BC hydro

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April 11, 2008

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

Dear Ms. Hamilton:

RE: British Columbia Utilities Commission (BCUC)
British Columbia Hydro and Power Authority (BC Hydro)
2004/05 to 2005/06 Revenue Requirements Application - Directive 66
Demand Side Management Evaluation Summary Report

BC Hydro is submitting its Demand Side Management Evaluation Summary Report (the Report), dated March 20, 2008 in compliance with Directive 66 (Page 197 of BCUC Decision dated October 29, 2004). Directive 66 directs BC Hydro to file the executive summaries of its milestone evaluation reports and full final evaluation reports for all its Power Smart programs. The Report summarizes the milestone evaluations carried out in F2008 on the following Power Smart programs:

- Product Incentive Program;
- Power Smart Partners Industrial Program;
- High Performance Buildings Program; and
- Residential CFL Program.

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

For further information please contact Lyle McClelland at 604-623-4306.

Yours sincerely,

Joanna Sofield
Chief Regulatory Officer

Enclosure (1)

Demand Side Management Milestone Evaluation Summary Report

March 20, 2008

Prepared by: Ken Tiedemann and Iris Sulyma
Power Smart Evaluation and Research

ABSTRACT

This report provides a summary of milestone evaluations completed by Power Smart Evaluation and Research during the Fiscal Year 2008. These studies are the impact evaluations for the Product Incentive Program, Power Smart Partners Industrial, High Performance Buildings, and Residential Compact Fluorescent Lighting.

ACKNOWLEDGEMENTS

Power Smart Evaluation and Research wishes to thank the members of the Evaluation Oversight Team for their assistance and for their support.

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MILESTONE EVALUATION REPORT - F2008

1.0 Introduction

BC Hydro evaluates its demand side management (DSM) programs to document their activities and impacts, to validate energy and peak savings, and to improve the design and operation of programs. The objective of BC Hydro's program evaluation function is to provide timely, credible, actionable and cost-effective evaluation studies. BC Hydro uses the California Evaluation Framework as a guide to undertaking program evaluations and related activities.

1.1 Background

BC Hydro resumed demand side management activity in 2002 and, since the resumption of Power Smart, undertaking evaluations of Power Smart programs has been a core activity. Program evaluation activities center on four main types of studies which are described below: baseline studies, process evaluations, market evaluations and impact studies. The basic objectives of program evaluations are to document program activities, assess program impacts, and identify opportunities for program improvement.

The BCUC Resource Planning Guidelines (RPG) note that "Because of measurement difficulties and uncertainty about consumer behaviour, DSM programs should be evaluated before and after implementation to determine their full impacts." Further in a Revenue Requirements Application decision, the BCUC directed that "BC Hydro file executive summaries of its milestone evaluation reports and the full final reports of all its Power Smart programs." The BCUC also suggested that "BC Hydro diversifies the composition of its evaluation oversight team with representatives from different lines of business and that the Chair of the team be designated from outside the Distribution line of business."

In response to these directives, BC Hydro determines the impact of its DSM programs in the following manner. First, a complete evaluation plan is prepared covering the scope, issues, timing and expected costs of the evaluation study(s). Second, process, market and impact evaluations are conducted at major milestones or at program completion. Third, evaluations are conducted, reviewed, and approved by a BC Hydro cross functional DSM Evaluation Oversight Team Committee chaired by a Senior Manager from BC Hydro's Engineering Services Business Unit. Fourth, BC Hydro has diversified the composition of the Evaluation Oversight Committee with members from all Lines of Business.

Executive summaries of the LED Traffic Light Program process and impact evaluation report and the Residential Lighting reconciliation report were filed with the BCUC on July 6, 2007. The present report provides the summaries for the remaining Evaluation Milestone Reports which were completed and approved by the Evaluation Oversight Committee during F2008. The following section outlines BC Hydro's approach to program evaluation.

1.2 Program Evaluation Principles and Approach

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

- Undertaking baseline studies and periodic data collection to understand the nature and size of the pre-program market and changes in the market over time.

- Leveraging existing program, market and customer data to minimize program evaluation costs.
- Using multiple lines of evidence to increase the credibility, validity and reliability of evaluation findings.
- Reviewing and approving completed evaluation studies by the Evaluation oversight team, which represent key stakeholders.

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

Baseline Studies. In baseline studies, the researcher describes the nature of the market, the roles of market actors and the market shares of more efficient and less efficient technologies. Key issues for baseline studies include the following. What are the sources of market data and how timely and reliable are they? What is the size of the market? What are the sales and market shares of more efficient and less efficient product? What are the prices of more efficient and less efficient product? Who are the key market actors? What are their roles? How can specific barriers to adoption of the technology be incorporated in program design?

Process Evaluations. In process evaluations, the researcher identifies and describes the program model or program logic, start-up procedures, implementation procedures and anticipated outcomes. Key issues for process evaluations may include the following. Are program goals clear, well defined, measurable and achievable? Are the goals clearly communicated through the organization? Is responsibility clearly defined? How efficient and effective are program processes? How can program processes be improved? What is the extent of stakeholder awareness of and participation in the program? How satisfied are the stakeholders with the program and its components?

Market Evaluations. In market evaluations, the researcher attempts to understand the impact of the program on the demand side and the supply side of the market. Key issues for market evaluations include the following. What is the size of the market? How much of the market has been captured? What is the remaining market potential? What are the barriers to market transformation? How successfully are the market barriers being addressed? What are the sales of more efficient and less efficient products? What are the prices of more efficient and less efficient products?

Impact Evaluations. In impact evaluations, the researcher evaluates program goals and objectives with respect to the program outcomes, whether intended or unintended. Key issues for impact evaluations include the following. What are the short-term impacts on clients or stakeholders? What are the long-term impacts on stakeholders? What the gross impacts of the program on energy and peak? What are the net impacts of the program on energy and peak?

2.0 Product Incentive Program Impact Evaluation

2.1 Introduction

The Power Smart Product Incentive Program (PIP) was launched in November 2003. The program utilizes financial incentives to encourage business customers to complete a variety of retrofit installations of energy efficient products, and it is administered primarily via the Internet through an online application site. Gross project savings are estimated automatically when the customer enters the project information into the online application using deemed savings algorithms for each technology type.

PIP is targeted at small and medium-sized commercial and institutional customers. However, customers in all sectors and tiers may participate in the program if they meet the eligibility requirements. PIP allows small and medium businesses to become more energy efficient through quick and easy retrofit projects. Larger businesses also benefit from the opportunity to undertake smaller projects that are not eligible for other Power Smart funding.

There have been two project phases to date. PIP I, which was launched in November 2003, focussed primarily on lighting technologies. PIP II, which was launched in November 2004, included an expanded product line. Process changes in March 2007 removed the pre-approval requirement, which changed the program structure to a more customer-friendly, rebate style model.

This report provides an evaluation of the Productive Incentive Program. The objectives for this evaluation are as follows.

- Provide a summary of program activity and customer characteristics.
- Determine customer program awareness, program satisfaction, non-participant energy conservation activities, free rider and spill over rates.
- Compare hours of use for program algorithms and logger data.
- Estimate gross energy and peak savings due to the program.
- Estimate net energy and peak savings due to the program.

2.2 Methodology

Updated data extracts containing information on all the PIP projects in the system were obtained in December 2006. The extract included a variety of information on PIP projects including project dates, application status, types and quantities of products installed, estimated energy savings and incentives awarded. This database was analyzed to provide an overview of program activity.

Telephone surveys were conducted with 62 program participants and 202 non-participants, from May 2006 through July 2006. Participant respondents were recruited from 229 PIP applications that were completed from February 9, 2004 to July 31, 2005. Non-participants were drawn mainly from a mailing list of customers who had received information about the program. This list was supplemented with strata dwelling customers who had also been contacted by the program. The surveys were used to collect information relevant to customer program awareness, customer satisfaction, program experience, free rider and spill over issues.

Gross and net energy savings were estimated for program activity for F2004, F2005 and F2006. The impact evaluation addressed program savings as follows. (1) The program's gross savings algorithms and parameter assumptions were adjusted using logger data on hours of use data by space type and building type. (2) These initial gross estimates were adjusted to compensate for space cooling cross effects. (3) Survey based free rider and spill over rates were used to calculate net program impacts. Evaluation issues, data sources and methods for this study are summarized in Table 2.1.

Table 2.1. Evaluation Issues, Data Sources and Methods

Issues	Main Data Sources	Method
Summarize program activity and customer characteristics	Program files Program interviews	File review Data base analysis
Determine customer program awareness, program satisfaction, non-participant energy conservation activities, free rider and spill over	Participant survey Non-participant survey	Cross tabulations
Compare hours of use for program algorithms and logger data	On-site logger data	Cross tabulations
Estimate gross energy and peak savings	Program data base Logger data on hours of use	Engineering algorithms
Estimate net energy and peak savings	Participant survey Non-participant survey	Free rider and spill over analysis

2.3 Results

Program Review. Program databases contain detailed information on applications and applicants, and this facilitated a detailed examination of program operations. This was supplemented with interviews with program marketing and delivery staff. Some key findings include the following.

- Tier 1 customers have completed the majority of PIP projects. The principal facility types are strata units and hotels, office building and elementary schools.
- These Tier 1 customers are also associated with projects which generate more than one-half of program savings, and PIP projects save an average of 50,000 kWh per year.
- T8 lighting products, CFLs and LED exit signs represent more than 96 per cent of all products installed under the program through December 31, 2005. T8 lighting products are the main technology followed by CFLs and LED exit signs.

Surveyed participants and non-participants were asked whether or not they had installed certain energy efficient equipment during the reference period. The selected products made up about 97 per cent of program savings for the period under review. Table 2.2 summarizes the results. The difference between the treatment and comparison group characteristics is examined using standard z-tests for difference of population proportions (z = 1.96 is the 95 per cent confidence threshold). The treatment group and the comparison group exhibit different behaviour for all four dimensions: treatment group are more likely to have purchased CFLs, energy saver T8s, standard T8s and LED exit signs over the reference period.

Table 2.2. Purchase of Energy Efficient Products

Product	Treatment (n = 62) (%)	Comparison (n = 202) (%)	Difference (%)	z-value
CFLs	51	34	17	2.47*
Energy saver T8s	23	6	17	3.85*
Standard T8s	35	9	26	4.96*
LED exit signs	65	17	48	7.21*

* indicates that the difference is significant at the 95 per cent level.

Survey Results. Participant and non-participant surveys were used to collect detailed information on program awareness, program satisfaction, non-participant energy conservation activities, free rider and spill over rates. Some key findings include the following.

- Some 53 per cent of non-participant survey respondents indicated that they were aware of BC Hydro's Product Incentive Program, and those who were aware of the initiative but had not participated cited needing more information, being too busy, perception that participation involved too much hassle and costs as the main reason for not participating.
- Participant satisfaction levels averaged over four out of five for all ten program dimensions examined, while non-participant satisfaction levels were substantially lower at between 2.9 and 3.6 for the five dimensions examined.
- About 70 per cent of participants would recommend the program to another customer.
- PIP qualifying products installed by non-participants in order of decreasing frequency included CFLs, LED exit signs, metal halide lights, T8 fluorescent tubes, high bay lighting, and occupancy sensors.
- Free rider rates were estimated at the technology level from participant survey data using a five-point scale rating for the organization PIP participation's importance in installing the rebated technology, where one is not at all important, and five is very important. Customers answering one, two or three were counted as free riders, and after aggregating results across technologies, this resulted in an estimated free rider rate of 19 per cent.
- Spill over rates were estimated by asking participants for each technology type if they had installed additional energy efficient products at the same site, and if the program had an influence on the install decisions. Again the results were aggregated across technologies, and this resulted in an estimated spill over rate for participants of 14 per cent.

Surveyed participants and non-participants were asked about their level of satisfaction with program elements, where one is very satisfied and five is very dissatisfied. Table 2.3 shows the top box score shares, or the percentages giving a four or five for that component. The difference between the treatment and comparison group characteristics is examined using standard z-tests for difference of population proportions (z = 1.96 is the 95 per cent confidence threshold). The treatment and comparison groups exhibit statistically different levels of satisfaction for five main program elements. Note also that the comparison group sample size is only 49 because many non-participants did not feel qualified to provide responses. For each program component, the treatment group had a higher satisfaction level than the comparison group.

Table 2.3. Satisfaction with Program Elements (% answering 4 or 5)

Dimension	Treatment (n = 62) (%)	Comparison (n = 49) (%)	Difference (%)	z-value
Program information by direct mail	85	42	43	4.63*
Program information by Internet	94	54	40	4.97*
Service by BC Hydro personnel	96	54	41	4.78*
Level of incentives	82	26	56	5.83*
Variety of eligible products	85	37	48	5.22*

* indicates that the difference is significant at the 95 per cent level.

Hours of Use. The main difference between the program energy savings algorithms and the evaluated results are due to differences in hours of use for lighting products. When compared to on-site measured hours of use, the hours of use assumptions used in the program algorithms appear to be high for many space types and building types. On-site monitoring data yielded a weighted average of 4,560 hours of use per year compared to program algorithm assumptions that yielded a weighted average of 5,886 hours of use per year.

Gross and Net Program Effects. Gross savings are estimated for program activity for the period from January 1, 2004 to March 1, 2006 using the revised hours of use estimates and an adjustment for space cooling cross effects. The space cooling adjustment is based on an engineering algorithm which is calibrated to the share of space that is cooled by building type.

Table 2.4 shows the program reported and evaluated savings. In the planning estimates, it was assumed that free riders and spill over were both five per cent, so that the gross and net savings were the same. Evaluated net energy savings are 18.7 GWh per year compared to reported net energy savings of 24.3 GWh per year. Evaluated peak savings are 2.6 MW compared to reported peak savings of 3.4 MW. The main difference between the reported gross energy savings and the evaluated gross energy savings is due to differences in the annual hours of use parameters employed as described just above. The combined effects of free riders and spill over rates yields a net to gross ratio for evaluated savings of 95 per cent, so that this is a relatively minor factor in determining the difference between program reported and evaluated energy savings estimates.

Table 2.4. Reported and Evaluated Energy Savings and Peak Savings

	Period	Energy Savings (GWh)		Peak Savings (MW)	
		Reported	Evaluated	Reported	Evaluated
Gross savings	F2004-06	NA	19.7	NA	2.7
Net savings	F2004-06	24.3	18.7	3.4	2.6

2.4 Conclusions

Program Design and Implementation. PIP has been successful in building a high level of product awareness and purchase behaviour for energy efficient lighting products in the commercial sector and institutional sector. The program has been gaining momentum, with increased customer applications for efficient lighting products leading to increased annual savings. It is worth noting that over 95 per cent of the program energy savings for the evaluated period of F2004 through F2006 are attributable to lighting products.

Energy and Peak Impacts. The program's engineering savings algorithms were modified to incorporate logger hours of use data and cooling system cross effects. This resulted in a gross savings realization rate of 81 per cent, with the main difference between reported and evaluated gross savings being driven by differences in hours of use estimates by space type and building type. PIP energy and peak impacts through F2006 are estimated at 18.7 GWh per year and 2.6 MW respectively. Since the estimated energy savings impact of 18.7 GWh per year is larger than the planned energy savings of 17.1 GWh per year for this period, the PIP program has successfully met its savings objective.

Program Monitoring. Applying BC Hydro's market transformation paradigm is enhanced when detailed information is collected on both supply side impacts and demand side impacts. Evaluation efforts to date have focussed on customer or purchaser behaviour with less attention paid to supply side considerations. For the next evaluation, it will be useful to interview supply side market actors to better understand their attitudes and roles and to determine how their activities can be leveraged to increase program impacts, particularly in the non-lighting products area.

2.5 Select Bibliography

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Habart and Associates (2006). Business Lighting Baseline Project Overview – Powerpoint Presentation to BC Hydro Power Smart, July 2006.

Intihar, C. (2004). Power Smart Product Incentive Program II Business Case, BC Hydro Power Smart Commercial Marketing, October 2004.

Longland, M. (2004). Process Evaluation of the Power Smart Product Incentive Program, BC Hydro Power Smart Evaluation, February 2005. .

Sampson Research (2004). BC Hydro PIP II Baseline Research, August 2004.

3.0 Power Smart Partners Industrial Program Process and Impact Evaluation

3.1 Introduction

The Power Smart Partner Industrial Program was launched in April 2002. The basic concept was that BC Hydro's largest business customers (who purchase at least $50,000 worth of electricity annually) have the most to gain from implementing long-term energy-saving strategies, not just one-time projects. BC Hydro partners with these companies, and it contributes matching funding and other resources to help them overcome barriers to realizing energy savings opportunities.

Requirements of the Power Smart Partners (PSP) program include: commitment to improve overall electrical energy efficiency: signing a Power Smart Partner Program agreement outlining their commitment, energy-efficiency target and the Energy Champion who will be responsible for carrying out the plan; and commitment to match dollars to identify and implement energy-saving opportunities.

BC Hydro in turn provides: energy savings opportunity identification: matching funds for businesses to identify electrical energy savings opportunities which may be used towards an energy manager, electrical energy audit, and building re-commissioning: education and training to help in developing the company's pool of energy management skills; e.Points bonus: an ongoing recognition program that rewards customers for the attainment of five per cent electrical efficiency targets with further financial incentives; a Fixed Incentive Fund for energy saving projects is available for customers with a distribution rate account; and a large project fund.

The purpose of this study is to conduct a process, market and impact study of the Power Smart Partners Program through March 2006. The objectives for the evaluation of the PSP Industrial program are as follows.

- Conduct process evaluation, including analysis of program awareness, customer decision making and program satisfaction.
- Conduct a market analysis, including determination of market penetration of standard and efficient technologies in participating and non-participating customers.
- Estimate realisation rates on the gross energy savings and peak savings.
- Estimate net program energy and peak savings.

3.2 Method

The main features of the approach used for the impact evaluation are as follows. The objectives for this evaluation are as follows.

- Data for the study was collected through interviews with program staff, review of program materials and processes, on-site inspections, end-use metering, and interviews with 42 participating firms.
- Based on program data, sample designs were developed for on-site data collection for the impact evaluation and for the telephone survey to collect decision-making information for net-to-gross analysis.
- Sample sizes were determined that would provide savings estimates for the program with ±10 precision at the 90 per cent confidence level.
- On-site visits were used to collect data for savings impacts calculations, while telephone surveys provided the information for the net-to-gross analysis and process evaluation.
- The on site visits at 59 participant and 65 on-participating sites were used to verify installations and to determine any changes to the operating parameters since the measures were first installed. Facility staff were interviewed to determine the operating hours of the installed system and to locate any additional benefits or shortcomings with the installed system.

- For some sites, monitoring of equipment was conducted to obtain more accurate information on hours of operation. The data collected on-site were used to estimate gross savings.
- Proven techniques, including engineering calculations using industry standards and computer simulations, were used to determine energy savings. Survey-based techniques for estimating free ridership in a program were applied to the data collected through a telephone survey of decision-makers.

Evaluation issues, data sources and methods for this study are summarized in Table 3.1.

Table 3.1. Evaluation Issues, Data Sources and Methods

Issues	Main Data Sources	Method
Conduct process evaluation, including determination of customer program awareness, decision making, program satisfaction	Participant survey	Cross tabulations
Conduct a market analysis, including determination penetration of efficient technologies	Participant and non-participant survey	Cross tabulations
Estimate gross energy and peak savings	Program files Site visits	On-site metering Engineering algorithms
Estimate net energy and peak savings	Participant survey	Free rider and spill over analysis

3.3 Results

Process Evaluation. The process evaluation used participant and non-participant surveys were used to collect detailed information on program awareness, program satisfaction, non-participant energy conservation activities, free rider and spill over rates. Some key findings include the following.

- The initial source of information on the program used by customers was the respective Key Account Manager, followed by calls to BC Hydro, with other sources much less important.
- The most important source of information on energy efficiency used by customers their BC Hydro representative, followed by an architect, engineer, or energy consultant, again with other sources much less important.
- Key determinants of energy efficient investments included BC Hydro financial incentives, cost savings, other benefits, recommendation from a BC Hydro study or report, and past experience with energy efficient equipment.

The following Table 3.2 shows customer satisfaction with key program components.

Table 3.2. Customer Satisfaction

Most Favourable	Mid-range	Least Favourable
Overall project result	Estimates of costs	Ease of understanding process
Operation of equipment	Estimates of savings	Actual process savings
Quality of installation work	Ease of completing paperwork	Post project inspection
Information from BC Hydro	Vendor or consultant support	Time to receive incentive
-	Amount of incentive	Amount of paperwork

Market Evaluation. The market evaluation focussed on key end uses, market penetration and opportunities, and participant versus non-participant shares of technologies. Some key factors include:

- The most important end uses in terms of consumption are: industrial processes including materials handling; pumps; fans; compressors; and lighting.
- The share of market captured by energy efficient technologies is generally high for industrial processes and pumps, but is somewhat lower for lighting, fans, pumps and compressors. Major opportunities include T8 lamps, electronic ballasts, premium efficiency motors, adjustable speed drives and appropriate sizing of key system components including motors, pumps and piping.
- Participants have higher shares of the energy efficiency technologies, and the program has been successful in encouraging energy efficient technology use.

Participants and non-participants were asked about the penetration of efficient technologies by end use as shown in Table 3.3.

Gross Savings Impacts. The gross savings impact analysis included first, re-estimating savings for sampled facilities and then, second, applying the realization rates to the total treated population. Expected saving for the sample facilities were determined by: (a) reviewing the documentation for the projects at a facility; (b) visiting the facilities to verify that the energy efficiency measures had been installed and the conditions under which the measures were operating; and (c) undertaking revised savings estimates as appropriate. Project documentation was collected and reviewed for each facility that was selected for the evaluation sample. For this review, a documentation checklist was used to record whether the following types of information had been provided: (a) documentation for equipment changed, including descriptions, schematics, performance data, and other supporting information; (b) documentation for new equipment installed, including descriptions, schematics, performance data, and other supporting information; and (c) information about the savings calculation methodology, including what methodology was used, specifications of assumptions and sources for these specifications, and correctness of calculations. This information was used to calculate a realization rate for sampled sites, and the realization rates were then used to calculate gross savings for each type of savings (incentive, consultative and both).

Table 3.3. Penetration of Energy Efficient Industrial Technologies (% penetration)

End Use	Technology	Treatment (n =59)	Comparison (n =65)	Difference	z-value
Lighting	T8	65.5	30.8	34.7	4.12*
Lighting	CFL	32.8	12.3	20.5	2.79*
Lighting	HPS	72.4	61.5	10.9	1.30
Lighting	Metal halide	72.4	72.3	1.2	0.01
Lighting	LED	29.3	10.8	18.5	2.62*
Lighting	Elect ballast	70.7	43.1	27.6	3.23*
Fan/blower	ASDs	27.1	6.2	20.9	3.21*
Fan/blower	Cog belts	35.6	6.2	29.4	4.25*
Fan/blower	Motor sizing	8.5	1.5	7.0	1.78
Fan/blower	EE motors	67.8	40.0	27.8	3.23*
Pumps	EE pumps	55.9	27.7	28.2	3.31*
Pumps	Pump sizing	69.5	38.5	31.0	3.64*
Pumps	Pipe sizing	69.5	40.0	29.5	3.46*
Pumps	ASDs	32.2	13.9	18.4	2.47*
Pumps	Motor sizing	8.5	1.5	7.0	1.78
Pumps	EE motors	67.8	40.0	27.8	3.23*
Compression	Low air temp	11.9	4.6	7.3	1.47
Compression	Controls	64.2	27.9	36.3	4.34*
Compression	Heat recovery	10.2	3.1	7.0	1.58
Compression	ASDs	27.1	6.2	27.8	3.21*
Compression	Motor sizing	8.5	1.5	37.6	1.78
Compression	EE motors	67.8	40.0	10.9	3.23*
Process	Motor sizing	8.5	1.5	7.0	1.78
Process	EE motors	84.8	61.5	27.8	3.23*
Process	PF correction	57.6	20.0	37.6	4.63*
Process	ASDs	67.8	56.9	10.9	1.26

* indicates that the difference is significant at the 95 per cent level.

Net Savings Effects. Net savings were defined as gross realized savings minus free rider effects plus spill over effects. Detailed survey information was used to calculate the free rider and spill over rates. Table 3.4 provides the results of this analysis for the period F2003-F2006. Evaluated energy savings were 469.3 GWh while evaluated peak savings were 64.5 MW.

Table 3.4. Reported and Evaluated Energy Savings and Peak Savings

	Period	Energy Savings (GWh)		Peak Savings (MW)	
		Reported	Evaluated	Reported	Evaluated
Gross savings	F2003-06	NA	513.4	NA	70.6
Net savings	F2003-06	497.3	469.3	68.3	64.5

3.4 Conclusions

Program Design and Implementation. The Industrial Power Smart Partners program has been successful in building a high level of knowledge of and interest in energy efficient technologies. Savings have been distributed across a wide range of end uses and technologies, suggesting that the program has effectively avoided cream skimming, which can sometimes be detrimental to longer term savings. Customer satisfaction with most of the program elements is high, and is in every case at least satisfactory.

Energy and Peak Impacts. Detailed on-site data collection combined with limited metering has been used to validate project savings estimates. For the period covered by the evaluation, net energy savings are estimated at 469.3 GWh per year while peak savings are estimated at 64.5 MW.

Program Monitoring. Monitoring and understanding changes in the industrial market for energy efficiency is complicated because the largest industrial customers use a variety of complicated and sometimes unique technologies. One consequence of this is that regression-based evaluation methods which are frequently applicable for the residential and commercial sectors may be difficult to apply. It would be useful to undertake a comprehensive baseline study to understand and update: (1) penetration information on energy efficient technologies: (2) end-use energy consumption; and (3) the scope for further energy efficiency improvements at the industrial site level.

3.5 Select Bibliography

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4.0 High Performance Buildings Program Impact and Process Evaluation

4.1 Introduction

The Power Smart High Performance Buildings (HPB) program was launched in July 2005. The objective of the HPB program was to accelerate the demand for and production of energy efficient new commercial and industrial buildings and industrial plants. HPB focuses on integrated design and whole building performance rather than selection and installation of individual energy efficient technologies.

The rationale for HPB is that by identifying and addressing barriers to energy efficiency during the design phase, new commercial buildings and industrial plants will capture energy efficiency opportunities. The program provides the following components to promote energy efficient design.

- Tools and financial incentives to address financial barriers.
- Education and training to address industry capacity constraint barriers.
- Promotional campaigns to address knowledge barriers.
- Recognition programs to address awareness barriers.

Minimum savings criteria apply, and projects are considered as qualified once certain guidelines have been met. The primary audience for the program includes: Building Owners; Building Developers; and Design Teams of new construction projects including architects, consultants and engineers. BC Hydro will assist the customer through two phases of the High-Performance Building Program: (1) BC Hydro will co-fund an energy study to develop a high-performance design that delivers energy savings, compared with conventional building design; (2) BC Hydro may provide incentives to help qualified projects implement the approved design, if the energy efficiency measures in the high-performance design involve added capital costs.

This report provides an evaluation of the High Performance Buildings program. The objectives for this evaluation are as follows.

- Review the rationale for the program.
- Assess the effectiveness of program activities.
- Characterize the new commercial construction market in British Columbia.
- Forecast the potential size of the new commercial construction market in British Columbia.
- Estimate energy savings and demand savings for the program.

4.2 Methodology

In this study we use a multiple lines of evidence approach, because no single line of evidence or method of analysis can provide information on all of the evaluation issues of interest. We use a combination of interviews with program staff and stakeholders; file review; literature review; on site-measurement of equipment run-time and loads; statistical forecasts and engineering analysis in this study. Evaluation issues, data sources and methods for this study are summarized in Table 4.1.

Table 4.1. Evaluation Issues, Data Sources and Methods

Issues	Main Data Sources	Method
Program rationale	Stakeholder and program staff interviews File and literature review	Logic framework analysis
Assess the effectiveness of program activities	Stakeholder and program staff interviews File and literature review	Logic framework analysis
Characterize the new commercial construction market	Stakeholder and program staff interviews B.C. Assessment Authority	Market analysis
Forecast the potential size of the new commercial construction market	Stakeholder and program staff interviews B.C. Assessment Authority	Market analysis
Estimate energy and demand savings	Six case studies	Engineering algorithms

4.3 Results

Program Rationale. The summary program logic model is shown in the following table. The program rationale is to address the four key market barriers (financial, capacity, knowledge and understanding, and awareness) to improve energy efficiency in new construction through four distinct but integrated strategies. These strategies are financial assistance, workshops and tools, promotional campaigns, and recognition programs. For each of the four strategies used, the program logic model shows the linkages between activities, outputs, program purpose and program goal. A review of the program logic reveals that the linkages are both reasonable and plausible, thus demonstrating that the underlying program logic is a valid one.

Figure 3.2.3. Program Logic Model

Market barrier	Financial barriers	Capacity constraints	Knowledge and understanding	Awareness
Activity	Financial assistance offered	Workshops and lunch and learn sessions held and tools developed	Promotional campaigns implemented	Recognition programs in place
Output	Building design costs and energy efficient equipment costs reduced	Construction and building design community capability increased	Knowledge and understanding of energy efficiency increased	Stakeholder awareness of energy efficiency importance increased
Purpose	Accelerate demand for and production of energy-efficient building and industrial facilities			
Goal	Reduce energy consumption and peak			

Program Effectiveness. Based on the file review, literature review, program interviews and stake holder interviews, a number of major finding emerged. First, incentive levels vary substantially across the new construction programs of various utilities, but many programs provide incentives equivalent to about 40 per cent to 60 per cent of incremental costs, which is about the share of incremental costs covered by BC Hydro for the case studies examined. Second, tiered incentives, where the incentive level is based on the level of energy efficiency improvement above the baseline, are successfully used by some utilities. Third, for many U.S. utilities, whole building baseline is determined through whole building simulations such as DOE 2.1 to establish the expected energy savings over the baseline. Fourth, program procedures are not viewed as particularly burdensome per se, but some concerns were raised about the length of time required for BC Hydro turn-around of documentation. Fifth, some interviewees felt that the effectiveness of program marketing could be improved, since program marketing depends heavily on Lunch and Learn sessions, which do not necessarily reach the key intended audiences including developers, owners and senior officials of architectural and engineering firms.

Market Characterization. Several key features of the new non-residential market in British Columbia stand out. (1) The construction industry is primarily cost driven by the underlying economics, with construction costs, operating costs, vacancy rates, revenues and return on investment being the key drivers. (2) Construction design typically focuses on visible building features, because they are what sell new commercial and industrial space. (3) Increased energy efficiency is a hard sell because triple net leasing means that the agent owning the building does not capture the gains from energy efficiency and because economic pay-back longer than five years is not viewed as attractive. (4) Energy efficiency is often an after thought, with relatively little attention paid to integrated design in the early stages of building design. (5) Three main end-use areas stand out as offering both broad savings potential and pay-back periods of five years or less - advanced lighting and controls, energy efficient chillers and mechanical systems including fans, pumps and compression.

Market Potential. New construction in British Columbia goes through fairly regular cycles in response to changes in the level of economic activity, interest rates, vacancy rates, the incremental stock currently under construction and forecasts of future economic conditions. Levels of new construction vary by segment in response to changes in rates of return and risk by segment. Construction activity is anticipated to increase through 2007 and 2008 and hit a short-term peak in 2009, and then fall back due to a reduction in major projects. The key non-residential construction segments are expected to be industrial, large and small offices, non-food retail, wholesale and warehouse, educational facilities and hotels and motels over the next three years. The program has a medium-term opportunity to significantly affect energy efficiency and capture lost opportunities on the order of at least 7 GWh in 2007, 13 GWh in 2008 and 15 GWh in 2009.

Energy and Demand Savings. The first six buildings participating in the High Performance Building program were the subject of detailed and comprehensive monitoring and verification. All six projects received post-completion monitoring and verification which involved metering of equipment run times and loads for periods up to twelve months to determine actual equipment loads combined with engineering modeling to determine energy savings. Since this is a new construction program, here were no pre-installation measurements available for comparison, so estimates of energy savings were based on engineering modelling calibrated to the measure loads. There was no evidence of free riders or spill over for these case studies.

Figure 3.2.1. High Performance Building Case Studies

Project	Project Summary	Analysis
Multiplex arena	Energy efficient lighting (T-8 lamps with electronic ballasts, CFLs, occupancy sensors, computerized, area specific time clock) and new ammonia refrigeration plant for 85,000 square foot complex (computer controls, larger evaporative cooler, supplementary 7.5 HP pony pump for low load conditions, VSD on 30 HP condenser fan, condenser fan)	22 lighting loggers installed for three months to capture lighting HOU, power loggers installed for seven months or more on fans, pumps, compressors
Refrigerated warehouse	New refrigeration system serving four blast freezers, two freezer storage rooms, one cooler and one loading dock with features including evaporative cooler with lower discharge pressure, multiple condenser fans, waste heat recovery, compressor oil cooling, defrost thicker insulation, VSDs on compressors (capacity increased from 140,000 to 318,000 lb/day)	Refrigeration system modeling using design refrigeration loads, run hours, and part load operating conditions, calibrated to metered load
Refrigerated warehouse	New refrigerated warehouse including a 92 ton refrigeration system serving food packaging and preparation areas at 30°F and a 137 ton refrigeration system serving a spiral freezer for storing product at -45°F with the following features: reduced condensing temperature, thermosyphon oil cooling, computer system controls, condenser fan and compressor VSDs	Savings based on measured operating hours on compressors and the condenser combined with on-site inspections to ensure proper system operation
Food processor	New refrigeration system serving two blast freezers, freezer storage room and cooler and production room with one-100 ton compressor, one-200 ton compressor with VSD, one-250 ton compressor with VSD, added insulation, waste heat recovery, defrost	Power meters were installed for one year on three compressors and actual and modeled consumption compared
Food processor	New refrigeration system using serving blast freezers and freezer storage room with ASDs on compressors	Power metering showed no savings
Residence	Space heating (plate frame heat exchanger with water at 375°F on primary side and 200°F on secondary side mixed to 120°F for radiant floor tubing with two 3 HP, four 1 Hp and two ¾ HP pumps), water heating (two 350 gallon storage tanks heated with two shell and tube heat exchangers, two small pumps), ventilation heating (two roof-mounted heat recovery ventilation units) by central steam plant for dormitory/dining hall	Heating water energy use calculated by measuring water flow and the temperature drop across the primary heat exchanger, using DDC package sensors with data collected for one year

The following table summarizes key impact results and compares these to initial reported estimates. Energy savings were estimated at 5.0 GWh per year and peak savings were estimated at 0.7 MW.

Table 2.2. Reported and Evaluated Energy Savings and Peak Savings

	Period	Energy Savings (GWh)		Peak Savings (MW)	
		Reported	Evaluated	Reported	Evaluated
Net savings	F2004-06	7.9	5.0	1.1	0.7

4.4 Conclusions

Program Design and Implementation. Energy efficiency in new commercial buildings is critical because once a building is constructed and occupied, the major building systems may be in place for ten years or more, leading to substantial lost opportunities. The High Performance Building program could address these lost opportunities through a prescriptive program offer that emphasizes energy efficient technology investments in: (1) advanced lighting technologies and lighting controls: (2) energy efficient chillers and HVAC controls: (3) energy efficient mechanical systems including fans, pump and compressors, which offer highly visible savings and rapid pay-back.

Building and System Baselines. There may be advantages in terms of stakeholder understanding and support by moving to a widely accepted and well understood baseline such as the ARSHAE/IESNA 90.1 standard. This may also increase program participation.

Design Assistance. Many commercial, institutional and industrial buildings are designed with limited attention paid to energy efficient systems and less attention is paid to integrated, energy efficient design. Energy efficiency considerations often enter the design process when the major mechanical and lighting systems are being designed, which is often too late for an integrated system to be sued. Support for early design assistance during the concept phase could help to overcome this barrier.

Energy and Peak Impacts. Energy savings were estimated at 5.0 GWh per year and peak savings were estimated at 0.7 MW.

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5.0 Residential CFL Program Impact and Market Evaluation

5.1 Introduction

The CFL residential lighting initiatives is an electricity acquisition and market transformation program aimed at motivating residential customers to obtain the best long-term value from their choice of household lighting and to shift customer behaviour and the lighting market so that efficient usage becomes a way of life. In the early stages of this program CFLs were purchased in bulk by Power Smart and then distributed free to BC Hydro utility customers through redeemable vouchers at partnering retail outlets. Vouchers were redeemable at Power Smart booths that rotated among participating retailers. The PS booths included knowledgeable staff and interactive displays to help educate customers on the benefits of CFL bulbs, how to choose the right bulb, and the best places to use them. Mail-in and point-of-sale rebate coupons were used in conjunction and in separate campaigns to stimulate the purchase of CFLs.

The 2006-07 CFL campaign involved the availability of $3 in-store instant rebate coupons for the purchase of Energy Star CFLs worth $9.90 or more. These coupons were distributed through Power Smart in-store promotions held with participating retailers throughout BC Hydro's service territory. The CFL coupon was a co-promotion with rebate coupons for Energy Star qualifying light fixtures. Users of the $3 CFL coupon were not required to provide contact information to redeem the coupon. For the purposes of follow-up market research, contact information for potential CFL coupon users came from contest entry forms for a one-year lease of a Toyota Prius automobile.

This report provides an evaluation of the Residential CFL Program for F2007. It also provides an update of the evaluation of the Residential CFL program for F2006, using final statistics on coupon redemptions that were not available at the time the evaluation of the F2006 program was undertaken. Issues for this study are as follows.

- Describe the recent supply-side developments in the British Columbia market for CFLs, including stocking behaviour, product variety and prices.
- Describe the recent demand-side developments in the British Columbia market for CFLs, including product awareness, purchase behaviour and purchases.
- Estimate program effects for both energy and peak savings due to the program for F2007.
- Revise the program effects for both energy and peak savings due to the program for F2006.

5.2 Methodology

Supply-side characteristics were determined primarily through the in-store shelf space study of 43 major retailers of CFLs across BC Hydro's four service regions. The shelf space survey collected information on CFL product availability, pricing and placement. Specific information collected included the overall shelf space devoted to lighting products, CFL share of the space, bulb styles, rated life, wattages, prices and presence of the Energy Star label on the package. Demand-side characteristics were determined mainly through three customer surveys conducted in March 2007 with 350 program participants, 600 BC Hydro customers and 512 comparison group households in North and South Dakota.

Table 6.1 compares the British Columbia and North and South Dakota customer samples on several key characteristics, which are believed to be drivers of CFL purchase and use. The difference between the treatment and comparison group characteristics is examined using standard z-tests for difference of population proportions (z = 1.96 is the 95 per cent confidence threshold). Since none of the differences are statistically significant, this comparison suggests that the treatment group and the comparison group are reasonably comparable, so that differences in CFL awareness, purchase or use are likely due to program activity rather than differences in the populations.

Table 6.1. Treatment and Comparison Group Characteristics

Dimension	Treatment (n = 600) (%)	Comparison (n =512) (%)	Difference (%)	z-value
Home ownership rate	85	85	0	0.018
Percentage of households with children under 19	32	31	1	0.338
Percentage with incomes under $40,000	34	38	-4	-1.416

* indicates the difference is significant at the 95 per cent level.

Energy savings were estimated for program activity (direct effects) and for market effects (indirect effects) for F2006 and F2007. The impact evaluation addressed program savings as follows. (1) Engineering algorithms were used to estimate the direct effects of the program using information on the number of coupons redeemed, the installation rate, the estimated free rider rate, hours of use and cross effects. (2) Total effects were estimated using information on incremental purchase rates for the treatment and comparison groups, the installation rate, hours of use and cross effects. (3) Market effects are defined as total effects minus direct effects. Issues, data sources and methods for this study are summarized in Table 6.2.

Table 6.2. Evaluation Issues, Data Sources and Methods

Issues	Main Data Sources	Method
Supply side analysis	Retail shelf space study	Cross tabulations
Demand side analysis	Consumer survey	Cross tabulations
Energy and peak savings for F2007	Participant, non-participant and consumer surveys Program data	Engineering algorithms
Energy and peak savings for F2006	Participant, non-participant and consumer surveys Program data	Engineering algorithms

5.3 Results

Supply-Side Analysis. The shelf space survey of major retailers operating in BC Hydro's service territory assessed the supply-side developments in the availability, accessibility, and affordability of CFLs. Compared to the previous year's study, the November 2006 shelf stock study found a modest increase in CFL availability and a significant decrease in CFL prices. Some key supply side findings include the following.

- Total shelf space allocated to screw-based CFLs by retailers increased to 13.8 per cent in November 2006 from 13.0 per cent in November 2005. CFLs accounted for 6.1 per cent of shelf space in the 2002 baseline survey.
- Spiral CFLs dominate the market, accounting for 75 per cent of all CFLs on store shelves in 2006. They are typically packaged in multiples of two or more, and offer the best value on a per-CFL bulb basis. Spiral CFLs accounted for only 22 per cent of all CFL product surveyed in the baseline year (2002).
- CFLs rated at 13 to 15 watts accounted for the majority (49 per cent) of CFL product surveyed in 2006. General merchandise and home improvement / hardware stores offer the greatest selection of CFLs in terms of wattages, brands, and models. Grocery stores continue to offer the least selection. In total, 190 different models of CFLs were observed across the four retail segments in 2006, down slightly from 196 models in 2005. Ninety (90) models were observed during the baseline year (2002).
- Share of CFLs rated at 10,000 hours continued to decline, accounting for 20 per cent of all CFL product in 2006, compared to 46 per cent in 2003. CFLs rated at 8,000 hours were most common, accounting for 37 per cent of all CFLs surveyed. The DOE Energy Star® logo was displayed on 79 per cent of all CFLs surveyed in 2006, unchanged from 2005.
- CFL prices continued their long-term decline in 2006 with 50 per cent of all CFLs priced at less than $4 each (adjusted for multi-packs), and 11 per cent of all CFLs priced at less than $2 each. On a weighted average basis, globe, circular, tube, and par/reflector style CFLs recorded price declines.
- Based on the current capital and operating costs of a typical 15 watt CFL versus a 60 watt incandescent bulb, the expected payback for a CFL based on average use of four hours a day is now nine (9) months, compared to 27 months in 2002.

Demand-Side Analysis. The general consumer survey of BC Hydro residential customers indicated that awareness of CFLs remains unchanged, but the incidence and penetration (saturation) has increased significantly since the last survey conducted in January 2006. A survey of BC Hydro customers who took advantage of the in-store instant rebate coupon for CFLs (participant survey) supplemented this information. Key findings from the consumer and participant surveys include:

- Ninety-one per cent (91 per cent) of BC Hydro residential customers are aware of CFLs, which is statistically unchanged from the previous three years (89 per cent to 90 per cent).
- Recall of information, advertising, or promotions from BC Hydro Power Smart regarding CFLs declined to 68 per cent from 73 per cent recorded during January 2006 survey.
- Seventy-three per cent (73 per cent of BC Hydro residential customers have at least one CFL in use (incidence) as of March 2007, up from 70 per cent in 2005, and 23 per cent in 2002. On average, these homes have 9.0 CFLs installed, up significantly from the 6.9 average recorded in January 2006. The average numbers of installed CFLs increased for both indoor and outdoor applications.
- Nearly six in every ten (58 per cent) BC Hydro residential customers purchased a CFL in 2006. On average, 7.4 CFLs were purchased per household, with or without using a Power Smart sponsored coupon.
- The average price paid for the most recent CFL purchase was $3.77 a CFL, down considerably from January 2006 when the average price paid was $5.00 per CFL.
- Seventeen per cent (17 per cent) of households reported using a Power Smart sponsored coupon in 2006. These households purchased an average of 10.1 CFLs,

8.2 CFLs during the last three months of the year. Households using a coupon purchased an average of 5.7 CFLs each using the discount coupon.

- The proportion of households with one or more CFLs in storage rose to 68 per cent in March 2007 from 57 per cent in January 2006. The average quantity of CFLs sitting unused also increased; rising to 2.1 CFLs per user-household from 1.8 CFLs in January 2006. The most commonly mentioned reasons why the CFLs are not in use include waiting for existing CFLs or incandescent bulbs to burn out (29 per cent and 13 per cent of responses, respectively), and that they didn't have a use for them (29 per cent).
- Overall, 81 per cent of CFLs purchased during calendar year 2006 were installed as of March 2007. This installation rate is down from the 87 per cent record high during the January 2006 survey, but consistent with higher average purchase quantities and the increase in CFLs in storage.
- Thirty-nine per cent (39 per cent) of user households replaced one or more CFLs in 2006. On average, these households replaced 2.9 CFLs each. Eight-two per cent (82 per cent) of these CFLs were replaced with another CFL.
- Of the households with at least one CFL currently in use, 91 per cent indicated they still have incandescent lights in use either indoors or outdoors. The most frequently mentioned reasons why CFLs are not used in these fixtures include frugalness (i.e., waiting for existing incandescent bulbs to burn out) (20 per cent of all responses), technical issues with using CFLs in the fixture (19 per cent), issues with the performance of CFLs (15 per cent), and cost of CFLs (11 per cent).

Table 6.3 compares the British Columbia and North and South Dakota customer samples on several CFL awareness and purchase characteristics. The difference between the treatment and comparison group characteristics is examined using standard z-tests for difference of population proportions (z = 1.96 is the 95 per cent confidence threshold). The treatment and comparison groups exhibit different behaviour for all four dimensions: BC Hydro customers are more likely to be aware of CFLs, to have at least one CFL installed in their home, to have purchased at least one CFL in the last year, and to have used a coupon to purchase a CFL.

Table 6.3. CFL Awareness and Purchase Behaviour

Dimension	Treatment (n = 600) (%)	Comparison (n = 512) (%)	Difference (%)	z-value
Aware of CFLs	91	81	10	4.74*
Have at least one CFL installed	73	36	37	12.41*
Purchased at least one in the last year	58	22	36	12.12*
Purchasers used coupon to buy CFL	21	7	14	6.58*

* indicates that the difference is significant at the 95 per cent level.

Energy and Peak Savings. Net savings for F2006 and F2007 are shown in Table 6.4. For F2006, evaluated net energy savings are 32.5 GWh per year compared to reported net energy savings of 29.0 GWh per year, and evaluated peak savings are 8.3 MW compared to reported peak savings of 9.0 MW. For F2007, evaluated net energy savings are 80.1 GWh per year compared to reported net energy savings of 11.8 GWh per year, and evaluated peak savings are 20.3 MW compared to reported peak savings of 3.0 MW.

Table 6.4. Reported and Evaluated Energy Savings and Peak Savings

	Period	Energy Savings (GWh)		Peak Savings (MW)	
		Reported	Evaluated	Reported	Evaluated
Net savings	F2006	29.0	32.5	9.0	8.3
Net savings	F2007	11.8	80.1	3.0	20.3

5.4 Conclusions

Program Design and Implementation. Power Smart's Residential CFL program has been successful in building a high level of product awareness and purchase behaviour for energy efficient lighting products in the residential sector. BC Hydro may have the highest residential CFL penetration and saturation rates of any major utility service territory in North America. The Residential CFL program has successfully made the transition from a give-away and incentive program to a market transformation program. Given the high level of residential use, it will be major challenge for the program to sustain momentum and further increase the residential saturation and penetration of CFLs.

Energy and Peak Impacts. We saw above that for F2006, evaluated net energy savings are 32.5 GWh per year compared to reported net energy savings of 29.0 GWh per year, and evaluated peak savings are 8.3 MW compared to reported peak savings of 9.0 MW. And for F2007, evaluated net energy savings are 80.1 GWh per year compared to reported net energy savings of 11.8 GWh per year, and evaluated peak savings are 20.3 MW compared to reported peak savings of 3.0 MW.

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