the fiscal year).

Table 3.15 Estimate of energy savings from codes and standards

Fiscal Year	Reported Savings from Industrial Codes and Standards (GWh/yr)	Estimate of Savings from Codes and Standards for estimate of unreported DSM (GWh/yr)
F2017	7	4
F2018	9	6
F2019	10	6
F2020	17	11
OVERALL (F2017-F2020)	**43**	**27**

Step 3.8 Estimates for deduction of natural conservation

Natural conservation was estimated for RS1823B customers that were included in the econometric model. The estimate of natural conservation is given as a range based on the two independent approaches used to estimate the magnitude of this impact, as explained in Section 2.3.4. The first approach is based on the free ridership estimates of program DSM projects and TSR reported DSM projects. The following free ridership estimates were applied to the list of incentivized and customer-funded projects from Step 3.1 above.

Table 3.16 Estimate of free ridership of program DSM projects

Project Type	Evaluated F2015-F2017 Free Ridership Estimate	Deemed F2018-F2020 Free Ridership Estimate
Utility-funded projects (with LEM-T incentives)	6%	6%
Customer-funded projects (with LEM-T program enabling activities)	10%	10%

The second estimate of natural conservation was based on a flat rate elasticity of -0.1, applied to the consumption of RS1823B customers, and the rate increases of RS1823A (the flat rate) for each fiscal year. A flat rate elasticity of -0.10 for the large industrial rate class is used by BC Hydro Load Forecasting in the absence of an evaluated flat rate elasticity. As noted earlier, the value of -0.1 was adopted in accordance with recommendations stemming from a comprehensive review by DNV-GL[26].

The results for the two methods and the range of natural conservation are given in the table below.

Table 3.17 Estimate of energy savings due to natural conservation

Fiscal Year	Estimate of natural conservation based on free ridership of reported savings (GWh/yr)	Estimate of natural conservation based on flat rate elasticity assumption (GWh/yr)	Range of estimated savings from Natural Conservation (GWh/yr)
F2017	11	36	11 to 36
F2018	11	11	11
F2019	10	5	10 to 5
F2020	7	59	7 to 59
OVERALL (F2017-F2020)	**39**	**111**	**39 to 111**

These estimates of natural conservation represent changes of 0.1 percent to 0.3 percent per year in the site energy consumption of RS1823B customers.

Calculation of Unreported DSM Savings

Table 3.18 summarizes all the reported DSM deductions to be made from gross TSR impact in order to calculate unreported DSM savings. In addition, the range estimates of natural conservation that need to be deducted are shown in Table 3.19. Given all the adjustments to the gross TSR impacts, the average TSR unreported DSM savings for the evaluation period from F2017 to F2020 are evaluated in the range of -7 GWh to -25 GWh per year as shown in Table 3.19.

Unreported savings are calculated as the residual after deducting other DSM savings from gross energy saving impacts which is estimated as an average annual figure through econometric modelling over the evaluation period. Therefore, the fluctuation of DSM savings from other initiatives will affect the estimate of unreported DSM savings for each year. Unlike earlier years in the evaluation period, fiscal year 2020 saw no incremental TMP savings and smaller savings from other DSM activities, which led to a relatively large and positive unreported savings estimate. Overall, the average unreported DSM savings are negative.

[26] DNV-GL Memo – Price elasticity Findings and Recommendations, 9/6/2018.

Table 3.18 Summary of energy savings (GWh/yr) to be deducted from gross TSR impact (F2017-F2020)

	LEM-T program incentive savings	LEM-T program enabled savings	LEM-T program spillover savings	TMP savings	SEM savings (Y-on-Y)	Incremental self-generation savings	Codes and Standards savings	Gross Deductions
Fiscal Year	**Step 3.1 [A]**	**Step 3.2 [B]**	**Step 3.3 [C]**	**Step 3.4 [D]**	**Step 3.5 [E]**	**Step 3.6 [F]**	**Step 3.7 [G]**	**[H]= [A]+[B]+[C]+[D] +[E]+[F]+[G]**
F2017	21	55	11	52	24	-13	4	154
F2018	11	33	6	54	21	-51	6	80
F2019	15	22	5	32	3	-40	6	43
F2020	4	9	2	0	-10	45	11	61
Overall F2017-F2020	51	119	24	138	38	-59	27	338

* Self-generation by RS1823B customers was smaller by year-to-year comparison which resulted in overall negative incremental self-generation in the evaluation period.

Table 3.19 TSR unreported DSM savings (GWh/yr) based on econometric model #1

	Gross TSR Impacts	Gross Deductions	Natural Conservation		Unreported DSM Saving	
			Estimate #1	Estimate #2	Estimate #1	Estimate #2
Fiscal Year	**[I]**	**[J]**	**[K1]**	**[K2]**	**[L]=[I]-[J]-[K1]**	**[M]=[I]-[J]-[K2]**
F2017	109	154	11	36	-56	-81
F2018	35	80	11	11	-56	-56
F2019	17	43	10	5	-36	-31
F2020	188	61	7	59	120	68
Overall F2017-F2020	349 (sum)	338 (sum)	39 (sum)	111 (sum)	-7 (avg)	-25 (avg)

3.4.2 Results based on econometric model #2

The approach followed for econometric model #2 was generally the same as for model #1 presented above, with the notable exception of how TMP Initiative savings were treated. This alternative model was based on a modified consumption term to remove the impacts of the TMP initiative projects. The gross TSR energy impact (Equation 11 in Section 2.3.4) was calculated in the same way as in Step 2 of section 2.3.4. The deductions carried out from this gross impact were the same as before, except that TMP project savings no longer needed to be deducted since their impact was negated in the consumption term. For brevity, only key results are discussed below.

Step 1. Estimate the TSR stepped rate elasticity based on econometric model #2

The results of estimating Tier 1 and Tier 2 price elasticities based on the second econometric model are shown in Table 3.20. The resulting estimates of Tier 1 and Tier 2 price elasticity are -0.13 and -0.59, respectively. This shows that, once the TMP projects savings were added back to TSR customer energy consumption, the econometric model attributed less sensitivity to both Tier 1 and Tier 2 price changes compared to the results from the first econometric model. These results led to lower Gross TSR price impact as calculated in step 2.

Table 3.20 Parameter estimates from econometric model #2

Variable	Parameter	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	α	21.52818	0.13133	163.93	<.0001
Ln(Tier 1 Price)	β	-0.13314	0.04791	-2.78	0.0063
Ln(Tier 2 Price)	θ	-0.58665	0.12028	-4.88	<.0001
Employment (Non-Durable)	φ	0.00000852	0.00000227	3.76	0.0003

Step 2. Estimate gross TSR energy impact based on the price elasticity estimates

The gross TSR energy impact was calculated based on the energy consumption adjusted by TMP project savings, the Tier 1 and Tier 2 price changes, and the new estimates of price elasticities. With this alternative model, the total gross TSR impact was reduced to 183 GWh/yr over the evaluation period, as shown in Table 3.21.

Table 3.21 Evaluated gross TSR energy impact using model #2 (GWh/yr)

Fiscal Year	Tier 1 Energy Impact	Tier 2 Energy Impact	Tier 1 and Tier 2 Energy Impact	Gross TSR Energy Impact
F2017	41	6	11	57
F2018	14	1	3	18
F2019	7	1	2	9
F2020	72	10	16	99
Overall (F2017-F2020)	134	17	31	183

* Figures may not sum due to rounding.

Step 3. Estimate of Unreported DSM Savings

Unreported DSM savings were calculated by deducting energy savings as listed in Table 3.22 below. Table 3.23 shows the results for unreported DSM savings once all the deductions have been carried out. This shows that the alternative model also yields negative estimates of unreported DSM savings, with estimated ranging from -14 GWh/yr to -32 GWh/yr.

Table 3.22 Summary of energy savings (GWh/yr) to be deducted from gross TSR impact (F2017-F2020)

	LEM-T program incentive savings	LEM-T program enabled savings	LEM-T program spillover savings	SEM savings (Y-on-Y)	Incremental self-generation savings	Codes and Standards savings	Gross Deductions
Fiscal Year	**Step 3.1 [A]**	**Step 3.2 [B]**	**Step 3.3 [C]**	**Step 3.5 [D]**	**Step 3.6 [E]**	**Step 3.7 [F]**	**[G]= [A]+[B]+[C]+[D]+[E]+[F]**
F2017	21	55	11	24	-13	4	102
F2018	11	33	6	21	-51	6	26
F2019	15	22	5	3	-40	6	11
F2020	4	9	2	-10	45	11	61
Overall F2017-F2020	51	119	24	38	-59	27	201

* Figures may not sum due to rounding.

Table 3.23 TSR unreported DSM savings (GWh/yr) based on econometric model #2

	Gross TSR Impacts	Gross Deductions	Natural Conservation		Unreported DSM Savings	
			Estimate #1	Estimate #2	Estimate #1	Estimate #2
Fiscal Year	**[H]**	**[G]**	**[K1]**	**[K2]**	**[L]=[H]-[G]-[K1]**	**[L]=[H]-[G]-[K2]**
F2017	57	102	11	36	-56	-80
F2018	18	26	11	11	-19	-19
F2019	9	11	10	5	-13	-8
F2020	99	61	7	59	31	-21
Overall F2017-F2020	183 (sum)	201 (sum)	39 (sum)	111 (sum)	-14 (avg)	-32 (avg)

* Figures may not sum due to rounding and persistence.

In summary, and despite the uncertainty in the individual results, the two approaches used to arrive at estimates of unreported DSM savings both produced negative estimates, thus providing no evidence to support the reported value of 10 GWh/yr claimed for these savings. Given these results, no savings can be ascribed to Unreported DSM under the TSR in this evaluation.

3.5 Results for Objective 5: Total energy and capacity savings

In this section, the net evaluated and reported energy savings are summarized and compared by fiscal year for TSR reported DSM and incremental self-generation. TSR unreported DSM is also discussed, but since no evidence was found to support any claim for TSR unreported DSM, no savings for this category are accounted for in total net evaluated savings. Peak demand savings were calculated by applying the peak demand to energy ratio of 0.117 MW per GWh for the transmission rate class to the relevant components of TSR energy savings.

Energy savings from TSR reported DSM

Evaluated and reported energy savings from TSR reported DSM are given by fiscal year in Table 3.24. Reported savings were typically claimed in the fiscal year the customer started being billed on rate schedule RS1823B, which often lagged the fiscal year of project implementation, and were adjusted by a deemed net to gross ratio of 65 percent.

Table 3.24 Evaluated and reported energy savings from TSR reported DSM by fiscal year

Fiscal Year	Reported Net Energy Savings (GWh/yr)	Evaluated Net Energy Savings (GWh/yr)	Reported Net Peak Demand Savings (MW)	Evaluated Net Peak Demand Savings (MW)
F2017	0	0	0	0
F2018	214	144	25	17
F2019	19	27	2	3
F2020	10	11	1	1
TOTAL (F2017-F2020)	**242**	**182**	**28**	**21**

* Figures may not sum due to rounding.

The evaluated TSR reported DSM projects achieved 75 percent of reported savings. The variance between overall reported and evaluated net savings was primarily due to the lower net-to-gross ratio estimated in the evaluation. Because the distribution of project types and energy savings varied by year, so too did the yearly net-to-gross ratios. Years with a greater proportion of energy savings from projects that were program enabled without energy savings prediction, such as in F2018, saw a lower net-to-gross ratio.

Energy savings from TSR incremental self-generation

Reported and evaluated net energy and capacity savings for TSR incremental self-generation are shown below. The variance between reported and evaluated energy savings is primarily due to the allocation and reporting of incremental self-generation energy to sites with load displacement projects for which savings had already been reported under a BC Hydro DSM program. Some of the variance is also due to the refinement of energy estimates that occurred through the CBL review process, as these updates were not carried over to the energy savings for DSM reporting. Average savings between F2017 and F2020 are shown at the bottom of the table instead of a total because these savings are not additive due to the one-year persistence assigned to customer-funded incremental self-generation.

Table 3.25 Reported and evaluated net energy and peak demand savings from TSR incremental self-generation

Fiscal Year	Reported Net Energy Savings (GWh/yr)	Evaluated Net Energy Savings (GWh/yr)	Reported Net Capacity Savings (MW)	Evaluated Net Capacity Savings (MW)
F2017	110	107	11	11
F2018	60	57	5	5
F2019	103	92	1	0
F2020	110	115	5	5
Average per Year (F2017-F2020)	**96**	**93**	**5**	**5**

Evaluated net energy savings from customer-funded incremental self-generation achieved 97 percent of reported savings during the evaluation period.

Energy savings from TSR unreported DSM

Table 3.26 summarizes the combined evaluation results for TSR Unreported DSM based on the two econometric models. Since both evaluation methods rely on regression models that produce average estimates over a lengthy analysis period, the results in individual fiscal years must be interpreted with caution. The results also vary over a wide range because of the different estimates of natural conservation used in the calculations. The overall results show estimated savings in the negative range using both approaches, thus providing no evidence to support the existence of TSR unreported DSM savings. This leads to the evaluated results shown in Table 3.27 where unreported DSM savings are shown as zero. In comparison, BC Hydro claimed a total 10 GWh of TSR unreported DSM for each fiscal year during the evaluation period.

Table 3.26 Energy savings of TSR unreported DSM

Fiscal Year	Energy savings of unreported DSM (GWh/yr)	Energy savings of unreported DSM (GWh/yr)	Claimed energy savings for unreported DSM (GWh/yr)
	First Method	Second Method	
F2017	-56 to -81	-56 to -80	10
F2018	-56	-19	10
F2019	-31 to -36	-8 to -13	10
F2020	68 to 120	-21 to 31	10
Average per Year (F2017-F2020)	-7 to -25	-14 to -32	10

Table 3.27 Evaluated vs. reported energy savings of TSR unreported DSM

Fiscal Year	TSR Unreported DSM Saving (GWh/yr)		Peak Demand Savings (MW)	
	Reported	**Evaluated**	**Reported**	**Evaluated**
Average per Year (F2017- F2020)	10	0	1.2	0

Table 3.28 summarizes Total Energy and Capacity Savings under the TSR by fiscal year from F2017 to F2020. The overall total evaluated energy savings were 275 GWh per year and 26 MW with no contribution from TSR unreported DSM.

Table 3.28 Total evaluated and reported energy and capacity savings from TSR by fiscal year

Fiscal Year	Reported Net Energy Savings (GWh/yr)	Evaluated Net Energy Savings (GWh/yr)	Reported Net Peak Demand Savings (MW)	Evaluated Net Peak Demand Savings (MW)
F2017	110	107	11	11
F2018	264	201	30	22
F2019	122	119	3	3
F2020	220	126	6	6
Overall (F2017-F2020)	**348**	**275**	**33**	**26**

* Figures may not sum due to rounding and persistence.

Overall, evaluated net energy savings achieved 79 percent of reported savings.

3.6 Confidence and Precision

The analysis and estimate of two-tiered rate elasticities are reasonably accurate given the high statistical significance of the parameter estimates and the reasonable overall explanatory power of the econometric model of TSR energy consumption (See Appendix D.1). Other studies have yielded a wide range of estimates for the price elasticity of industrial electricity consumption and the results from the econometric modelling in this evaluation fall within this range. The gross TSR price impacts derived from the estimates of elasticities obtained through modelling RS1823B consumption are considered to have a reasonable degree of precision.

TSR energy impacts are derived from price elasticity estimates which represent an average price response over a period of time—from 2012 to F2020 in the current evaluation. Therefore, the elasticity estimates should be considered as an "average" price response over this period. The price impacts derived from the elasticity estimates reflect the "average" consumption impacts induced by TSR price changes. This averaging effect means that, in a given year, there may be a difference between real price impact and the estimated impact, particularly if price response is expected to vary between years and change over time. Also, because of the specification of the regression model, the price elasticity estimates reflect overall changes in electricity consumption that correlate with price changes in a tiered rate structure with an adjustable CBL. This would include, in addition to the pure influence of price changes, the impact of DSM initiatives and possibly other factors that correlate with price changes.

The evaluation has strived to improve confidence and precision of unreported DSM savings given that they are derived as residual energy savings, starting from an estimated gross impact and deducting savings from DSM incentive program and spillover, SEM and other program reported savings, incremental self-generation, savings from Codes and Standards, and natural conservation. Each of these components are estimates that carry uncertainty and, in some cases, have not been evaluated yet. The econometric model used to estimate overall gross TSR energy impacts, although having a fairly high degree of statistical significance, may not capture the entire savings of these components. All these factors contribute to the relatively low precision of evaluated TSR unreported DSM savings.

During the external review process for this evaluation, different econometric model specifications were tested as potential improvements. This work has shown that small changes in model specification could lead to large changes in the predicted outcome, suggesting that the model is not very stable. Given the fact that there are no DSM projects associated with unreported DSM saving claims and subsequently reported to BC Hydro, it is hard to measure and verify such savings in another way such as engineering measurement and verification. While this may be considered to reduce the confidence in the model results, it also suggests that it is appropriate to be conservative and assume no unreported DSM savings.

4.0 FINDINGS AND RECOMMENDATIONS

4.1 Findings

Findings and recommendations are presented below.

Customer Experience

1. Among Leaders in Energy Management-Transmission participants that completed a program enabled project, 72 percent reported that the financial benefits through the TSR had been 'very influential' or 'somewhat influential' on their organization's decision to implement the energy-efficient measure.

Energy Savings from TSR reported DSM

2. The evaluated gross energy savings of TSR reported DSM for F2017 to F2020 were estimated at 368 GWh per year, with a gross realization rate of 99%.
3. The evaluated net energy savings from TSR reported DSM for F2017-F2020 were estimated at 182 GWh per year. The net-to-gross ratio of TSR reported DSM projects was found to be 50 percent. Free ridership of 54 percent was estimated based on evaluation review of the TSR reported DSM projects using free ridership scores and criteria from industrial program evaluations of similar projects. Participant spillover of 4 percent was estimated from conservation measures installed but not recognized for CBL administration.
4. Evaluated net energy savings from TSR reported DSM projects achieved 75 percent of reported savings. The variance between reported and evaluated savings was primarily due to the difference between the deemed and evaluated net-to-gross ratio for TSR reported DSM for new plant design energy conservation measures. The average expected persistence of TSR reported DSM projects was found to be 10.6 years.

Energy Savings from TSR incremental self-generation

5. Annual average energy savings from TSR incremental self-generation were estimated at 93 GWh per year and achieved on average 97 percent of reported savings. Incremental self-generation for customers without an Electricity Purchase Agreement was found to have capacity savings, whereas, incremental self-generation for customers with an Electricity Purchase Agreement had no associated capacity savings.

6. The variance between reported and evaluated energy savings from TSR incremental self-generation is primarily due to the removal of self-generation energy from two load displacement projects that had also been reported to the BC Hydro Leaders in Energy Management program. A secondary source of variance was the refinement of energy estimates that occurred through the CBL review process, as these updates were not carried over to the energy savings for DSM reporting.

7. The persistence of energy savings from TSR incremental self-generation was one year, i.e., the fiscal year where the savings occurred. Due to the highly variable output and unpredictable fluctuations in savings from self-generation, they were subject to a rigorous annual verification process.

Energy Savings from TSR unreported DSM

8. Analysis of TSR RS1823B customers' energy consumption through econometric modelling did not provide evidence for unreported DSM savings during the evaluation period and no savings were ascribed to TSR Unreported DSM in this evaluation.

Total Electricity Savings from TSR

9. For the evaluation period from F2017 to F2020, total net energy savings under the TSR are evaluated at 275 GWh per year, and total net capacity savings are evaluated at 26 MW. Evaluated net energy savings achieved 79 percent of reported savings.

4.2 Recommendations

The following recommendations flow from the findings of this evaluation.

1. Consider applying the evaluated Net-to-Gross ratio of 0.50 from this evaluation to future savings claimed for TSR reported DSM if the projects fall in the category of new plant design.
2. Remove savings from TSR incremental self-generation for sites with a DSM program-based load displacement agreement and without Electricity Purchase Agreement (EPA) as these were reported through the program.
3. Adjust TSR unreported DSM savings to zero for the evaluation period and consider discontinuing future claims for such savings.

5.0 CONCLUSIONS

Total net energy savings under the Transmission Service Rate were evaluated at 275 GWh per year in the period from F2017 to F2020, representing 79 percent of reported savings. The associated capacity savings were evaluated at 26 MW.

EVALUATION OVERSIGHT COMMITTEE SIGN-OFF

BC Hydro's Evaluation Oversight Committee is made up of DSM stakeholders from various parts of the company and is mandated to ensure that BC Hydro's DSM evaluations are objective, unbiased and of sufficient quality.

The Evaluation of the Transmission Service Stepped Rate (TSR) Impact Evaluation: F2017-F2020 meets the following criteria for approval by the Evaluation Oversight Committee:

- The evaluation complied with the defined scope.
- The evaluation methodology is appropriate given the available resources at the time of the evaluation.
- The evaluation results are reasonable given the available data and resources at the time of the evaluation.

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Serina Grahn, Finance manager, Business Services

Evaluation Oversight Committee Chair

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ABBREVIATIONS AND GLOSSARY

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

B.C. Hydro Service Area: The portion of the Province of B.C. that receives retail electricity service from BC Hydro. The service area excludes the portion of the Province of B.C. served by FortisBC, and certain factories or communities that are not customers of BC Hydro.

Customer Baseline Load (CBL): an energy quantity, established in accordance with principles described in Tariff Supplement 74, that is intended to be representative of a customer's normal historic annual electricity purchases.

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".

Enabling activities: Activities that are designed to help facilities with the identification, appraisal and implementation of projects to reduce energy consumption. Among other things, enabling activities include: energy studies and audits, energy managers, energy-efficiency education and training, and employee awareness events.

Energy Bill Adjustment (EBA): An adjustment made to a customer's energy bill for the purpose of CBL administration. A customer can thereby receive a credit for the energy savings from a DSM project, and the credit is added to their actual energy consumption to determine if they meet the threshold to avoid a CBL reset.

Expected Savings: Estimate of gross energy savings based on the initial engineering estimates. These estimates represent the unverified savings.

Free ridership: Energy use of a program participant or ratepayer under a conservation rate who would have implemented the conservation measure or practice in the absence of the program or rate.

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

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

Natural Conservation: Natural conservation refers to those efficiency improvements that would occur in the absence of any DSM activity. This may be due to equipment efficiencies, behaviors, changes to codes and standards or simply reactions to general rate increases

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.

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

Peak demand savings: The maximum reduction in demand (MW) that occurs during BC Hydro's peak hours (from 5 p.m. – 7 p.m., Monday through Friday, in December and January) as a result of the DSM measure.

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

Program enabled savings: Savings from customer-funded electricity conservation measures that are linked to a program-funded enabling activity such as an energy study or energy manager.

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

Reported Savings: Estimate of energy savings being recorded in the program tracking database. In the case of the Transmission Service Rate, this can also refer to energy savings reported to BC Hydro for energy bill adjustments and recorded in a separate tracking database. Reported savings are based on best information available from technical review of the initial engineering estimate, post-implementation review of documentation and/or inspection, or measurement and verification results, as well as a deemed 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 may not be permanent and may not continue in the absence of continued program activity.

TSR Reported DSM Projects: These are customer-funded energy conservation projects that are recognized by BC Hydro under the TSR with verified energy savings but are not reported through BC Hydro's Leaders in Energy Management program.

TSR Incremental Self-generation: The verified annual amount of customer-funded self-generation energy in excess of any contracted customer based self-generation and recognized under the TSR to offset an equivalent portion of energy purchases from BC Hydro.

Unreported DSM: energy savings from energy conservation and efficiency measures that were initiated and funded by the customer but were neither reported to nor verified by BC Hydro.

APPENDIX A RESULTS SUMMARY

Net energy and capacity savings for TSR customers for each fiscal year and the comparison to program reported savings are presented in Table A.1 below.

Table A.1 Evaluated and reported energy savings from TSR reported DSM by fiscal year

Fiscal Year	Reported Net Energy Savings (GWh/yr)	Evaluated Net Energy Savings (GWh/yr)	Reported Net Peak Demand Savings (MW)	Evaluated Net Peak Demand Savings (MW)
F2017	0	0	0	0
F2018	214	144	25	17
F2019	19	27	2	3
F2020	10	11	1	1
TOTAL (F2017-F2020)	24	182	28	21

* Figures may not sum due to rounding.

Table A.2 Reported and evaluated energy and capacity savings from TSR incremental self-generation

Fiscal Year	Reported Gross Energy Savings (GWh/yr)	Evaluated Gross Energy Savings (GWh/yr)	Reported Gross Peak Demand Savings (MW)	Evaluated Gross Peak Demand Savings (MW)
F2017	110	107	11	11
F2018	60	57	5	5
F2019	103	92	1	0
F2020	110	115	5	5
Average (F2017-F2020)	96	93	5	5

Table A.3 Energy savings (GWh/yr) of TSR unreported DSM based on econometric model #1

	Gross TSR Impacts	Gross Deductions	Natural Conservation		Unreported DSM Saving	
			Estimate #1	Estimate #2	Estimate #1	Estimate #2
Fiscal Year	**[I]**	**[J]**	**[K1]**	**[K2]**	**[L]=[I]-[J]-[K1]**	**[M]=[I]-[J]-[K2]**
F2017	109	154	11	36	-56	-81
F2018	35	80	11	11	-56	-56
F2019	17	43	10	5	-36	-31
F2020	188	61	7	59	120	68
Overall F2017-F2020	349	338	39	111	-7	-25

Table A.4 Energy savings (GWh/yr) of TSR unreported DSM based on econometric model #2

	Gross TSR Impacts	Gross Deductions	Natural Conservation		Unreported DSM Savings	
			Estimate #1	Estimate #2	Estimate #1	Estimate #2
Fiscal Year	**[H]**	**[G]**	**[K1]**	**[K2]**	**[L]=[H]-[G]-[K1]**	**[L]=[H]-[G]-[K2]**
F2017	57	102	11	36	-56	-80
F2018	18	26	11	11	-19	-19
F2019	9	11	10	5	-13	-8
F2020	99	61	7	59	31	-21
Overall F2017-F2020	183	201	39	111	-14	-32

* Figures may not sum due to rounding.

Table A.5 Evaluated vs. reported energy savings of TSR unreported DSM

Fiscal Year	TSR Unreported DSM Saving (GWh/yr)		Peak Demand Savings (MW)	
	Reported	Evaluated	Reported	Evaluated
Average (F2017-F2020)	10	0	1.2	0

Table A.6 Total evaluated and reported energy and capacity savings from TSR by fiscal year

Fiscal Year	Reported Net Energy Savings (GWh/yr)	Evaluated Net Energy Savings (GWh/yr)	Reported Net Peak Demand Savings (MW)	Evaluated Net Peak Demand Savings (MW)
F2017	110	107	11	11
F2018	264	201	30	22
F2019	122	119	3	3
F2020	220	126	6	6
Overall (F2017-F2020)	**348**	**275**	**33**	**26**

* Figures may not sum due to rounding and persistence.

APPENDIX B ADVISOR MEMOS ON EVALUATION REPORT

Advisor Memo on Evaluation Report

Date March 8, 2023
To: BC Hydro
From: Rafael Friedmann
EOC Evaluation Advisor
Oakland, California

Re: TSR F2017-F2020 Evaluation Report

1. ***What is your assessment of the quality of the research design? If you identify any shortcomings, what is your assessment of their potential risk for the validity of the evaluation results?***

- Similar to past evaluations of the TSR.
- Comprehensive effort that seeks to understand and improve the TSR's customer experience and savings impacts.
- Design appropriate to what is a very difficult, varied, and limited engagement customer base that is subject to numerous business drivers besides TSR. Causes lots of "noise" that the evaluation has to contend with.

2. **What is your assessment of the quality of the input data? If you identify any shortcomings, what is your assessment of their potential risk for the validity of the evaluation results?**

- Data from a variety of sources (program tracking, billing, B.C. economic statistics, interviews, literature) is mostly adequate for the analyses.
- Some economy-wide data and of other industrial evaluations was used as proxy for TSR customers' situation in the econometric analyses. This could introduce uncertainty but often, more customer specific data is difficult to use due to the need to protect customer confidentiality.

3. **What is your assessment of the quality of the analytical methods? If you identify any shortcomings, what is your assessment of their potential risk for the validity of the evaluation results?**

- Methods used are similar to those used in past evaluations for TSR's gross and net savings determinations.
- Uses a mix of econometric regressions and engineering analyses that are aligned to the data available for this effort.
- Prefer more Case Study work to self-report surveys to develop NTGR results.
- Assumptions used likely lead to conservative savings results. Econometric elasticity analyses gave divergent results for unreported TSR savings, which you are zeroing out and proposing not be claimed in the future.

4. **How does the methodology compare to common industry practice for evaluations of similar initiatives?**

- Similar to other efforts used previously to evaluate TSR impacts and customer views and knowledge of it.
- Evaluations of the large industrial customers, both here and elsewhere, typically use a mix of engineering and econometric analyses, and surveys and interviews.
- Two-tier stepped rate of TSR for industrial is unique. Elsewhere similar rates are applied to residential customers; and thus evaluation methods there cannot be used with small, very dissimilar industrial customers.

5. **Suggestion for future evaluations**

- Include in recommendations lessons for future evaluations.
- Consider interviewing KAMs before interviewing customers when seeking to understand their views about the TSR and the impact of the TSR in any changes they made to their operations and/or facilities.

6. **Any other comments**

- Well written report, with thorough explanations on assumptions and analyses done.
- Commend the evaluation team for the extra effort and analyses done to respond to advisor comments.

Advisor Memo on Evaluation Report

Date March 9, 2023
To: BC Hydro
From: Dan Hansen
Managing Director – Energy at Christensen Associates Energy Consulting
Madison, Wisconsin

Re: Assessment of the Transmission Service Rate Evaluation: F2017-F2020

1. **What is your assessment of the quality of the research design? If you identify any shortcomings, what is your assessment of their potential risk for the validity of the evaluation results?**

I would first note that my assessment focuses on the methods used to estimate energy savings from unreported DSM, as this portion of the report best aligns with my expertise. The research design is a plausible attempt to make the best use of the available data (the limitations of which are described in Section 2 below).

2. **What is your assessment of the quality of the input data? If you identify any shortcomings, what is your assessment of their potential risk for the validity of the evaluation results?**

The input data do not provide a true counterfactual against which we can compare usage on the stepped rate. That is, there is no data for similarly situated customers on a flat rate, nor is there data available to conduct a before/after comparison of customer usage when switching to the stepped rate (because the change in rate design happened too far in the past). As a result, year-over-year changes in the stepped rates effectively serve as a proxy for a stepped rate vs. flat rate comparison. The data limitations are outside of the analysts' control but do represent a significant threat to the validity of the results.

3. **What is your assessment of the quality of the analytical methods? If you identify any shortcomings, what is your assessment of their potential risk for the validity of the evaluation results?**

I raised a potential issue in the specification design, with the expectation that correcting the issue would lead to a small change in the outcome. This did not turn out to be the case, indicating that the result is not robust to changes in model specification. That lack of robustness argues in favor of taking a conservative approach to the conclusions, which in this case means concluding that there is no evidence of unreported DSM savings.

4. **How does the methodology compare to common industry practice for evaluations of similar initiatives?**

Existing studies on this topic relate to residential customers. The estimates from those studies do not inform this study because the differences between the applicable customer groups are too significant. In addition, the methodology used to estimate residential impacts from stepped rates employed a control group consisting of similarly situated customers in a neighboring service territory that did not face stepped rates. No such group is available to assist in this analysis.

5. **What are your suggestions for future evaluations of this DSM initiative?**

I recommend not conducting the statistical analysis in future evaluations. The following factors support this conclusion:

- No appropriate counterfactual data are available;
- There is little reason to expect significant unreported DSM savings, particularly with SEM savings now being included as a defined category (unlike previous TSR Evaluations);
- The analysis is not robust to small specification changes; and
- BC Hydro is proposing to end stepped-rate pricing.

If an estimate of unreported DSM savings is required, I suggest the following potential approaches:

- Discussions with customer account representatives regarding plausible sources of unreported DSM savings, which (if found) could lead to customer-specific analyses to validate the savings or an intuitive approximation of the savings based on available information.
- A simulation-based approach in which total stepped-rate energy savings are first approximated by assuming a price elasticity and applying it to the difference between the stepped rates and the flat rate they would otherwise pay. The analysis would then proceed to subtract the savings from reported DSM sources as in the current study.

6. **Do you have any other comments that you would like to make?**

The TSR Evaluation is thorough, well documented, and clearly presented. This greatly helped my ability to assess the data, methods, and results. While I have concerns about the data limitations faced by the analysis team, all available evidence indicates to me that the study reached the correct conclusion: that there is no evidence of unreported DSM savings. While prior TSR Evaluations found such savings, it is important to note that savings from Strategic Energy Management (SEM) were unreported in prior studies but are now reported as a separate category. This removes a significant potential source of unreported DSM savings.

APPENDIX C DETAILS ON THE APPROACH

C.1 Details on the Case Study Approach to Free Ridership of TSR reported DSM Projects

Various methods exist to estimate free ridership. The most common method used for industrial and commercial programs involves analysing the results of decision maker surveys that ask a customer representative about the projects that their organization implemented through the program. A complementary method for large and complex projects involves the use of case studies. BC Hydro Conservation and Energy Management (CEM) Evaluation team has developed a case study method for estimating free ridership of large and complex projects. The case study method draws on the records included in the project file to assess whether or not critical barriers to implementation existed, and if those barriers were overcome by the program.

The case study method recognizes that customers face several barriers to implementing energy conservation measures. The BC Hydro CEM business case for its program and initiatives define the primary, relevant barriers for their target participants as: awareness, acceptance, affordability, and availability. These programs employ a range of influence tactics to address these barriers. Typical program influence tactics are: transmission service conservation rate benefits for program enabled projects, capital incentives, energy studies, energy managers, technical and strategic support, and training.

The case study method design is based on assessing and scoring how closely the program influence tactics addressed the specific barriers faced by individual projects. Scores are converted to a measure of free ridership using an algorithm with the following characteristics:

- **Barriers are project specific.** If a particular project did not face one or more of the four barriers, then that barrier did not affect the free ridership outcome for that project. For example, one of the four barriers is affordability, which is commonly measured in the industrial sector using simple payback. The higher the simple payback of the project without a capital incentive or rate benefit, the greater the affordability barrier. Operational efficiency projects are a class of energy efficiency measures that typically have immediate payback (i.e., minimal capital cost outlay) and, therefore, do not face an affordability barrier. Affordability does not enter into the estimation of free ridership for such projects.

- **Influence tactics contribute to reducing free ridership only to the extent that they address a specific barrier faced by the project**. For example, many industrial energy efficiency projects have uncertain benefits, because estimation of energy savings requires custom engineering calculations and site specific data. Such projects face an acceptance barrier. The program can address this barrier by funding an Energy Study. Evidence that the project faced an acceptance barrier that was addressed by a suitable tactic (e.g., energy study) would increase program attribution and decrease free ridership.

- **A single critical barrier can stop a project from proceeding, and well targeted influence to overcome that barrier can move it to implementation.** A critical barrier is deemed to exist when evidence suggests that the project would not proceed unless this barrier is addressed, regardless of the level of effort expended by the program addressing secondary barriers. An example of a critical barrier is an energy conservation measure with a simple payback before incentive that far exceeds the customer's maximum acceptable payback threshold. When a critical barrier is identified, the assigned barrier and influence tactic scores are multiplied by a factor of one hundred so that they outweigh the scores of other barriers and influence tactics.

As with all evaluation methods, the case study approach has some limitations. These are:

- The case study results are not intended to be used as the only line of evidence for the estimation of free ridership for a program. They should be supported by other lines of evidence such as decision maker survey results.
- The case study method is not expected to measure spillover.
- The quality of the case study method is limited by the depth and completeness of information on the project file. This method is not applicable for projects with scant or inaccurate records.

The procedure for applying the case study method is as follows:

1. Retrieve and review the project file. Engineering training is required, as file contents will commonly include engineering reports. Interview available file contributors, such as BC Hydro Key Account Managers and Engineering technical reviewers, as needed.
2. Based on the evidence on file, assess each barrier to implementation that the customer faced on a scale of zero to three, using the standardized scoring criteria below.
3. Also based on the evidence on file, assess each influence tactic that the program exerted on a scale of zero to three, using the standardized scoring criteria below.

Scoring for the case study method is described below.

- For each barrier, if the project barrier score is greater than the program influence score, then the difference is indicative of other drivers in the project that may contribute to free ridership.
- When a critical barrier or project driver is identified, both the project barrier and influence tactic score are multiplied by a factor of 100 to drive the importance thereof.
- Scoring for the case study critical barrier method is the sum of differences between project barrier and program influence weighted to the total barrier score.
- In cases where the evidence is weak or mixed, the case study method is not used to assess free ridership.
- For projects where both case study and survey results are available, a single free ridership score is estimated by combining the results as described in the methodology of objective 5 in Section 2 of this report.

BARRIER	Score	Criteria
AFFORDABILITY (Measured by simple payback, against common standards for large industry)	**0**	Simple Payback before capital incentive, or proxy incentive (estimated based on the approximate capital incentive program enabled projects would have received instead of the TSR benefit) over the energy savings at average unit energy cost, is <3 month
	1	Simple Payback before capital or proxy incentive 0.25>SP<1.0 year
	2	Simple Payback before capital or proxy incentive 1.0> SP <2.0 years
	3	Simple Payback before capital or proxy incentive > 2 years
ACCEPTANCE (Extent and customer understanding of technical / performance risk)	**0**	Tried and proven at site in identical application
	1	Requires 'like-for-like' equipment replacement (catalogue engineering specification)
	2	Requires energy engineering calculations and estimates for project screening purposes only (often without detailed load profile analysis or site visit)
	3	Requires custom energy engineering calculations including field measurements and/ or modeling for value proposition of business case (often with site visit and/or lab, pilot plant or mill trial).
AWARENESS (Level of customer awareness prior to implementing the energy conservation measure)	**0**	Energy conservation measure is tried and proven at the facility or customer staff brought the idea forward and developed the project scope all by themselves.
	1	Gaining awareness required reading or hearing about the measure at any training, workshop, conferences, case studies, websites related to energy efficiency and energy savings, but not including opportunity screening.
	2	Gaining awareness required reading or hearing about the measure at any training, workshop, conferences, case studies, websites related to energy efficiency and energy savings, and including some opportunity screening.
	3	Gaining awareness requires passing through a customer prioritization criteria including opportunity screening and preliminary project scope development by supplier/vendor or subject matter expert.
AVAILABILITY (Extent to which lack of customer management commitment, or resource availability is a barrier)	**0**	No incremental labour is required. E.g., an equipment replacement is needed, and the energy-efficient option requires the same labour input as the baseline option.
	1	Incremental labour and management attention is required and is available.
	2	Substantial incremental skilled labour, management attention & commitment is required
	3	Company policy change, Senior level customer support, and/or substantial human resources are required.

INFLUENCE	Score	Criteria
AFFORDABILITY (Existence and importance of a financial incentive)	**0**	No capital incentive, and / or the value of the incentive or proxy incentive (estimated based on the approximate capital incentive program enabled projects would have received instead of the TSR benefit), is less than 10% of the incremental project cost or simple payback with incentive is only marginally reduced.
	1	The capital or proxy incentive is between 10-33% of the incremental project cost, or the simple payback with the incentive is reduced but not substantially so.
	2	The capital or proxy incentive is between 33-75% of the incremental project cost or the simple payback with the incentive reduced significantly.
	3	The capital or proxy incentive is greater than 75% of the incremental project cost, or the simple payback with incentive is reduced substantially.
ACCEPTANCE (Program influence on increasing the certainty of costs and benefits)	**0**	No evidence of program assistance on the estimation of savings.
	1	Program supported preliminary or screening type energy calculations only (based on design capacity or rated horsepower and estimated hours of use) to an accuracy of +/-50%
	2	Program supported detailed energy calculations including non-electrical impacts if applicable, to an accuracy of +/-30%.
	3	BC Hydro funded Energy Efficiency Feasibility Study (EEFS), Energy Manager calculations for direct incentives. Estimates are incentive ready to an accuracy of +/-15%, including non-energy impacts, as applicable.
AWARENESS (Program influence on customer awareness of the energy conservation measure)	**0**	No evidence of program influence
	1	Program-funded case study or promotional material
	2	Evidence of Key Account Manager, Industrial Marketing or BC Hydro Alliance Member influence, for example through completing a similar project elsewhere, with a documentation trail.
	3	Program-funded Customer Site Investigation (CSI), End Use Assessment (EUA), and / or there is a strong document trail of awareness raising activities by Energy Manager or Program-funded staff.
AVAILABILITY (Program influence customer management commitment, availability of required labor & expertise)	**0**	No program-funded resources available
	1	Some program-funded resources, such as technical staff or consultants, available on an ad-hoc basis
	2	Industrial energy manager, technical and strategic support from the program
	3	Completion of a strategic energy management plan, access to a dedicated program-funded energy manager, technical and strategic support from the program.

Potential project drivers of business alignment and market adoption were assessed only for program enabled projects of brown field new plant design and plant expansions (6 projects) due to their hypothetical baseline and potential for substantial non-energy benefits associated with new process technologies.

PROJECT DRIVER	Score	Criteria
Business ALIGNMENT (Existence and importance of potential business drivers between increasing business revenue and reducing operating costs)	**0**	Project is primarily focused on reducing operating costs through energy reduction.
	1	Potential for project to enable energy trade-offs with increased production or improved quality but not likely during project persistence.
	2	Potential for project to enable energy trade-offs with increased production or improved quality and likely during project persistence.
	3	Project is primarily focused on increasing business revenue with increased production or improved quality.
Market ADOPTION (Degree of influence of industry standard practice on the equivalent service alternative baseline)	**0**	The equivalent service alternative considers existing technology, although industry standard practice for new equipment has marginally improved in energy efficiency and with marginal non-energy benefits.
	1	The equivalent service alternative considers existing technology, although industry standard practice for new equipment has somewhat improved in energy efficiency and often with some non-energy benefits.
	2	The equivalent service alternative considers existing technology, although industry standard practice for new equipment has significantly improved in energy efficiency and often with significant non-energy benefits.
	3	The equivalent service alternative considers existing technology, although industry standard practice for new equipment has substantially improved in energy efficiency and often with substantial non-energy benefits.

C.2 Details on the Calculation of Gross TSR unreported DSM impacts

Calculation of Gross TSR savings

The following calculations illustrate how gross TSR energy impacts are derived based on energy consumption figures, the stepped rate price changes, and the elasticity estimates of Step 1 and Step 2 rates.

Step 1. For monthly energy consumption charged at the Tier 1 rate only:

Equation C.1 represents monthly Tier 1 energy consumption as a function of Tier 1 price and monthly employment in the non-durable goods producing sector in B.C.

Equation C.1

$$\ln(Tier1\ Consumption\ ) \ = \alpha \ + \ \beta \cdot \ln(Tier1\ Price) \ + \ \varphi \cdot Employment\_Non\_Durable \ + \ \mu$$

Taking the partial derivative with respect to Tier 1 price yields:

Equation C.2

$$\frac{1}{Tier1\ Consumption}\frac{\partial Tier1\ Consumption}{\partial Tier1\ Price} = \beta\frac{1}{Tier1\ Price};\ \text{or}\ \ \frac{\partial Tier1\ Consumption}{\partial Tier1\ Price} = \beta\frac{Tier1\ Consumption}{Tier1\ Price}$$

The total derivative of Tier 1 Consumption can be expressed as:

Equation C.3

$$d(Tier1\ Consumption) = \frac{\partial Tier1\ Consumption}{\partial Tier1\ Price}d(Tier1\ Price) + \frac{\partial Tier1\ Consumption}{\partial Employment\_Non\_Durable}d(Employment\_Non\_Durable)$$

The two terms on the right-hand side respectively represent the impact of Tier 1 price changes and employment changes on Tier 1 consumption. The impact of price change can thus be isolated by retaining only the first term. After replacing the partial derivative with the expression in Equation C.2, the impact of Tier 1 price change on Tier 1 consumption can be expressed as:

Equation C.4

$$d(Tier1\ Consumption) = \beta \cdot Tier1\ Consumption\ \cdot \frac{d(Tier1\ Price)}{Tier1\ Price}$$

Equation C.4 indicates that the rate impact on Tier 1 energy consumption is equal to the Tier 1 price elasticity β multiplied by Tier1 energy consumption and Tier 1 rate change in percentage terms.

Step 2. For monthly energy consumption charged at the Tier 2 rate only:

Equation C.5 represents monthly Tier 2 consumption as a function of Tier 2 price and monthly employment in the non-durable goods producing sector in B.C.

Equation C.5

$$\ln(Tier2\ Consumption\ ) \ = \alpha \ + \ \beta \cdot \ln(Tier2\ Price) \ + \ \varphi \cdot Employment\_Non\_Durable \ + \ \mu$$

Applying a similar method as the previous step, the following can be demonstrated as below

Equation C.6

$$d(Tier2\ Consumption) = \theta \cdot Tier2\ Consumption\ \cdot \frac{d(Tier2\ Price)}{Tier2\ Price}$$

Equation C.6 indicates that the rate impact on Tier 2 energy consumption is equal to the Tier 2 price elasticity θ multiplied by Tier2 energy consumption and Tier 2 rate change in percentage term.

Step 3. For monthly energy consumption including both Tier 1 and Tier 2 charge:

The energy consumption model for this portion of TSR energy consumption is based on the following equation.

Equation C.7

$$\ln(Tier1\ and\ Tier2\ Consumption) = \alpha \ + \ \beta \cdot \ln(Tier\ 1\ Price) + \ \theta \cdot \ln(Tier\ 2\ Price) +$$

$$\varphi \cdot Employment\_Non\_Durable \; + \; \mu$$

To derive gross energy savings induced by the stepped rate changes for this portion of consumption, a similar approach can be taken as in the previous two steps. The key difference is that the total differential of energy consumption includes term associated with both Tier 1 and Tier 2 prices, both of which need to be retained to capture the rate impact. The final result is:

Equation C.8

$$d(Tier1 \; and \; Tier2 \; Consumption) = \left[\beta \cdot \frac{d(Tier\ 1\ Price)}{(Tier\ 1\ Price)} \; + \; \theta \cdot \frac{d(Tier\ 2\ Price)}{(Tier\ 2\ Price)}\right] \cdot (Tier\ 1 \; and \; Tier2 \; Consumption)$$

Equation C.8 indicates that price impact on combined Tier1 and Tier2 monthly energy consumption is a combination of Tier 1 price elasticity, Tier 2 price elasticity, and the respective rate changes.

Step 4. Calculating Gross TSR impacts

The final step to calculate gross TSR impacts is simply to sum up the energy impacts calculated in Step 1 through Step 3 (summation of Equations C.4, C.6 and C.8).

APPENDIX D DETAILED RESULTS OF ECONOMETRIC ANALYSIS

D.1 Results of Econometric Modelling for Evaluation Objective 4

The following tables provide the econometric modelling results that were applied to the calculations of the unreported TSR savings in evaluation Objective 4.

Table D.1 Statistics and parameter values of econometric model 1

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	3	0.42695	0.14243	62.01	<0.0001
Error	104	0.23867	0.00229		
Corrected Total	107	0.66562			
Root MSE		0.04791	R-Square		0.6414
Dependent Mean		20.65809	Adj R-Square		0.6311
Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**T Value**	**PR > |t|**
Intercept	1	22.02053	0.18610	118.32	<0.0001
Ln (Tier 1 Price)	1	-0.28250	0.03944	-7.16	<0.0001
Ln (Tier 2 Price)	1	-0.71575	0.13091	-5.47	<0.0001
Employment (Non-Durable	1	0.00000468	0.00000238	1.96	0.0522

Table D.2 Statistics and parameter values of econometric model 2

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	3	0.54252	0.18084	75.53	<.0001
Error	104	0.30646	0.00239		
Corrected Total	107	0.84898			
Root MSE		0.04893	R-Square		0.6390
Dependent Mean		20.64323	Adj R-Square		0.6306
Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**T Value**	**PR > |t|**
Intercept	1	21.52818	0.13133	163.93	<.0001
Ln (Tier 1 Price)	1	-0.13314	0.04791	-2.78	0.0063
Ln (Tier 2 Price)	1	-0.58665	0.12028	-4.88	<.0001
Employment (Non-Durable	1	0.00000852	0.00000227	3.76	0.0003

D.2 Additional Research and Econometric Modelling

The TSR design is unique and complex in that it provides many different options for customers to engage in energy conservation and efficiency improvements in order to minimize the cost of energy consumption. Published research on elasticity of industrial electric rates has been scant. Most of the available literature deals with the flat rate elasticity of industrial electricity rates. To better understand how TSR customers respond to the unique stepped-rate design, additional econometric modelling was carried out in an effort to understand how prices under the TSR rate schedule influenced TSR customers' energy consumption.

Model 1. Using annual data series to estimate Tier 1 and Tier 2 elasticity

Unlike the models adopted in the current evaluation where monthly data was used to derive the price elasticity estimates, the annual data of Tier 1 and Tier 2 consumption and employment data were applied to the following models (Equation D.4 and D.5) to estimate Tier 1 and Tier 2 price elasticity:

Equation D.4

$$\ln(Tier1\ Consumption\ ) \ = \alpha \ + \ \beta \cdot \ln(Tier1\ Price) \ + \ \varphi \cdot Employment\_Non\_Durable \ + \ \mu$$

where,

Tier 1 consumption is total Tier 1 energy consumption of all TSR RS1823B customers for each fiscal year from F2009 to F2020,

Tier 1 Price is real Tier 1 price for each fiscal year from F2009 to F2020, and

$Employment\_Non\_Durable$ is annual employment in the non-durable goods producing sector in B.C.

Equation D.5

$$\ln(Tier2\ Consumption\ ) \ = \alpha \ + \ \beta \cdot \ln(Tier2\ Price) \ + \ \varphi \cdot Employment\_Non\_Durable \ + \ \mu$$

where,

Tier2 consumption is total Tier2 energy consumption of all TSR RS1823B customers for each fiscal year from F2009 to F2020,

Tier2 Price is real Tier 2 price for each fiscal year from F2009 to F2020, and

Employment_Non_Durable is annual employment in the non-durable goods producing sector in B.C.

The annual model had a much shorter annual data series as compared to the monthly data used in the main model in this evaluation. The results indicated that Tier 1 price elasticity was -0.43 while the Tier 2 price elasticity estimate was not statistically significant. The results of this model were less satisfactory as Tier 2 energy consumption is a portion of total TSR energy consumption charged at a higher price than the Tier 1 rate, a major driver for TSR customers to partake in various DSM projects to offset Tier 2 energy consumption.

Table D.3 Modelling results of Tier 1 elasticity with annual consumption data

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	2	0.04957	0.02479	27.66	<0.0003
Error	8	0.00717	0.00089617		
Corrected total	10	0.05674			
Root MSE		0.02994	R-Square	0.8736	
Dependant Mean		23.08975	Adj R-Square	0.8421	
Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	23.62225	0.13233	178.52	<0.0001
Ln (Tier 1 Price)	1	-0.42725	0.07054	-6.06	0.0003
Employment_Non_Durable	1	-0.00000163	0.00000262	-0.62	0.5511

Table D.4 Modelling results of Tier 2 elasticity with annual consumption data

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	2	0.10175	0.05088	0.43	0.6634
Error	8	0.94178	0.11772		
Corrected total	10	1.04354			
Root MSE		0.34311	R-Square	0.0975	
Dependant Mean		19.78165	Adj R-Square	0.1281	
Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	22.92954	3.49253	6.57	0.0002
Ln (Tier 2 Price)	1	-1.99861	2.79605	-0.71	0.4951
Employment_Non_Durable	1	0.00001105	0.00004507	0.25	0.8125

Model 2. Estimate of Tier 2 Elasticity Using Expense of Tier 1 Energy Consumption as an Independent Variable

In this model, only Tier 2 elasticity was estimated when Tier 1 consumption was used as an independent variable. This model assumed that TSR customers were only concerned with the Tier 2 rate, the marginal price, for which customers had to pay when consumption was over the Tier 1 consumption threshold. Two model specifications were applied to estimate Tier 2 as described in Equation D.6 and Equation D.7.

Equation D.6

$$\ln(Total\ Consumption) = \alpha + \beta \cdot \ln(Tier1\ Consumption) + \theta \cdot \ln(Tier2\ Rate) + \varphi \cdot Employment\_Non\_Durable + \mu$$

where,

Total consumption is the monthly total TSR RS1823B customers' energy consumption from F2009 to F2020,

Tier1 consumption is the monthly consumption of all TSR RS1823B customers charged at the Tier 1 rate.

Tier2 Price is real Tier2 price that TSR RS1823B customers were charged at for their Tier 2 energy consumption, and

$Employment\_Non\_Durable$ is annual employment in the non-durable goods producing sector in B.C.

Equation D. 7

$$\ln(Total\ Consumption\ ) = \alpha + \beta \cdot \ln(Tier1\ Consumption) + \theta \cdot \ln(Tier2\ Rate) + \mu$$

Equation D.7 was similar to Equation D.6 but omits the $Employment\_Non\_Durable$ variable.

The results (Table D.5 and Table D.6) from the above models produced Tier 2 elasticity estimates of -0.61 and -0.59, which were somewhat lower (in absolute value) than the estimate from the main model adopted in this evaluation. Nonetheless they were within the range of the industrial rate elasticity estimates reported by various research studies. These estimates, together with the results from the main model, were consistent and in a relatively tight range given the wide estimate range produced by different studies.

Table D.5 Modelling results of Tier 2 elasticity with annual consumption data

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	3	0.77478	0.25826	120.80	<0.0001
Error	140	0.29930	0.00214		
Corrected total	143	1.07408			
Root MSE		0.04624	R-Square	0.7213	
Dependant Mean		20.63457	Adj R-Square	0.7154	
Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	15.26378	0.67211	22.71	<0.0001
Ln (Tier 1 Consumption)	1	0.31618	0.02975		<0.0001
Ln (Tier 2 Price)	1	-0.61131	0.09620	-6.35	<0.0001
Employment_Non_Durable	1	5.35149E-7	0.00000187	0.29	0.7752

Table D.6 Modelling results of Tier 2 Elasticity with annual consumption data

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	2	0.77461	0.38730	182.35	<0.0001
Error	141	0.29947	0.00212		
Corrected total	**143**	**1.07408**			
Root MSE		0.04609	R-Square	0.7212	
Dependant Mean		20.63457	Adj R-Square	0.7172	
Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	15.19568	0.62654	24.25	<0.0001
Ln (Tier 1 Consumption)	1	0.31898	0.02801	11.39	<0.0001
Ln (Tier 2 Price)	1	-0.58947	0.05839	-10.10	<0.0001

Model 3. Incorporating flat rate consumption into the elasticity model

TSR customers will be charged at a flat rate RS1823A if their CBL cannot be determined due to various reasons (new plant/production site, production capacity changes, temporary shut-down, etc.). Over years, the flat rate consumption fluctuates as some TSR customers exited or re-entered the TSR step rate schedule (RS1823B). There may be a certain degree of correlation between RS1823B consumption and RS1823A consumption. Therefore, a model estimating Tier 1 and Tier 2 elasticity with RS1823A consumption incorporated was set up as follows:

Equation D. 8

$$\ln(RS1823B\ Consumption_t) = \alpha + \beta \cdot \ln(Tier1\ Rate_t) + \theta \cdot \ln(Tier2\ Rate_t) + \varphi \cdot \ln(RS1823A\ Consumption_{t-i}) + \mu$$

Where

subscript *t* represents month t,

subscript *i* represents the number of months lagging from month *t*,

RS1823B Consumption$_t$ is the total monthly consumption of all TSR RS1823B customers in the month *t,*

Tier1 Price$_t$ is real Tier 1 price that TSR RS1823B customers were charged at for their Tier 1 energy consumption in the month *t-i,*

Tier2 Price is real Tier 2 price that TSR RS1823B customers were charged at for their Tier2 energy consumption, and

RS1823A consumption$_{t-i}$ is the total monthly consumption of all TSR RS1823A customers in the month *t-i.*

This model was fitted with a flat rate consumption using different lagging periods (*i*) to get optimal modelling results. The results were different with different lagging periods and the results with 14 months as the lagging period shown in Table D.7. This yielded a negative coefficient (-0.03872) associated with RS1823A consumption indicating a negative correlation with RS1823B consumption. This result was expected as TSR customers who switched in or out of the two rates (RS1823A vs. RS1823B) would have a negative impact on one type of consumption or another. It also showed that the Tier 2 elasticity was estimated at -0.40, while Tier 1 elasticity estimate was not statistically significant.

Table D.7 Modelling results of Tier 1, Tier 2 and flat rate elasticity with annual consumption data

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	3	0.50604	0.16868	64.96	<0.0001
Error	126	0.32721	0.00260		
Corrected total	129	0.83325			
Root MSE		0.05096	R-Square	0.6073	
Dependant Mean		20.62480	Adj R-Square	0.5980	
Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	22.22687	0.33914	65.54	<0.0001
Ln (Tier 1 Price)	1	-0.09965	0.13265	-0.75	0.4539
Ln (Tier 2 Price)	1	-0.40443	0.11987	-3.37	0.0010
Ln (RS1823A Consumption$_{14}$)	1	-0.03871	0.01773	-2.18	0.0308

D.3 Elasticity Studies of Electricity Rate for Industrial Customers

The table below lists some of the industrial rate elasticity studies with results of elasticity estimates by different industrial sectors or in different jurisdictions/markets. Full references of the studies can be found in References.

Study	Industry/Sector	Own Price Elasticity	Study Period
Short and long-run electricity demand elasticities at the sub-sectoral level: A co-integration analysis for German manufacturing industries	Pulp, Paper, Printing	-0.57	1997-2007
Assessing Energy Price Induced Improvements in Efficiency of Capital in OECD Manufacturing Industries	Pulp, Paper, Printing, Publishing	-0.54 ~ -1.01	1990-2005
	Chemical, rubber, plastics and fuel	-0.21 ~ -0.48	
	Basic metal and fabricated metals	-0.86 ~ -1. 05	
Explaining the Declining Energy Intensity of the U.S. Economy	Rubber, plastics	-0.7	1958-2000
	Coal Mining	-0.34	
	Paper &allied	-0.2	
	Printing and publication	-0.27	
	Lumber & wood	-0.28	
	Chemical	-0.16	
	Basic metal and fabricated metals	-0.19 ~ -0.34	
	Mean	-0.24	
The Price Elasticity of Electricity Demand in the United States: A Three-Dimensional Analysis	Industrial	-1.17 ~ -1.71	2003-2015
An Econometric Assessment of Electricity Demand in the United States Using Utility-specific Panel Data and the Impact of Retail Competition on Prices	Industrial	-0.47	1972-2009
Price and income elasticities of residential and industrial electricity demand in the European Union	Industrial	Short-run: -0.08 ~ -0.1, Long-run: -0.75 ~ -1.01	1997-2007

APPENDIX E SURVEY QUESTIONNAIRE

Leaders in Energy Management Participant Survey

INTRODUCTION TEXT

Thank you for taking the time to complete this survey.

Our records indicate that your organization's site located at (insert service address, service town) **participated in BC Hydro's conservation programs for Transmission customers between** (insert date range) **. We are interested in your organization's experience with the program and would appreciate your feedback. If you feel that this survey should be completed by another individual at your organization, please forward the original email invitation to that person. In recognition of your time and effort to complete this survey you will receive a $50 gift certificate upon completing and submitting the survey.**

In consideration of privacy issues, do not self-identify (unless for the purposes of receiving the gift card) or identify other specific individuals in your written comments. Any comments including self-identification or identification of third parties will be discarded.

Note: Only two questions from this survey were relevant to the TSR evaluation and are presented here.

51. For the project listed below…

Type of Assistance:	(insert assistance name)
Brief Project Description:	(insert brief project description)
Incentive amount:	(insert incentive amount)

…had there been no financial (FOR TSRflag=0) **"incentive from BC Hydro (i.e., money paid directly from BC Hydro to your organization – which does not include money for energy audits, studies or Energy Managers),"** (FOR TSRflag=1) **"benefits through the Transmission Service Rate (i.e., energy bill credit given for customer-funded DSM or program enabled projects – which does not include money for energy audits, studies or Energy Managers)" – would the energy-efficient measure have met your organization's financial criteria around site investments?** ☐1 Yes, it would have met our financial criteria

☐2 No, it would NOT have met our financial criteria

☐999 Don't know

☐998 Not Applicable

54. For the project listed below…

Type of Assistance:	(insert assistance name)
Brief Project Description:	(insert brief project description)
Incentive amount paid by:	(insert incentive amount)

…overall, how influential were BC Hydro's conservation programs for Transmission Customers (for TSRflag=1, include "and the financial benefits through the Transmission Service Rate (i.e., energy bill credit given for customer-funded DSM or program enabled projects)" on your organization's decision to implement the energy-efficient measure listed above at this site?

			Very influential	Somewhat influential	Not too influential	Not at all influential	Don't know
a.	BC Hydro's conservation programs for Transmission customers	→	☐1	☐2	☐3	☐4	☐999
b.	The financial benefits through the Transmission Service Rate (TSR)	→	☐1	☐2	☐3	☐4	☐999