DSM Potential Studies Are Alive and Well and Living in Canada

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ABSTRACT

The Conservation Potential Review (CPR) 2007 is the most comprehensive of any done so far. The results of this study will help to ensure that British Columbia's future energy needs will be met through cost-effective and environmentally friendly conservation measures.

This paper presents the results of a 16-month study conducted for BC Hydro by a team of consultants led by Marbek Resource Consultants. The study assessed the potential energy and peak demand savings over 20 years from existing technologies, emerging technologies, behavioral changes, lifestyle changes, customer-supplied renewable energies and fuel switching. Some methodologies, especially those involving technologies, are well established while others, especially around behaviors and lifestyle, are new. The study results guide strategic planning, program design and the demand-side management (DSM) portion of BC Hydro's Integrated Electricity Plan (IEP). They will also be used by stakeholder organizations in promoting conservation.

Background

Since the early 1990s, BC Hydro has been carrying out Conservation Potential Review (CPR) studies to determine how much electricity conservation is available in its service area, at what cost, when it will be available, where it will be available and in what sectors, end uses and technologies. BC Hydro continues to pursue conservation as the most cost-effective resource option.

Since completing a previous CPR in 2002, new pressures in the electricity industry and on the environment have led to a renewed interest in conservation, load management and demand-side management (DSM). In addition, the performance efficiency of major energy-using technologies has continued to improve, technology prices have changed, new products have become available and additional technologies, based largely on advances in information technology (IT) and materials science, are under development.

In June 2006, BC Hydro initiated its third CPR (CPR 2007). The study, conducted by a team of consultants led by Marbek Resource Consultants Ltd., was carried out in consultation with an External Review Panel (ERP), a panel of representatives from community groups, First Nations and customer sectors from across B.C.

BC Hydro serves more than 1.7 million customers. BC Hydro's various facilities generate between 43,000 and 54,000 gigawatt hours of electricity annually, depending on prevailing water levels. In fiscal 2006, revenue was $Cdn 4.3 billion, which resulted in a return on equity of 9.26 per cent.[1] British Columbians enjoy some of the lowest electricity rates in North America, due in large part to hydroelectric heritage resources, with residential users paying approximately 6.5 cents per kilowatt-hour.

[1] BC Hydro, Quick Facts, http://www.bchydro.com/info/reports/reports921.html, accessed November 18, 2007.

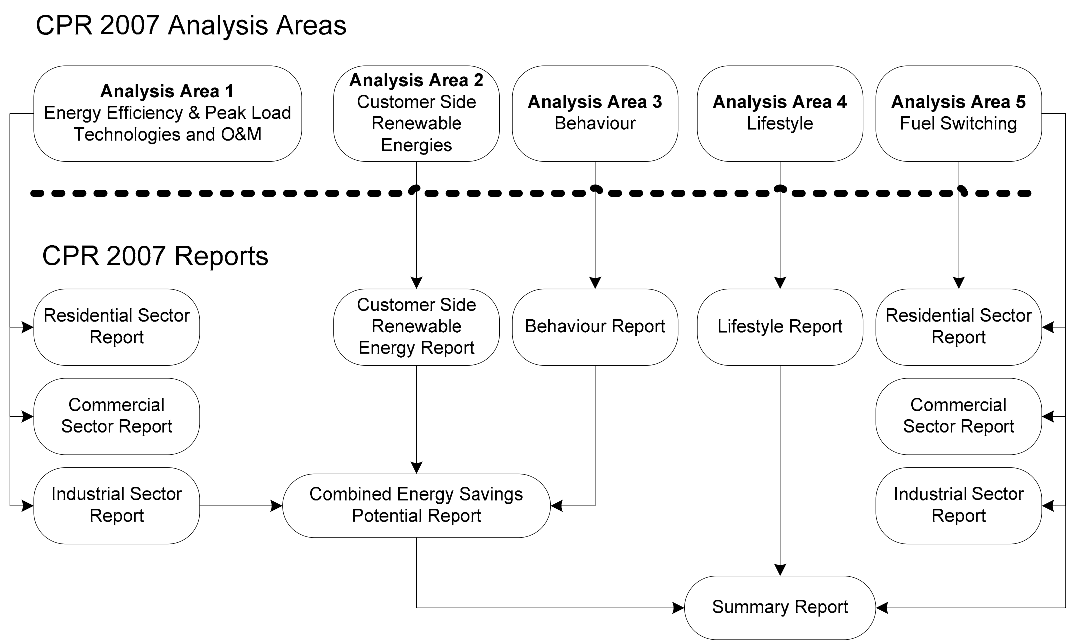
Objectives and Scope

The objective of CPR 2007 was to develop estimates of electricity conservation potential in BC Hydro's service area to the fiscal year F2026. This included analyzing a broad range of energy-saving technologies, behavioural and lifestyle changes, small-scale renewable energies and fuel switching. The study outputs will be used to:

- Provide input to the DSM Plan for BC Hydro's long-term goals for energy conservation and efficiency
- Develop new conservation programs and modify existing ones
- Provide estimates for future Integrated Electricity Plans
- Provide input for load forecasts
- Develop new capacity programs to meet the needs of the British Columbia Transmission Corporation (BCTC) and BC Hydro Distribution Planning.

The scope of CPR 2007 was the broadest of any BC Hydro CPR study to date. The study was organized into five Analysis Areas and the results are presented in 11 individual reports. Figure 1 provides an overview of the study organization.

Figure 1. Overview of CPR 2007 Organization – Analysis Areas and Reports



Analysis Area 1 – Energy Efficiency and Peak Load Technologies and O&M. This area of the CPR 2007 assessed electricity and peak load reduction opportunities that could be provided by electrical efficiency and peak load reduction technologies that are expected to be commercially viable by the year 2011; this area also addresses operation and maintenance (O&M) practices in the Commercial and Industrial sectors.

Analysis Area 2 – Customer-supplied Renewable Energies. This area of the CPR 2007 assessed electricity and peak load reduction opportunities that could be provided by small-scale customer-supplied renewable energies in the Residential and Commercial sectors.

Analysis Area 3 – Behaviour. This area of the CPR 2007 assessed electricity and peak load reduction opportunities that could be provided by the actions of Residential and Commercial sector customers who habitually save energy within their daily routines.

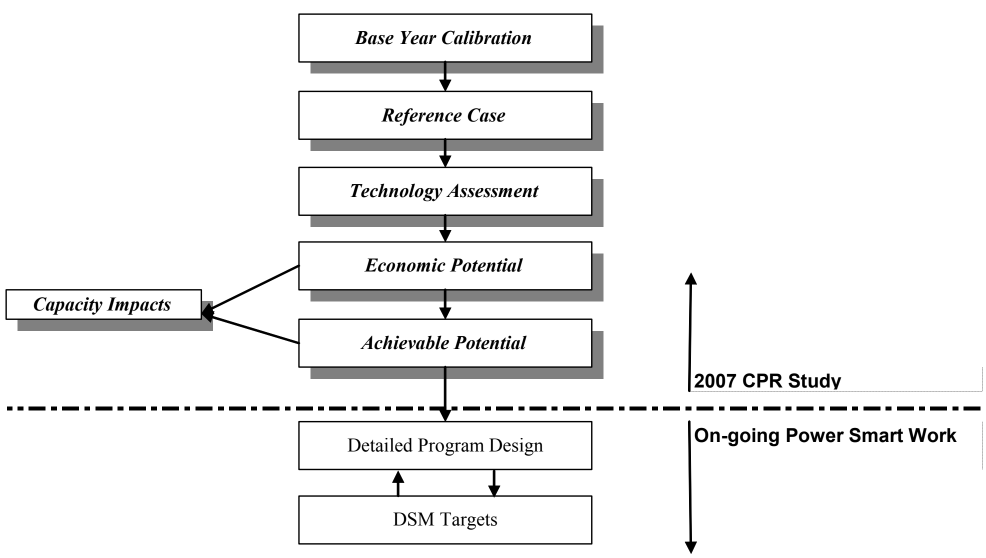
Analysis Area 4 – Lifestyle. This area of the CPR 2007 assessed electricity and peak load reduction opportunities that could be provided by customer choices related to the energy-consuming systems that they purchase or use (e.g., purchasing a refrigerator that is not only efficient but also smaller in size, or purchasing a home that is both energy efficient and smaller).

Analysis Area 5 – Fuel Switching. This area of the CPR 2007 assessed electricity and peak load reduction opportunities that could be provided by switching selected end uses, such as space or water heating, from electricity to natural gas.

Methodology

Each of the five Analysis Areas was assessed using a consistent set of steps, as outlined in Figure 2. Moreover, to support downstream use of the results, each Analysis Area was initially assessed in isolation but also defined at the outset in a manner that would support the subsequent aggregation of results into a combined energy savings report, as noted above in Figure 1.

Figure 2. Study Approach – Major Analytical Steps



Step 1: Develop Base Year Calibration Using Actual BC Hydro Sales Data

The Base Year (F2006) is the starting point for the analysis. This step provides a detailed description of "where" and "how" electricity is currently used, based on actual electricity sales.

Consistent with the expanded scope of CPR 2007, the Base Year calibration applied to both electric energy and electric peak loads.

Step 2: Develop Reference Case

The Reference Case estimates the expected level of electricity consumption and peak loads that would occur over the study period with no new (post-F2006) DSM initiatives from BC Hydro. The Reference Case provides the point of comparison for the calculation of Economic and Achievable electric energy and peak load savings potentials.

Step 3: Develop and Assess Energy Efficiency Upgrade and Peak Load Savings Options

The study team researched existing and emerging technologies and practices that can enable BC Hydro customers to use electricity more efficiently, as well as those that enable them to shift[2] their electricity use away from periods of high demand to periods of lower electricity demand. In each case, the study team assessed how much electricity the technology could save or shift together with the expected cost, including purchase (capital) and operating and maintenance costs. Each measure's performance and cost data were combined to create a Cost of Conserved Energy (CCE), which provides easy comparison with the cost of new electricity supply options.[3]

Step 4: Estimate Economic Electric Energy and Peak Load Savings Potential[4]

The Economic Potential is the level of electricity consumption that would occur if B.C. residents installed all "cost-effective" technologies. "Cost effective" for the purposes of this step in the study means that the technology's CCE is less than or equal to 13 cents per kilowatt-hour. The energy economic screen of 13 cents per kilowatt-hour was calculated based on BC Hydro's 2006 energy reference price plus an adder of 50%.

BC Hydro's energy reference price was determined to be $88/MWh, or $0.088/kWh, based on an average of the results of the 2006 call for new energy supply. The 50% adder was included to allow for uncertainties in the energy reference price over time and ensures that the study results are not rendered obsolete in the short term due to a new energy reference price that exceeds the study's economic screen. The resulting energy economic screen used in this analysis was, therefore, $0.13/kWh = ($0.088/kWh*1.50). The electric energy Economic Potential forecast incorporates all the electric energy-efficient upgrades that the technology assessment found with a CCE equal to or less than $0.13/kWh.

Selection and analysis of the electric peak load measures included in the peak load forecast followed a similar approach as for electric energy. In this case, a capacity economic screen of $170/kW/yr ($115/kW/yr*1.50) was employed.[5]

Step 5: Estimate Achievable Electric Energy and Peak Load Savings Potential

The Achievable Potential is the proportion of the savings identified in the Economic Potential forecast that could realistically be achieved within the study period. Achievable Potential recognizes that it is difficult to induce customers to purchase and install all the

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[2] CPR 2007 assessed two sources of peak load savings: peak load savings from electric energy savings and peak load savings from capacity-only measures.

[3] The CCE for an energy-efficiency measure is defined as the annualized incremental cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs required to achieve full use of the technology or measure.

[4] All estimates of savings are net of interactive effects.

[5] $115/kW was the latest draft capacity reference price available at the time of the analysis.

electrical efficiency technologies that meet the criteria defined by the Economic Potential forecast. The results are, therefore, presented as a range, defined as “Upper” and “Lower.” The Lower Achievable Potential assumes that market conditions, program efforts and incentive levels remain similar to existing levels. The Upper Achievable Potential assumes that market conditions and government policy are very supportive and that energy savings are much more aggressively pursued.

Estimates provided were developed in collaboration with Power Smart personnel, External Review Panel members and industry experts. They are based on a combination of empirical results from earlier DSM initiatives, results in other jurisdictions and a qualitative assessment of current market and customer receptivity to electrical efficiency investments. The range of estimates also recognizes that, in addition to factors within BC Hydro’s control (e.g., program design), factors external to the utility (e.g., state of the economy, climate change implications, etc.) could significantly influence the Achievable Potential.

Selected Results

CPR 2007 confirmed that, despite two decades of successful DSM program delivery, significant cost-effective electric energy and peak load savings opportunities exist in every sector in BC Hydro’s service area.[6]

Total Savings Potential – The Combined Results

To determine the total electric energy and peak load savings potential, CPR 2007 combined[7] the results contained in Analysis Areas 1, 2 and 3. These include the potential electric energy and peak load savings from:

- Technology adoption in the Residential, Commercial and Industrial sectors
- Operation and maintenance improvements in the Commercial and Industrial sectors
- Behavioural changes in the Residential and Commercial sectors
- Small-scale customer-supplied renewable energies.

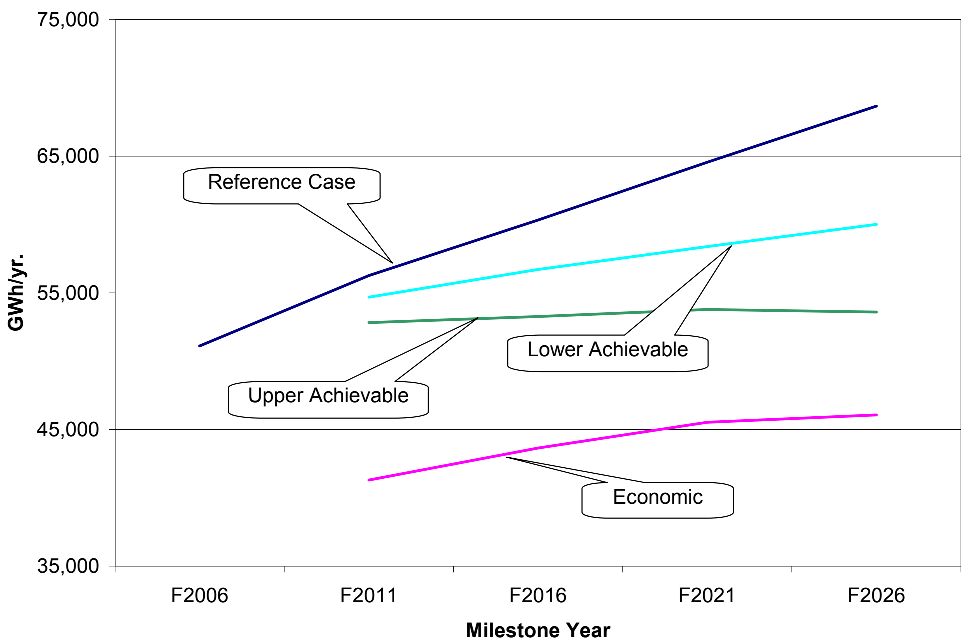
The CPR 2007 notes that there are additional Achievable Potential electricity savings that could be provided by the results of Analysis Area 4 Lifestyle; these measures, detailed in a stand-alone report, challenge customers to take action beyond technology and eliminating waste, and to change their consumption choices. The Lifestyle changes were not included in the combined total above as they are not directly additive and there is currently no existing methodology to combine them. Similarly, it was also agreed at the outset of CPR 2007 that Analysis Area 5 Fuel Switching would not be included in the calculation of combined savings.

Figure 3 summarizes the combined Achievable Potential electricity savings that were identified. As illustrated:

[6] All savings are at the customer meter and do not include line losses.
[7] The combined results are net of overlapping measures that, if simply summed, would result in double counting of results.

- In the Reference Case, total electricity consumption increases from 51,000 GWh/yr. in F2006 to about 68,700 GWh/yr. in F2026.
- In the Upper Achievable Potential scenario, total electricity consumption would grow to about 53,600 GWh/yr. in F2026, a decrease of about 15,100 GWh/yr., or 22% relative to the Reference Case.
- In the Lower Achievable Potential scenario, total electricity consumption would grow to about 60,000 GWh/yr. in F2026, a decrease of about 8,700 GWh/yr., or 13% relative to the Reference Case.

Figure 3. Combined Achievable Electricity Consumption (GWh/yr.), F2006 to F2026



CPR 2007 also confirmed that significant cost-effective opportunities exist for peak load savings. CPR 2007 assessed two sources of peak load savings:

- Peak load savings from electric energy savings
- Peak load savings from capacity-only measures.

The study defined four peak load periods. For the purposes of this paper, the results of Peak Period 1 – the Annual System Peak Hour - are presented in Figure 4.[8]

- In the Base Year F2006, the peak load for BC Hydro's total service area was approximately 9,650 MW for Peak Period 1. In the absence of new DSM initiatives, the study estimated that the total peak load in Peak Period 1 would grow to about 13,180 MW by F2026, an increase of about 37%.

[8] For BC Hydro, this has traditionally been the hour ending at 6 pm on a day in December or January; it is highly correlated with the coldest day of the year.

- Electric energy savings would provide peak load savings of between 2,230 MW and 1,415 MW during BC Hydro's Annual System Peak Hour by F2026 in, respectively, the Upper and lower Achievable Potential scenarios, a decrease of between 17% and 10% relative to the Reference Case.
- Capacity-only measures would provide peak load savings of between 900 MW and 670 MW by F2026 in, respectively, the Upper and Lower Achievable Potential scenarios, a decrease of between 8% and 5% relative to the Reference Case.

Figure 4. Peak Load Savings in Peak Period 1 from Electric Energy Savings and Capacity-Only Measures, Total BC Hydro Service Area

Average Peak Load (MW)			Peak Load Savings from Electric Energy Savings (MW)		Peak Load Savings from Capacity-Only Measures (MW)	
Milestone Year	**Base Year**	**Reference Case**	**Upper Achievable**	**Lower Achievable**	**Upper Achievable**	**Lower Achievable**
F2006	9,653	9,653				
F2011		10,556	621	276	320	165
F2016		11,613	1,168	592	659	399
F2021		11,992	1,729	1,066	922	563
F2026		13,183	2,278	1,415	1,084	673

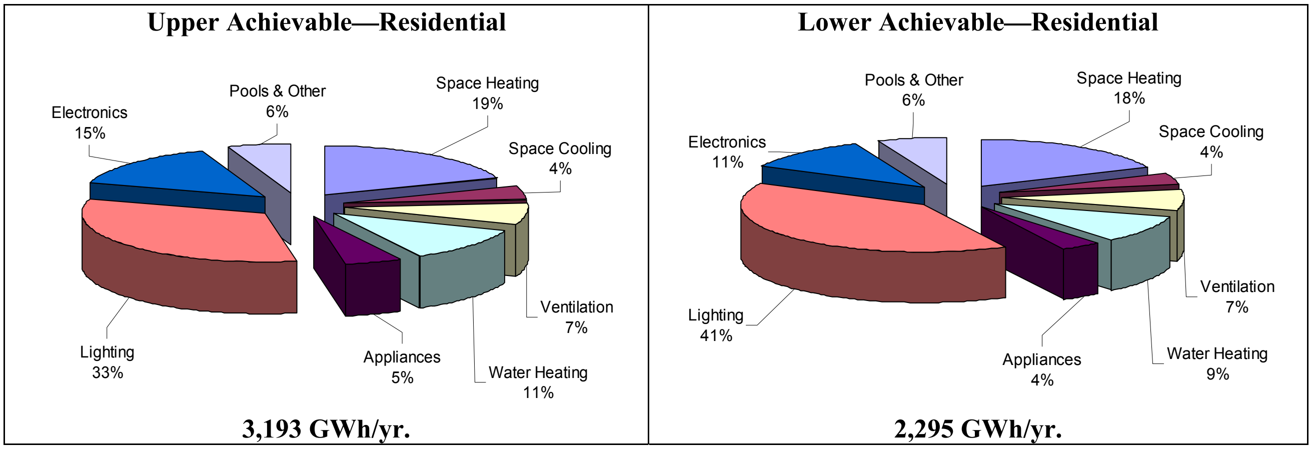
Notes: Industrial peak load savings from capacity-only measures are not practical for Peak Period 1 and are not included in the results shown. However, the 4 to 9 pm timeframe defined by Peak Period 2 – System Critical Peak Day – is a good match; industrial capacity-only peak load savings for Peak Period 2 are estimated to be between 579 MW and 374 MW by F2026 in, respectively, the Upper and Lower Achievable Potential scenarios.

Residential Sector Technology Savings[9]

The Residential sector includes single-family homes, duplexes, row homes, high-rise and low-rise apartment buildings and mobile homes. Electric energy savings from technology efficiency improvements would provide between 3,193 GWh/yr. and 2,295 GWh/yr. of electricity savings by F2026 in, respectively, the Upper and Lower Achievable Potential scenarios, or about 14% and 10%, respectively, relative to the Reference Case. As shown in Figure 5, the most significant Achievable savings opportunities were in the actions that addressed lighting, space heating and household electronics (e.g., computers and peripherals, televisions and television peripherals).

[9] Results presented in this section focus on electric energy savings due to space limitations; full reporting of the peak load analysis, including specific measures and savings, are contained in the detailed reports available from BC Hydro.

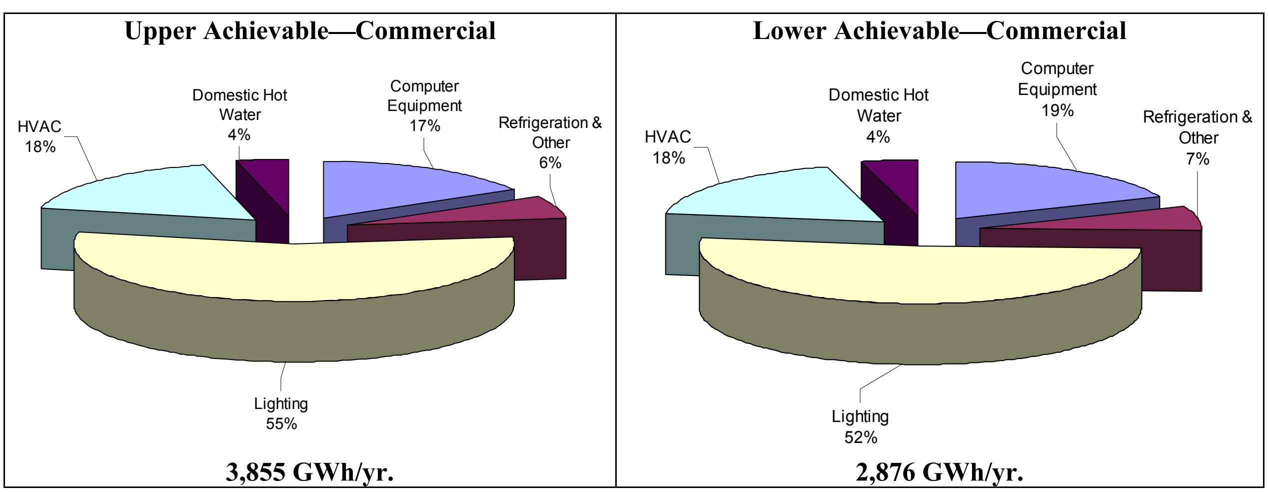
Figure 5. Residential Achievable Savings



Commercial Sector Technology and O&M Savings

The Commercial sector includes office and retail buildings, hotels and motels, restaurants, warehouses and a wide variety of small buildings. In this study, it also includes buildings that are often classified as "institutional," such as hospitals and nursing homes, schools and universities. The Commercial sector also includes some non-building electricity uses such as telephone exchange buildings, but they were not modelled in this study. Electric energy savings from technology and O&M efficiency improvements would provide between 3,855 GWh/yr. and 2,876 GWh/yr. of electricity savings by F2026 in, respectively, the Upper and Lower Achievable Potential scenarios, or about 20% and 15%, respectively, relative to the Reference Case. As shown in Figure 6, the most significant Achievable Savings opportunities were in the actions that addressed lighting, computer equipment and HVAC (heating, ventilation & cooling).

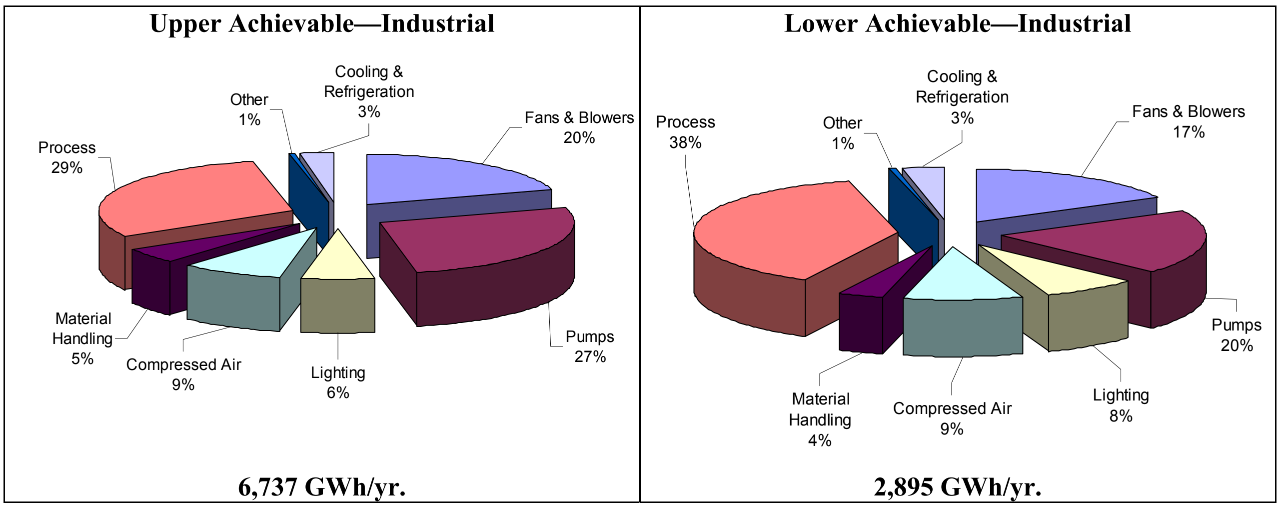
Figure 6. Commercial Achievable Savings



Industrial Sector Technology and O&M Savings

B.C.'s Industrial sector is a complex mix of facilities, including: resource companies, such as forestry and mining extractors, primary and secondary manufacturers, such as wood, metal and chemical producers, and a wide variety of other companies. Electric energy savings from technology and O&M efficiency improvements would provide between 6,737 GWh/yr. and 2,895 GWh/yr. of electricity savings by F2026 in, respectively, the Upper and Lower Achievable Potential scenarios, or about 25% and 11%, respectively, relative to the Reference Case.[10] As shown in Figure 7, the most significant Achievable Savings opportunities were in the actions that addressed the process end use, particularly in the Mechanical Pulp sub sector, as well as the pumps, compressed air, fans and blowers and lighting end uses in all sub sectors.[11]

Figure 7. Industrial Achievable Savings



Customer Supplied Renewable Energy

This component of CPR 2007 addressed a selected number of small-scale[12] customer-supplied renewable energies (CSRE). They include solar photovoltaic (PV), wind electric, micro hydro, solar hot water and space heating and biomass space heating systems. The potential reductions in purchased electricity from the use of CSRE technologies was estimated to be between 409 GWh/yr. and 102 GWh/yr. by F2026 in, respectively, the Upper and Lower Achievable Potential scenarios.

The study concluded that solar PV electric represents the most significant opportunity for small-scale CSRE. At the time of this study, none of the solar PV electric technologies passed the economic screen. However, PV technology improvements and cost reductions are expected over the 20-year study period. Consequently, for the purposes of this study, it was assumed that

[10] Industry constraints related to factors such as facility layout, business uncertainty, production impacts and changes to product mixes may affect the potential savings estimates and are beyond the influence of BC Hydro.
[11] Opportunities related to increasing self-generation through the consumption of additional fuel were not considered.
[12] Small-scale was defined as suitable for application at the level of an individual residential dwelling or commercial facility that is connected to the BC Hydro grid.

PV systems would become economic in the last quarter of the study period. The study did not attempt to predict any large step-type advancements in technology or changes in price.

Solar space heat and hot water systems are both estimated to have small potential over the study period. However, only solar thermal systems with collector areas greater than 100 m^2 currently meet the study's economic criteria. In contrast to solar PV electric, these technologies are relatively mature and, therefore, only modest performance and cost improvements were assumed over the study period.

Behaviour Savings

This component of CPR 2007 addressed the major behaviours that can affect electric energy use and peak loads in B.C.'s Residential and Commercial sectors.[13] These measures represent energy savings realized through the actions (behaviors) of individuals to habitually save energy within their daily routine, without reducing the level of energy service provided (e.g., light levels, space heat temperature, size of home, etc.). For the Residential sector, these focus on the actions that all household members can take to reduce electricity consumption without affecting their quality of life. For the Commercial sector, they focus on the activities that employees can take in their daily routines that will reduce electricity consumption but not productivity.

There are a wide range of possible behaviors that residents and employees can undertake to reduce the usage of electricity in buildings. The project started with a long list of possible behaviors, which was narrowed to 25 behaviors that affect the major end uses in the Residential sector and 15 in the Commercial sector.

The study found that in the Residential sector, the Upper and Lower Achievable Potential for electrical efficiency behaviors would provide between 1,377 GWh/yr. and 720 GWh/yr. of electricity savings by F2026. Behaviors related to computers, domestic hot water use, lighting and space heating showed the greatest potential for electricity savings.

In the Commercial sector, the Upper and Lower Achievable Potential for electrical efficiency behaviors would provide between 548 GWh/yr. and 410 GWh/yr. of electricity savings by F2026. Behaviors related to lighting and plug loads showed the greatest potential for electricity savings.

Lifestyle Savings

This component of CPR 2007 addressed the potential for lifestyle changes that could result in reductions in electricity consumption within the Residential sector. In contrast to the behaviour changes, the lifestyle component includes changes that affect the amount of energy service provided (e.g., the amount of lighting used or the size of home). Three potential future scenarios were defined.

The Housing Scenario presents a vision for the next 20 years in which B.C. makes changes towards smart growth and sustainable community design. The scenario focused on wide-scale

[13] CPR 2007 did not consider the Industrial sector as it was agreed that changes in the usage of equipment in this sector would be under management control and hence would be considered as operation and maintenance (O&M).

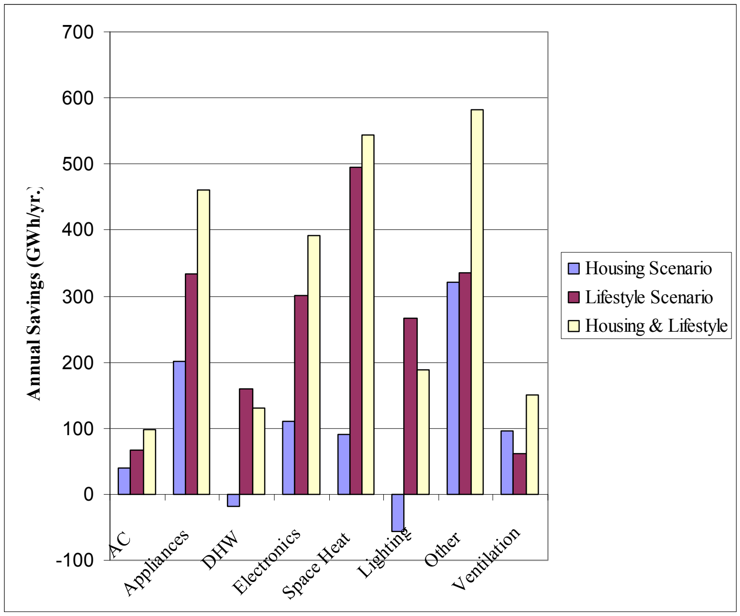
changes to the types of housing that are developed to meet the demand of a growing and changing population.

The Lifestyle Scenario focuses on changes that B.C. residents could make to their lifestyles in the home. The scenario focused on end uses and measures where lifestyle changes could reduce electricity use most significantly, such as reduced thermostat temperatures in the winter or reduced reliance on air conditioning in the summer.

The Housing and Lifestyles Scenario combines the changes contained in the Housing and Lifestyle Scenarios.

A summary of results is presented in Figure 8. The combined Housing and Lifestyle Scenario resulted in electric energy savings of 2,545 GWh/yr. by F2026, or about 11% relative to the Residential Reference Case. On its own, the Housing Scenario provided savings of about 786 GWh/yr. by F2026 while the Lifestyle Scenario provided electric energy savings of about 2,017 GWh/yr. in the same period. While significant electric energy savings occurred in all three scenarios, the analysis showed some unexpected results. For example, the Housing Scenario includes a shift to more compact housing, such as apartments and row houses. However, in B.C., these housing types are more likely to use electricity rather than natural gas for space heating. Consequently, part of the electricity savings from the reduced space heating load in these more compact housing types were offset by the greater share of space heating provided by electricity. Similarly, as shown in Figure 8, domestic hot water (DHW) and lighting end uses both increased modestly in the Housing Scenario. The DHW increase occurred because electricity is more commonly used for hot water heating in B.C.'s apartments, and the Housing Scenario assumes a greater share of apartments than in the Reference Case. The lighting end use also increased modestly in the Housing Scenario as apartment lighting for hallways, stairwells, lobbies and parking areas tends to have longer operating hours compared to single-family homes.

Figure 8. Lifestyle Scenarios – Annual Electricity Savings (GWh/yr.), F2026



Conclusions

The results of CPR 2007 confirm that a CPR is an essential step in energy planning. When conducted in a collaborative manner that involves both key utility DSM program personnel and external utility stakeholders, the CPR results not only guide the question of how much DSM should be included in the energy plan, they also begin the process of building greater understanding and cooperation among the varied stakeholder perspectives. While such a study may initially appear to be expensive, its cost is a very small fraction of the value gained through being able to optimize an energy plan by including all cost-effective DSM.

This study confirmed that the target of meeting 50% of B.C.'s future electricity growth through conservation, as set out in the BC Energy Plan, is achievable. The CPR's results along with other inputs will provide a sound basis for BC Hydro's DSM Plan, which in turn, will feed into the Integrated Electricity Plan (IEP). It is expected that the additional cost-effective conservation found in this study will reduce the cost of the next IEP by hundreds of millions of dollars. CPR 2007 also informs program development by Power Smart marketing, the provincial government and other stakeholder groups both inside and outside of B.C. needing to assess the potential for a specific market.

In short, CPR 2007 shows that there are huge savings available that make economic sense. However, to achieve these savings, new and expanded action is required; below are some of our thoughts in that direction.

Create a Conservation Culture

BC Hydro's goal is to develop and foster a conservation culture in B.C. that leads to customers choosing to make a dramatic and permanent reduction in electricity intensity—a visionary approach to energy use that will minimize the impact on the environment and ensure the province's electricity needs are met. BC Hydro wants British Columbians to move toward this new vision. Success in this new vision is defined as BC Hydro's domestic sales in 2027 will be no more than its domestic sales in 2007 while providing for a robust economy and population growth.

Think Beyond Technical Solutions

Although the largest savings continue to come from technology-related measures, the CPR results clearly show that meeting aggressive energy saving targets requires going beyond traditional technology solutions. The results of the Lifestyle and Behaviour analysis in CPR 2007 show that these components have a critical contribution to make to increased levels of energy savings. Efficient lifestyle and product choices can reduce electricity used in the home significantly. Commercial buildings can cut electricity use through efficient integrated design and operation, and more again is possible with integrated customer-side generation. Living green at home and working green is really about smart, integrated, efficient building design and using resources with respect.

Engage Others in Finding Solutions

Many of the energy saving opportunities identified in CPR 2007 are beyond the sole influence of any one utility. While BC Hydro is in a unique position to act as a catalyst for change in B.C., it cannot do it alone. To accomplish its new vision for British Columbia, BC Hydro must engage and work together with British Columbia's consumers, businesses and communities. Ultimately, if British Columbia is to meet its energy savings targets, efficiency and conservation must become a way of life and a way of doing business.

British Columbia now has the opportunity to join the world leaders in conservation and sustainability. We all contribute to the environmental problems of the world and it's now time for us to be leaders in the solutions.

References[14]

Marbek Resource Consultants. November 2007. *BC Hydro 2007 Conservation Potential Review Summary Report: The Potential for Electricity Savings In British Columbia 2006-2026*, Prepared for BC Hydro.

[14] A detailed list of references is contained in each of the reports, which are available from BC Hydro.