# BC Hydro Conservation Potential Review 2002

Summary Report
(Base Year: Fiscal 2000/01)

*Electricity Conservation Potential In BC Hydro's Service Area*

May 2003

# Contents

# Acknowledgements

Completion of the Conservation Potential Review 2002 on an accelerated time table is due in no small part to the consistent input from many BC Hydro staff members, as well as the hard work of the consultants engaged by BC Hydro.

## BC HYDRO CORE GROUP

The heaviest work load fell on the Conservation Potential Review Core Group, which oversaw the management of the effort. The Group consisted of the following members:

- Murray Bond – Quality Assurance Implementation, Power Smart Quality Assurance
- Dorell Carlson – Senior Resource Planning Specialist, Energy Planning
- Derek Henriques – Manager, Power Smart Quality Assurance & Evaluation
- Dennis Nelson – Manager, Business Systems Group
- John Oliver – Load Forecast Policy Analyst, Market Forecast
- Paul Robillard – Lead Consultant, Marbek Resource Consultants, Ltd., Ottawa
- Nancy Cooley – CPR Coordinator for BC Hydro – Nancy J. Cooley & Associates, Victoria

## OTHER BC HYDRO STAFF

In addition, there were many who provided reviews of draft reports and participated in periodic meetings and conference calls. These individuals included the following BC Hydro staff. All are from Power Smart, unless otherwise identified.

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## EXTERNAL REVIEW PANEL

A number of organizations in B.C. also agreed to serve on an External Review Panel. They reviewed and commented on draft reports. However, their participation on the Panel should not be construed as indicating agreement with, or endorsement of, any of the CPR 2002 reports. Members of the Panel include:

Canadian Home Builders' Association of B. C.
B.C. Public Interest Advocacy Centre – Michael Doherty and Dick Gathercole
Building Owners' and Managers' Association – Paul LaBranche
Joint Industry Electric Steering Committee – Lorne Grasley, Dal Scott, Lisa Doig and Dan Potts
Kootenay-Okanagan Electric Consumers' Association – Fred Marsh
Pembina Institute for Appropriate Development – Roger Peters
Sierra Club of B.C. – Tom Hackney, Bo Martin and Michael Mascall
David Suzuki Foundation – Dermot Foley
Union of B.C. Indian Chiefs – David Hunt and Don Bain

## CONSULTANTS

The Conservation Potential Review 2002 was undertaken by a team of consultants headed by Marbek Resource Consultants, Ltd. of Ottawa, Ontario. Consultants and sub-consultants were:

- **Residential sector:** Marbek Resource Consultants conducted the research, modelling and analysis of the residential sector, with the assistance of The Sheltair Group Inc., of Vancouver, B.C., and Dr. Edward Vine of the Lawrence Berkeley National Laboratory, of Berkeley, California.
- **Commercial sector:** Marbek Resource Consultants conducted the research, modelling and analysis of the commercial sector, with the assistance of Prism Engineering Ltd., of Burnaby, B.C.; EnerSys Analytics Inc., of Coquitlam B.C.; and Dr. Edward Vine of the Lawrence Berkeley National Laboratory, of Berkeley, California.
- **Industrial sector:** Willis Energy Services Ltd, of Vancouver, B.C. conducted the research, modelling and analysis of the industrial sector with assistance from BC Research Inc. of Vancouver, B.C.; CWA Engineers Inc., of Burnaby, B.C.; J & C Nyboer, of Surrey, B.C.; and Demand Side Energy Consultants, Inc. of Winnipeg, MB. Marbek Resource Consultants provided analytic design and ensured that research methods and reporting in the industrial sector were consistent with those in other sectors.

This summary of the Conservation Potential Review 2002 was written by Richard Banner of Polestar Communications Inc., of Burnaby, B.C.

The CPR effort was coordinated by Nancy J. Cooley of Nancy J. Cooley & Associates: Embracing Change Creatively, Inc. of Victoria. B.C., who provided day-to-day management and the contact point and interface for all participants.

# *Introduction*

## BACKGROUND AND OBJECTIVES

In 1991, BC Hydro launched a study to estimate the potential for electricity conservation in its British Columbia service area. The result was an in-depth analysis of where, how and at what cost energy efficiency and behavioural changes could reduce electricity consumption in British Columbia[1]. A decade later, continued provincial load growth as well as increasing environmental concerns have led to renewed interest in energy efficiency. In light of that interest, and in support of a new set of Power Smart initiatives, BC Hydro decided to undertake a new Conservation Potential Review (CPR).

The new study had the following objectives:

- To provide BC Hydro's Power Smart program planners with an updated assessment of the remaining hard-wired electricity efficiency potential in B.C. as a basis for designing new initiatives (Hard-wired measures are those that are not dependant upon repeated customer behaviour to be effective. From a utility's perspective they provide savings that are reliable and persistent.);
- To estimate the potential contribution of Power Smart efficiency programs to the reduction of BC Hydro's peak capacity requirements; and
- To identify additional technologies that could become available during the study period.

## SCOPE

BC Hydro initially expected that the scope of the current study would directly follow the structure and approach of the original Conservation Potential Review. However, the context has altered significantly in the ten years since the original Review:

- Electricity markets throughout North America have changed radically as a result of moves towards deregulation and privatization;
- Better energy-use data for buildings, equipment and industrial processes are available;
- Computer modelling tools for simulating energy use are more sophisticated; and

[1] Electricity Conservation Potential Review, 1988-2010: Summary Report, Phase 1: Unconstrained Potential (1993); Achievable Conservation Potential in British Columbia Through Technological and Operating Change: Final Report (1994); Conservation Potential Through Lifestyle Change: Final Report (1994).

- North American utilities have an additional 10 years' experience in the design, promotion and implementation of demand management programs to draw upon.

With limited resources available, BC Hydro decided to focus on areas that would best assist its staff with the planning and design of new Power Smart initiatives and rates. Hydro also intends that the results of this study have a good "shelf life" for resource planning purposes. (Note that the results of the current study are not directly comparable with the results of the original Review; further discussion of this point follows on page 6.)

**Sector Coverage:** The new study addresses three sectors: Commercial/Institutional, Residential and Industrial. In this report, use of the word "commercial" includes both commercial and institutional buildings unless otherwise noted. More specific descriptions of each sector are included in the appropriate section.

**Geographical Coverage:** The report studies the total BC Hydro service area, but excludes areas that are not integrated into BC Hydro's grid system. It also excludes the (former) West Kootenay Power service area. Where feasible, the study breaks out the results for the three regions of the BC Hydro service area:

- Vancouver Island, including all of Vancouver Island plus the Gulf Islands, which get their electricity supply from Vancouver Island;
- the Lower Mainland, including the Lower Mainland of BC, the Fraser Valley as far east as Hope, the Sunshine Coast and Powell River; and
- the Interior including the remainder of BC Hydro's service area, the southern Interior minus the area served by the former West Kootenay Power, the central interior and the northern interior regions.

**Study Period:** The study covers a 15-year period. The base year is the fiscal year (FY) 2000/01, with milestone periods at 5-year increments: 2005/06, 2010/11 and 2015/16. The base year of FY 2000/01 was selected because it was the most recent 12-month period for which complete data were available. BC Hydro's fiscal year extends from April 1 to March 31.

**Technologies:** The study focuses on estimating the Economic and Achievable potentials of technologies that increase electricity efficiency and that will be commercially viable by the year 2005. It also identifies and describes other technologies that are likely to become available within the remainder of the study period (to 2015/16). Other technologies that control or shift electrical demand (such as direct load control technologies and thermal storage) or that represent alternative sources of supply (such as solar energy and district cooling using sea water) are outside of the scope of this study.

**Line losses:** All electricity savings reported in all of the scenarios are measured at the customer's meter. This approach is consistent with the calibration of base year consumption, which is based on BC Hydro customer sales as measured at the customer's meter. Line losses were only used twice in the study:

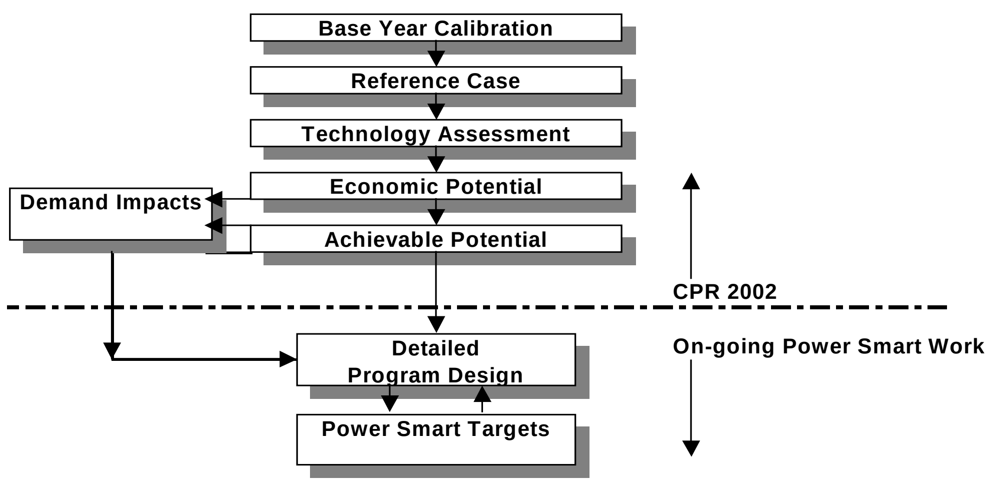
- Line losses are included in the calculation of the Cost of Conserved Energy (CCE, discussed in the next section), because the Cost of Conserved Energy is measured as the avoided cost of new supply at the regional distribution point.
- Line losses were also included in calculating the demand impact of customer savings on the BC Hydro system.

Tables and graphs are footnoted when line losses were calculated separately.

## ANALYTICAL APPROACH

Figure 1 summarizes the major steps involved in the analysis. They are defined and discussed in the following paragraphs. As illustrated, the results of this Conservation Potential Review (CPR 2002), and in particular the estimation of Achievable Potential, support on-going Power Smart work. However, the estimates of Achievable Potential are not Power Smart targets and they affect the design of Power Smart programs only as one of several factors that planners consider.

**Figure 1**
**Study Approach**
**- Major Analytical Steps -**




### *Major Analytic Steps and Definitions*

The key steps in the Conservation Potential Review 2002 are the following:

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

The Base Year (2000/01) 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. The study consultants used BC Hydro's billing data to verify the accuracy of the macro models they use to project future electrical use.

***Step 2: Develop Reference Case***

The Reference Case is the result of macro modelling that estimates the expected level of electricity consumption that would occur over the study period with no new (post 2000/01) Power Smart initiatives. The Reference Case includes projected increases in electricity consumption based on expected rates of population and economic growth, using the growth rates included in BC Hydro's 2000 Forecast[2]. The Reference Case also makes an estimate for "natural" conservation, that is, conservation that occurs without utility programs like Power Smart. The Reference Case provides the point of comparison for the calculation of "economic" and "achievable" electricity savings potentials.

***Step 3: Develop and Assess Energy Efficiency Upgrade Options***

The consultants researched new technologies and practices that experts believe will be commercially available in the province by 2005. They assessed how much electricity the technology could save and the expected cost, including purchase (capital), operating and maintenance costs. The consultants then used a formula to produce a value for cost per year per kilowatt-hour of saved electric energy, referred to as Cost of Conserved Energy (CCE). CCE is calculated as the annualized incremental cost (including operating and maintenance) of the measure divided by the annual kilowatt-hour savings achieved, excluding any administrative or program costs to achieve full use of the measure. Applying this formula allowed the consultants to compare a standardized cost for new technologies with the cost of new electricity supply, or other electricity-conserving technologies, and to determine whether or not to include the technology in the forecast of Economic Potential.

***Step 4: Estimate Economic Energy Savings Potential***

To forecast the potential electricity savings that are defined as economic, the consultants used macro models to calculate the level of electricity consumption that would occur if B.C. residents installed all "cost-effective" technologies. "Cost-effective" for the purposes of this study means that the CCE is less than or equal to six cents per kilowatt-hour.

BC Hydro's Energy Planning Group recommended that the Conservation Potential Review team use a levelized cost of $0.06/kWh to assess which measures to promote customer efficiency (Demand-Side Management or DSM measures) are economic. When the 1991/1994 Review was conducted, the avoided cost, or long-run marginal cost, was based on the cost of new large hydroelectric facilities. Today, planners expect the long-run marginal cost to be based on the cost of new efficient gas-fired Combined Cycle Gas Turbines (CCGT). The unit energy cost of CCGT supply is significantly determined by the long-run marginal cost of natural

[2] Electric Load Forecast 2000/01 – 2020/21, BC Hydro Market Forecast. Vancouver, B.C.: December 2000.

gas. Current estimates are that the cost of new supply is $0.055/kWh at the Lower Mainland load centre. However, $0.06/kWh was recommended for use in the CPR to allow a slightly more liberal screening of DSM measures for further assessment. BC Hydro does not consider the costs associated with a particular project, designed to meet specific needs, to be useful in screening categories of possible DSM measures in this Review. Using $0.06/kWh gives BC Hydro's Power Smart program planners a more robust set of data to work with as they go through the process of bundling measures into Power Smart programs. Using $0.06/kWh also ensures that the results of this study have a good "shelf life" for Power Smart program planning and resource planning purposes.

The consultants incorporated into the Economic Potential Forecast all of the electric energy efficiency upgrades that the technology assessment found with a CCE equal to or less than $0.06/kWh. BC Hydro's Core Group then reviewed the CCE results to ensure that no technology of consequence was being excluded by the six cents cutoff. They found no significant technologies had been excluded.

***Step 5: Estimate Achievable Electricity 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.

Since it is unrealistic to expect people to adopt all the technologies that are defined as economic within the study period, the consultants met with a number of experts to estimate what proportion of the economic potential that homeowners, tenants, commercial building owners and tenants and industrial producers are likely to install. The consultants grouped related technologies into possible "Actions" such as lighting efficiency improvements, appliance improvements and process upgrades. For each action, they prepared a profile including factors such as likely users, key barriers to use and actions to overcome barriers. Panels of experts assessed the profiles and attempted to agree on the Most Likely and Upper levels of customer participation, based on their experience and knowledge of earlier Power Smart initiatives, results in other areas of Canada and the United States and the openness of customers to energy efficiency investments. The consultants used the experts' opinions to project Most Likely and Upper estimates of electricity savings that might actually be achieved in the study period. The range of estimates from Most Likely to Upper allows for the uncertainty associated with factors such as new programs effectiveness, the state of the economy, Kyoto implications, the level of investment by BC Hydro and so forth, all of which can significantly influence the Achievable Potential.

***Step 6: Estimate Demand Impacts of Economic and Achievable Savings Potential***

In addition to looking at total electric energy use, the consultants reviewed the impact of the various projections on power demand in BC Hydro's electricity supply system. In the context of the Conservation Potential Review 2002, "demand impacts" refers to the average load reduction over the 6 am to 10 pm period during an average weekday in December and January that is anticipated to result from the various electricity saving technologies, programs or actions presented in this Review.

The Conservation Potential Review does not specifically study technologies or strategies to control demand; however, a methodology was developed to estimate how the estimated electricity savings would affect system demand. This information helps forecast future capacity requirements, in addition to the total electricity use that the other projections forecast.

## DIFFERENCES FROM THE 1991/1994 REVIEW

This Conservation Potential Review differs in approach from that of the 1991/1994 Review. The estimated potentials from the original Review were intended to establish what the outside limits of conservation might be if BC Hydro could get 100% of all the technological changes available and projected at the time, and if Hydro could get all its customers to behave in the most electricity conserving manner. Many initiatives to encourage customer efficiency have been undertaken by Hydro and others since the original Review. When Hydro wanted to update its estimates, it was more interested in how much of the remaining potential it could realistically achieve with renewed investment in DSM, rather than what could be achieved through customers changing their behaviour. Consequently, the 2002 Review focuses primarily on so-called "hard-wired" options, that is, those that are affected little or not at all by customer behaviour.

The resulting potential estimates should be read as a reasonable estimate of what BC Hydro could target with new Power Smart programs. Unlike the estimates in the 1991/1994 Review, it cannot be read as an estimate of what the potential pool of conserved electrical energy could be. The latter is much larger than this Review indicates, since it would also include the effects of changes in customers' attitudes and behaviours, in changes to electricity rate structures, and in changes to provincial and federal policies and programs with respect to electricity.

For the 1991/1994 Conservation Potential Review, a Collaborative Committee representing a diverse set of stakeholders established the approach to the analysis of the earlier Review, defined its assumptions and reviewed the work of the consultants. BC Hydro had an immediate need for new DSM estimates when it undertook this study and so pursued the 2002 Review on an accelerated timetable. As a result of the need for speed and the difficulty for stakeholders to devote substantial time to the Review, BC Hydro formed an advisory External Review Panel, rather than a second Collaborative Committee. Members of the Panel, some of whom participated in the original Review, have provided suggestions at various points during the study and have commented on draft reports. However, participation of Panel members should not be interpreted as any form of endorsement of the CPR 2002 results.

As noted previously, the context in which this Conservation Potential Review took place differs from that of the 1991/1994 Review. As a result, several aspects of this Review were changed from the original one. In particular, the following differences affect the results:

- The current Review compares conservation scenario forecasts with a base year and reference case rather than a projection based on “frozen efficiency” as in the 1991/1994 Review.
- To determine cost-effective technologies for the economic projections, the consultants used the same methodology as the original Review, but different terminology to describe it. In both Reviews, program and administrative costs were excluded. Since the Total Resource Cost (TRC) used in the original Review normally includes the program and administrative costs, it was considered clearer to use the term Cost of Conserved Energy (CCE) in the current effort. Adding 0.5 to one cent per kilowatt-hour to the CCE used in this Review would give a rough approximation of the TRC as it is usually calculated.
- The current Review focuses on estimating the potential savings from technologies that will be commercially available by 2005. It identifies other technologies that may be available within the study period, but does not attempt to quantify the potential savings that they might contribute between 2006 and 2015/16.
- The current Review generally does not include the possible effects of attitude or behavioural changes, such as switching off lights, as the original Review did.
- More complete data were available for the current Review than for the original one.
- The current Review includes an estimate of demand effects, which was not undertaken in the original Review.
- The current Review of the commercial sector focuses primarily on large and medium buildings. Electricity savings opportunities for small commercial buildings are presented as ratios derived from the sector as a whole.

**As a result of these differences, readers cannot directly compare the results of the current Review with those of the 1991/1994 Review.** The consultants have made no attempt to do so in this report.

## SUMMARY OF FINDINGS

The Review confirms that significant cost-effective electricity efficiency improvements do exist in every sector in BC Hydro's service area. Table 1 summarizes the total energy savings potential under the Economic and Achievable models compared with the Reference Case. Table 2 summarizes the demand implications of the projections. Figures 2 and 3 present the consumption data and demand implications in graphical form.

**Table 1: Forecast Summary – Total BC Hydro Service Area**
**Annual Electricity Consumption and Potential Savings (GWh/yr)***

| Annual Electricity Consumption (GWh/yr) All Sectors | | | | | | Potential Annual Savings (GWh/yr) | | |
|---|---|---|---|---|---|---|---|---|
| **Milestone Year** | **Base Year** | **Reference Case** | **Economic** | **Achievable** | | **Economic** | **Achievable** | |
| | | | | **Most Likely** | **Upper** | | **Most Likely** | **Upper** |
| **2000/01** | 47,834 | 47,834 | | | | | | |
| **2005/06** | | 49,772 | 42,546 | 48,542 | 47,685 | 7,226 | 1,231 | 2,087 |
| **2010/11** | | 52,727 | 41,920 | 49,272 | 47,470 | 10,807 | 3,455 | 5,257 |
| **2015/16** | | 54,808 | 42,346 | 48,973 | 46,586 | 12,462 | 5,835 | 8,222 |

*Line losses are not included.

**Table 2: Forecast Summary – Total BC Hydro Service Area**
**Demand Implications (MW)* of Economic and Achievable Forecasts**
(High-demand period, winter weekdays from 6 am to 10 pm, December and January)

| Average On-peak Demand (MW) All Sectors | | | | | | Potential On-peak Demand Savings (MW) | | |
|---|---|---|---|---|---|---|---|---|
| **Milestone Year** | **Base Year** | **Reference Case** | **Economic** | **Achievable** | | **Economic** | **Achievable** | |
| | | | | **Most Likely** | **Upper** | | **Most Likely** | **Upper** |
| **2000/01** | 7,167 | 7,167 | | | | | | |
| **2005/06** | | 7,526 | 6,404 | 7,349 | 7,224 | 1,121 | 177 | 302 |
| **2010/11** | | 7,990 | 6,357 | 7,498 | 7,233 | 1,634 | 491 | 754 |
| **2015/16** | | 8,353 | 6,472 | 7,504 | 7,140 | 1,879 | 842 | 1,204 |

*Includes line losses @ 7%. (This includes distribution losses of 4% and area transmission losses of 3%).

**Figure 2: Forecast Summary – Total BC Hydro Service Area**
**Annual Electricity Consumption (GWh/yr)**

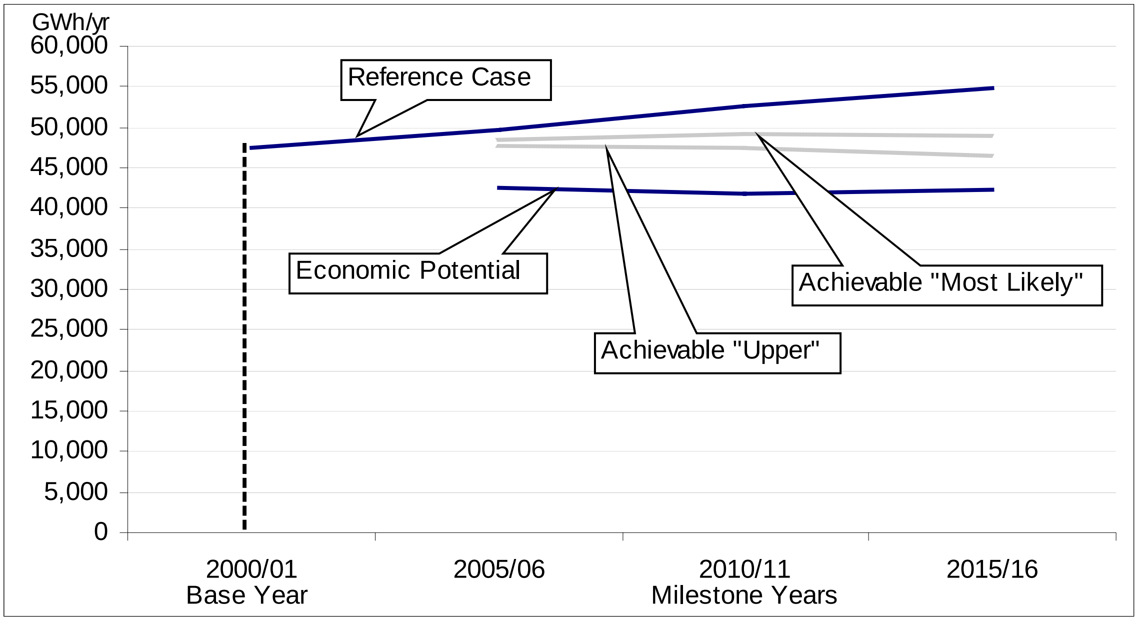



**Figure 3: Forecast Summary – Total Service Area**
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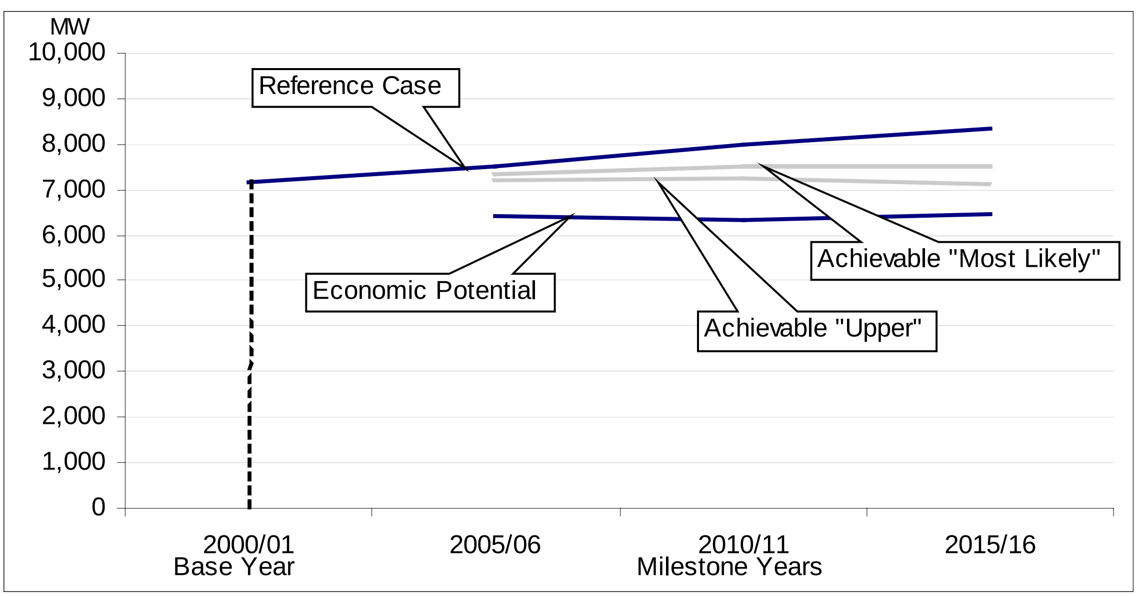



*Includes lines losses @ 7%. (This includes distribution losses of 4% and area transmission losses of 3%).

The Reference case projects annual electricity consumption in all sectors rising from 47,834 GWh per year in FY 2000/2001 to 54,808 GWh per year in FY 2015/16. The Review found that 12,462 GWh per year of electrical efficiency improvements would meet the definition of "economic" by FY 2015/16. By the same year, Achievable Potential ranged from 5,835 GWh per year under the Most Likely scenario to 8,222 GWh per year under the Upper scenario.

The demand implications of the Economic and Achievable projections suggest that demand savings of 1,879 MW could exist by FY 2015/16 under the Economic model. Under the Achievable projections for FY 2015/16, the study found 842 MW considered to be Most Likely and 1,204 MW considered to be the Upper estimate.

**Savings opportunities in the residential sector**
In the residential sector, savings potential is particularly significant in home lighting (which accounts for 39% of the savings in the Economic Potential Forecast), followed by kitchen and laundry appliances (25% of the savings). In the Most Likely and Upper Achievable scenarios, efficiency improvements would provide, respectively, between 1,333 and 2,265 GWh per year of electricity savings by FY 2015/16, as well as demand savings of approximately 234 to 398 MW.

**Savings opportunities in the commercial sector**
In the commercial sector, savings potential is particularly significant in the office and retail segments, followed by universities and colleges. Lighting, more efficient HVAC systems and new high-performance buildings account for nearly 60% of the identified Achievable Savings potential. In the Most Likely and Upper Achievable scenarios, total energy improvements in the commercial sector would provide, respectively, between 1,128 and 1,619 GWh per year of electricity savings by FY 2015/16, as well as demand savings of approximately 172 to 247 MW.

**Savings opportunities in the industrial sector**
Savings potential in the industrial is particularly significant in improvements to pump systems, mechanical pulping systems and steam plants, which together account for 74% of the Most Likely achievable savings. However, they will require a significant amount of specialized engineering and significant capital investment. In the Most Likely and Upper Achievable scenarios, those energy efficiency improvements would provide, respectively, between 3,374 and 4,338 GWh per year of electricity savings by FY 2015/16, as well as demand savings of 436 to 559 MW.

## ADDITIONAL TECHNOLOGIES

The consultants responsible for each sector prepared a brief descriptive report on technologies that did not meet the study criteria, but which could provide additional savings under the appropriate conditions. Magnetic refrigeration, for example, is about 20 per cent more efficient than traditional cooling, and could reduce electricity use in each sector. However, it is still in a prototype stage, and is unlikely to be commercially available in less than 10 years. Although some magnetic refrigeration units could be in use before the end of the study period, they were not studied in detail because they are not expected to be commercially available before 2005.

The consultants did not include these technologies in their models, and they are not included in this summary report, but readers can review the descriptions in section 8 of the full texts of the individual sector reports.

## CAVEATS

As in any study of this type, the results presented in this report are based on a number of important assumptions. Assumptions such as those related to the current penetration of efficient technologies and the rate of future growth in the economy and the stock of buildings are particularly influential. Wherever possible, the assumptions used in this study are consistent with those used by BC Hydro.

This summary describes the key assumptions underlying the report. However, the full text of the individual sector reports contain a number of specific definitions and cautions that could influence the interpretation of the results. Readers should review the full texts before drawing any conclusions based on this summary.

# *The residential sector*

The residential sector includes single family homes, duplexes, row homes, high-rise and low-rise apartment buildings and mobile homes.

Marbek Resource Consultants, of Ottawa, Ontario, conducted the research, modelling and analysis of the residential sector, with the assistance of The Sheltair Group Inc., of Vancouver, B.C., and Dr. Edward Vine of the Lawrence Berkeley National Laboratory, Berkeley, California.

## APPROACH

The consultants used two linked models to analyze ways to increase electrical energy efficiency in the residential sector:

- **HOT-2000,** a commercially-supported residential building energy use simulation model. Hot 2000 was used to define household heating, cooling and domestic hot water (DHW) energy use for each of the residential building archetypes used in this Review. The outputs from HOT-2000 provide the space heating and cooling energy use intensity (EUI) inputs for the Thermal Archetype module of RSEEM.
- **RSEEM** (Residential Sector Energy End-use Model), Marbek's in-house spreadsheet-based macro model, accounted for factors such as the number of dwellings, growth rates, building types and appliance use. RSEEM provided total electricity use for each service region, dwelling type and end use. It also lets the analyst estimate the demand impacts of energy efficiency measures.

Because high-rise apartment buildings have different building characteristics from detached homes and low-rise apartment buildings, the consultants used the modelling procedures developed for the commercial sector to calculate the electricity used to heat and maintain high-rise buildings. However, although the high-rise buildings were modelled with the same model used to analyze the commercial sector, the electricity savings are included in the residential estimates.

The five major steps in the general approach to the study are outlined in the Introduction under the title, Major Analytic Steps and Definitions. Specific procedures for the residential sector were as follows:

**Modelling of Base Year –** The consultants used BC Hydro customer data to break down the residential sector by four factors:

- Type of dwelling [single detached, row house, low-rise apartment (four or fewer stories), high-rise apartment (five or more storeys), etc.];
- Heating category (electric or non-electric heat);
- The age of the building; and
- BC Hydro service region.

Because many apartment buildings use a single meter for multiple apartments, and do not account separately for electricity used in common areas, the consultants calculated the number of units and common-area electricity use on the basis of BC Hydro's data for individually metered units.

To estimate the electricity used for space heating, the consultants factored in building characteristics such as insulation and airtightness using a Canadian "Energuide for Houses" database as well as climate data. They used BC Hydro survey data on supplemental heaters, hot water use and appliances to calculate an average total electricity use per dwelling unit. Comparing their calculated data with actual BC Hydro sales data, they found that the consultants' models produced a very close match.

**Reference case calculations –** For the residential sector, the consultants developed detailed profiles of new buildings for each type of dwelling. They estimated the growth in building stock and estimated the amount of electricity that would be used by existing building stock and by the projected new buildings and appliances. In doing so, they incorporated the energy savings that would be expected to occur naturally due to improvements to thermal characteristics of existing homes and appliances over the study period. As with the Base Year Calibration, the consultants' projection closely matches BC Hydro's own December 2000 forecast of future electricity requirements.

**Assessment of technical options** – The options assessed in order to estimate the economic and achievable potentials included technologies such as:

- Upgrades to the walls, roofs and windows of existing buildings;
- Improved designs for new buildings;
- Improved space heating and cooling equipment;
- Improved ventilation fans and furnace blowers;
- Improved water heaters and devices to reduce hot water use;
- Improved lighting systems; and
- More-efficient household appliances and other plug-in equipment.

**Estimation of demand impacts –** The consultants reviewed BC Hydro's daily and seasonal system demand patterns and, in consultation with BC Hydro personnel, identified the periods of highest (on-peak) electricity demand. The on-peak demand reduction impacts were then derived from the electricity savings for each end use and for the sector as a whole. End use savings in the residential sector that particularly contributed to the on-peak demand savings include: lighting and appliances (about 87% of most likely).

## RESULTS AND FINDINGS

Table 3 summarizes the results of the forecasts of annual electricity consumption and savings in the residential sector by milestone year for BC Hydro's service area. Tables 4a to 4c summarize potential annual savings for individual regions. Figure 4 presents the consumption data for BC Hydro's service area in graphical form. A discussion of the results follows.

**Table 3: Summary of Forecast Results – Residential Sector, Total BC Hydro Service Area Annual Electricity Consumption (GWh/yr)**

| Annual Electricity Consumption (GWh/yr) Residential Sector | | | | | | Potential Annual Savings (GWh/yr) | | |
|---|---|---|---|---|---|---|---|---|
| Milestone Year | Base Year | Reference Case | Economic | Achievable | | Economic | Achievable | |
| | | | | Most Likely | Upper | | Most Likely | Upper |
| **2000/01** | 15,342 | 15,342 | | | | | | |
| **2005/06** | | 16,296 | 14,141 | 16,003 | 15,794 | 2,155 | 293 | 502 |
| **2010/11** | | 17,497 | 14,546 | 16,778 | 16,313 | 2,951 | 719 | 1,184 |
| **2015/16** | | 18,931 | 15,206 | 17,598 | 16,666 | 3,725 | 1,333 | 2,265 |

**Table 4a: Summary of Results – Residential Sector, Lower Mainland Region, Potential Annual Economic and Achievable Electricity Savings (GWh/yr)**

| Potential Annual Savings (GWh/yr) | | | |
|---|---|---|---|
| Milestone year | Economic | Achievable | |
| | | Most Likely | Upper |
| **2005/06** | 1,178 | 173 | 294 |
| **2010/11** | 1,548 | 419 | 684 |
| **2015/16** | 1,913 | 760 | 1,307 |

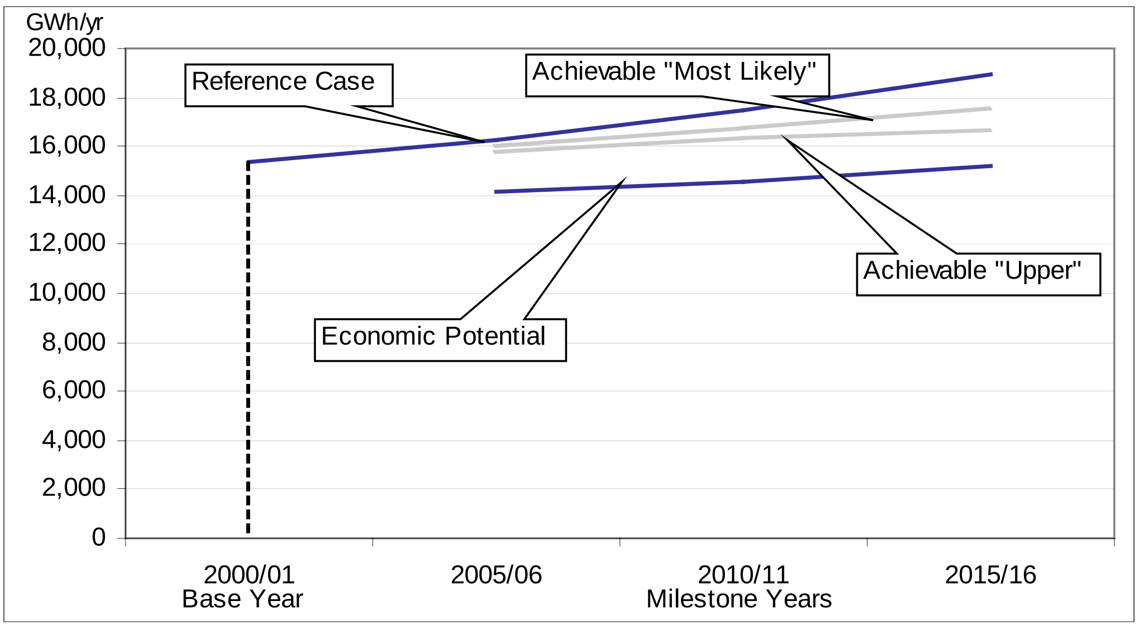
**Table 4b: Summary of Results – Residential Sector, Vancouver Island Region, Potential Annual Economic and Achievable Electricity Savings (GWh/yr)**

| Potential Annual Savings (GWh/yr) | | | |
|---|---|---|---|
| Milestone year | Economic | Achievable | |
| | | Most Likely | Upper |
| **2005/06** | 545 | 63 | 108 |
| **2010/11** | 807 | 155 | 264 |
| **2015/16** | 1,059 | 305 | 507 |

**Table 4c: Summary of Results – Residential Sector, Interior Region, Potential Annual Economic and Achievable Electricity Savings (GWh/yr)**

| Potential Annual Savings (GWh/yr) | | | |
|---|---|---|---|
| Milestone year | Economic | Achievable | |
| | | Most Likely | Upper |
| **2005/06** | 432 | 58 | 100 |
| **2010/11** | 596 | 145 | 237 |
| **2015/16** | 753 | 268 | 451 |

**Figure 4: Forecast Results – Residential Sector, Total BC Hydro Service Area, Annual Electricity Consumption (GWh/yr)**




## *Base Year Electricity Use and Calibration*

In the base year of FY 2000/2001, BC Hydro's residential sector consumed a total of 15,342 GWh per year. Figure 5 shows that heating is the major end use and accounts for 20% of total residential sector electricity use. Lighting is the second-largest end use, accounting for 17% of total electricity use, followed by "Other" (15%), which includes various appliances ranging from coffee makers and toasters to spas and whirlpools.

**Figure 5: Residential Sector, Total BC Hydro Service Area**
**Base Year Electricity Use By End Use**

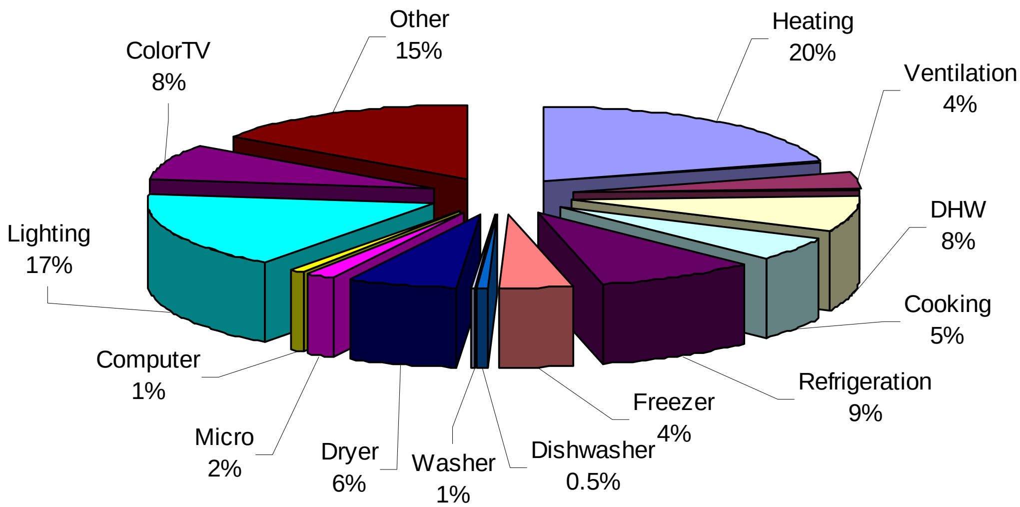
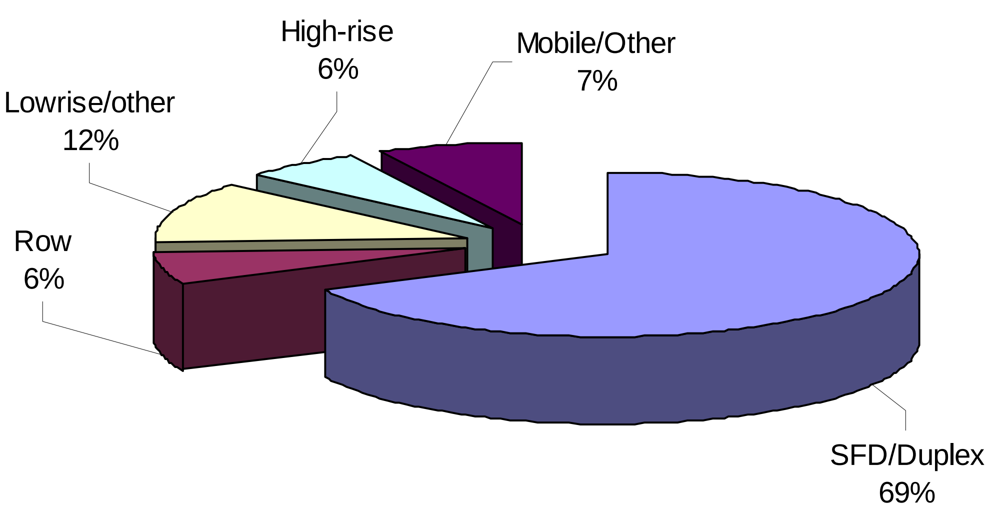



Figure 6 shows the distribution of base year electricity consumption by building segment. As illustrated, single-family detached/duplex dwellings account for the largest share (69%) of residential base year electricity use.

**Figure 6: Residential Sector, Total BC Hydro Service Area**
**Base Year Electricity Use By Building Segment**




## *Reference Case*

With no new Power Smart initiatives but expected rates of population and economic growth, the Review estimated that electricity consumption in the residential sector will grow to 16,296 GWh per year by FY 2005/06, to 17,497 GWh per year by FY 2010/11 and to 18,931 GWh per year by FY 2015/16. This represents an overall growth of about 23% in the period. It compares very closely with BC Hydro's own December 2000 forecast, which also includes consideration of the impacts of "natural conservation" – that is, conservation that is not stimulated by utility programs.

The number of residential units will grow as the province's population increases and only a small number of existing buildings are replaced. New buildings and renovated older buildings will have more insulation and more efficient equipment than existing buildings, but they will tend to be larger, with more windows. Natural conservation is expected to have the most impact on kitchen and laundry appliances such as refrigerators, freezers, washers and dryers, as homeowners replace existing appliances with more efficient new ones.

### *Economic Potential Forecast*

If all the technologies that were defined as "economic" under the conditions of the Economic Potential Forecast were adopted, the Review estimates that electricity consumption in the residential sector would grow to 15,206 GWh per year by FY 2015/16. Annual savings compared to the Reference Case are 3,725 GWh per year or about 20%. The Economic Potential annual savings in the remaining milestone years are 2,951 GWh per year in 2010/11 and 2,155 GWh per year in 2005/06. Efficient lighting accounts for 39% of total economic potential savings, while more-efficient appliances account for 25% of the total identified. Hot water systems, space heating systems and other electricity uses each account for about 10% of the identified savings.

The Vancouver Island region could achieve a larger share of the savings potential than other regions because electric space and water heating are more common there. Most of the savings occur in the first five years of the projection because many of the upgrades are economically attractive at their full replacement cost.

### *Achievable Potential Forecast*

The electricity savings opportunities that the consultants grouped into "Actions" are presented in Table 5 by Action and by milestone year, showing the different outcomes for the Most Likely and Upper scenarios. The most significant Achievable Savings opportunities came from lighting and appliances, with a substantial potential in the longer term for improved weatherization of homes, reduced standby losses from electronic equipment and appliances, and more efficient blower motors on fans and furnaces.

**Table 5: Residential Buildings, Total BC Hydro Service Area Summary of Achievable Savings, by Action and Milestone Year**

| Action | Annual Energy Savings (GWh/yr) by Milestone Year | | | | | |
|---|---|---|---|---|---|---|
| | 2005/06 | | 2010/11 | | 2015/16 | |
| | Most Likely | Upper | Most Likely | Upper | Most Likely | Upper |
| R1 – Lighting | 185 | 308 | 400 | 666 | 650 | 1,300 |
| R2 – Appliances | 101 | 176 | 273 | 417 | 502 | 696 |
| R3 – Water Heating | 1 | 2 | 1 | 2 | 2 | 4 |
| R4 – Efficient New Apartments | 0 | 0 | 2 | 3 | 8 | 11 |
| R5 – Blower Motors | 1 | 1 | 14 | 25 | 70 | 85 |
| R6 – Heat Pumps | 1 | 2 | 3 | 5 | 6 | 12 |
| R7 – Weatherization | 5 | 11 | 10 | 33 | 47 | 62 |
| R8 – Standby Losses | 0 | 3 | 15 | 31 | 47 | 93 |
| **Totals** | **293** | **502** | **719** | **1,184** | **1,333** | **2,265** |

Overall, Achievable savings by FY 2015/16 represent approximately 37% of the Economic Potential savings in the Most Likely scenario and 62% of the Economic Potential savings in the Upper scenario. The gap between Achievable and Economic Potential results from the fact that Economic Potential savings are based on BC Hydro's investment criteria and from the assumption that all technologies defined as "economic" would be adopted. Homeowners and tenants, however, use many other decision factors when they purchase new technology, so the likely Achievable Savings are lower than those defined as "economic."

## *Demand Impacts of Energy Efficiency Measures*

While the 2002 Conservation Potential Review did not focus on demand reduction, it did estimate the expected demand impacts of the estimated electric energy savings.

Compared to the Reference Case, demand savings in the Economic Potential Forecast are 427 MW in FY 2005/06, rising to 560 MW and 690 MW in, respectively, FYs 2010/11 and 2015/16. Achievable Potential demand savings in FY 2005/06 range from 51 MW (Most Likely) to 88 MW (Upper). By FY 2015/16, Achievable Potential demand savings range from 234 MW (Most Likely) to 398 MW (Upper).

Projections for individual regions closely follow the pattern of the total service area. Table 6 summarizes the forecasts for BC Hydro's total service area, as well as for individual regions. The consultants found no significant differences among BC Hydro service regions except for minor differences in economic potentials.

**Table 6: Residential Sector, Total BC Hydro Service Area**
**Demand Implications (MW)* for Economic and Achievable Forecasts**
**vs. Reference Case by Service Region and Milestone Year**
(High-demand period, winter weekdays from 6 am to 10 pm, December and January)

| Service Region | Milestone Year | Average On-peak Demand | | Potential On-peak Demand Savings Relative to Reference Case | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Reference Case (MW) | Economic Potential (MW) | Economic | | Achievable Most Likely | | Achievable Upper | |
| | | | | MW | % | MW | % | MW | % |
| Total BC Hydro | Base Year | 2,664 | | | | | | | |
| | 2005/06 | 2,843 | 2,415 | 427 | 15% | 51 | 2% | 88 | 3% |
| | 2010/11 | 3,064 | 2,504 | 560 | 18% | 126 | 4% | 207 | 7% |
| | 2015/16 | 3,323 | 2,633 | 690 | 21% | 234 | 7% | 398 | 12% |
| | | | | | | | | | |
| Lower Mainland | Base Year | 1,406 | | | | | | | |
| | 2005/06 | 1,501 | 1,263 | 237 | 16% | 28 | 2% | 49 | 3% |
| | 2010/11 | 1,612 | 1,314 | 299 | 19% | 67 | 4% | 111 | 7% |
| | 2015/16 | 1,748 | 1,388 | 360 | 21% | 122 | 7% | 208 | 12% |
| | | | | | | | | | |
| Vancouver Island | Base Year | 702 | | | | | | | |
| | 2005/06 | 747 | 642 | 104 | 14% | 13 | 2% | 21 | 3% |
| | 2010/11 | 812 | 665 | 148 | 18% | 33 | 4% | 55 | 7% |
| | 2015/16 | 885 | 696 | 189 | 21% | 64 | 7% | 109 | 12% |
| | | | | | | | | | |
| Interior | Base Year | 556 | | | | | | | |
| | 2005/06 | 595 | 510 | 86 | 14% | 10 | 2% | 18 | 3% |
| | 2010/11 | 639 | 526 | 113 | 18% | 26 | 4% | 42 | 7% |
| | 2015/16 | 690 | 549 | 140 | 20% | 48 | 7% | 81 | 12% |

*Includes line losses @ 7%. (This includes distribution losses of 4% and area transmission losses of 3%).

It should be emphasized that the CPR 2002 is not a demand study. Rather, the focus in this component of the Review is on demand impacts of the electric energy efficiency measures contained in the Economic and Achievable Potential forecasts. Numerous other technologies and load control strategies could be used to reduce demand requirements. However, they are beyond the scope of this study.

## SUMMARY OF FINDINGS

The study confirms that significant cost-effective electricity efficiency improvements do exist in B.C.'s residential sector. In the Most Likely and Upper Achievable scenarios, those efficiency improvements would provide, respectively, between 1,333 and 2,265 GWh per year of electricity savings by FY 2015/16, as well as demand savings of approximately 234 to 398 MW.

In the residential sector, savings potential is particularly significant in home lighting (which accounts for 39% of the savings in the Economic Potential Forecast), followed by kitchen and laundry appliances (25% of the savings).

Readers are referred to a number of caveats throughout the full text of the individual sector reports.

# *The commercial sector*

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. Throughout this report, use of the word “commercial” includes both commercial and institutional buildings unless otherwise noted. The commercial sector also includes some non-building electricity uses such as transportation, but they were not modelled in this study.

This study of the commercial sector focuses primarily on large buildings, as they represent a strong potential for electricity conservation. Street lighting and traffic and pedestrian signals, which are significant “institutional” electricity uses, are not included because they can easily be assessed from BC Hydro billing statistics and conservation strategies can be developed from that information.

Marbek Resource Consultants, of Ottawa, Ontario, conducted the research, modelling and analysis of the Commercial sector, with the assistance of Prism Engineering Ltd., of Burnaby, B.C.; EnerSys Analytics Inc., of Coquitlam B.C.; and Dr. Edward Vine of the Lawrence Berkeley National Laboratory, Berkeley, California.

## APPROACH

Marbek used two linked energy use models to analyze opportunities to increase electrical energy efficiency in the commercial sector:

- **CEEAM** (Commercial Energy and Emissions Analysis Model) is a Marbek simulation model, developed in conjunction with Natural Resources Canada for modelling energy use in commercial-institutional building stock. **CEEAM** was used to develop commercial energy end-use intensities (EUIs) for each of the commercial and institutional building archetypes.
- **CSEEM** (Commercial Sector Energy End-use Model) is a Marbek spread-sheet based macro model. It integrates data on floorspace growth projections in the commercial sector, and the energy used in different types of buildings to produce an estimate for the sector as a whole.

The two models have been used in a variety of national and international studies. They include elements that account for seasonal variations and interactive factors such as changes in heating needs when light sources change.

As noted in the Introduction, differences in the approach and available data between this Review and the 1991/1994 Review prevent direct comparison between the two. Key differences in the approach to the study of the commercial sector include:

- The current Review focuses primarily on large and medium customers; and
- The small commercial subsector was not modelled separately. Electricity savings opportunities are presented as ratios derived from the sector as a whole. Small commercial includes both building and non-building electricity uses.

The five major steps in the general approach to the study are outlined in the Introduction under the title, Major Analytic Steps and Definitions. Specific procedures for the commercial sector were as follows:

**Modelling of Base Year –** Marbek first established data describing the base year, FY 2000/01, including "where" and "how" electricity is currently used in existing commercial buildings. They created building energy use simulations for each of 15 large and medium types of building and calibrated the models to reflect actual BC Hydro customer sales data. They derived estimated savings for the "Small Commercial" and the "Other" categories from the results of the modelled segments. They did not directly model those categories because they are extremely diverse and difficult to design effective conservation programs for. Consequently, the modelling effort was concentrated in commercial segments where programs to reduce consumption were more likely to meet success.

**Reference case calculations –** For the commercial sector, Marbek developed detailed profiles of new buildings in each of the building segments, estimated the growth in building stock, and estimated "natural" changes affecting electricity consumption over the study period.

**Assessment of technical options** – The options assessed in order to estimate the economic and achievable potentials included technologies such as more efficient lighting and office equipment, improved construction in new buildings, and upgraded heating, ventilating and cooling systems.

**Estimation of demand impacts –** The consultants reviewed BC Hydro's daily and seasonal system demand patterns and, in consultation with BC Hydro personnel, identified the periods of highest (on-peak) electricity demand. The on-peak demand reduction impacts were then derived from the electricity savings for each end use and for the sector as a whole. End use savings that particularly contributed to the on-peak demand savings in the commercial sector include lighting, high performance new buildings and small commercial retrofit and design (about 80% of most likely).

## RESULTS AND FINDINGS

Table 7 summarizes the results of the forecasts of annual electricity consumption and savings in the commercial sector by milestone year for BC Hydro's service area. Tables 8a to 8c summarize potential savings for individual regions. (Numbers in Tables 8a to 8c do not necessarily add up to those in Table 7 due to rounding.) Figure 7 presents the consumption data for BC Hydro's service area in graphical form. A discussion of the results follows.

**Table 7: Summary of Forecast Results – Commercial Sector, Total BC Hydro Service Area Annual Electricity Consumption and Potential Savings (GWh/yr)**

| Annual Electricity Consumption (GWh/yr) Commercial Sector | | | | | | Potential Annual Savings (GWh/yr) | | |
|---|---|---|---|---|---|---|---|---|
| **Milestone Year** | **Base Year** | **Reference Case** | **Economic** | **Achievable** | | **Economic** | **Achievable** | |
| | | | | **Most Likely** | **Upper** | | **Most Likely** | **Upper** |
| **2000/01** | 12,739 | 12,739 | | | | | | |
| **2005/06** | | 14,314 | 12,155 | 14,124 | 13,918 | 2,159 | 191 | 396 |
| **2010/11** | | 16,185 | 13,431 | 15,600 | 15,170 | 2,754 | 585 | 1,015 |
| **2015/16** | | 18,056 | 14,984 | 16,928 | 16,437 | 3,072 | 1,128 | 1,619 |

**Table 8a: Summary of Forecast Results – Commercial Sector, Lower Mainland Potential Annual Electricity Savings (GWh/yr)**

| Potential Annual Savings (GWh/yr) | | | |
|---|---|---|---|
| **Milestone year** | **Economic** | **Achievable** | |
| | | **Most Likely** | **Upper** |
| **2005/06** | 1,481 | 130 | 271 |
| **2010/11** | 1,952 | 415 | 719 |
| **2015/16** | 2,190 | 804 | 1,154 |

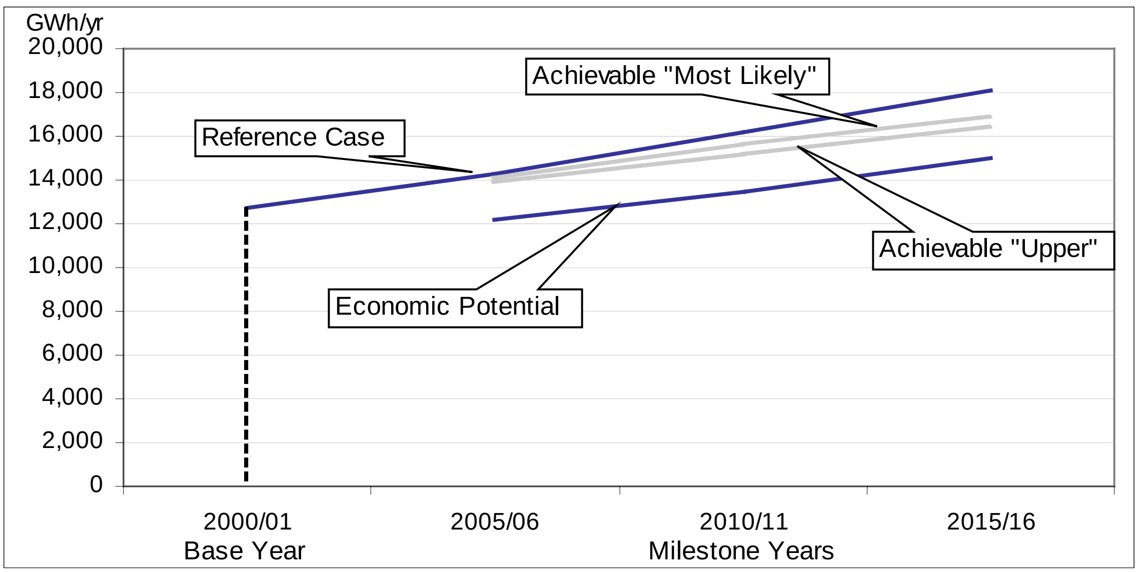
**Table 8b: Summary of Forecast Results – Commercial Sector, Vancouver Island Potential Annual Electricity Savings (GWh/yr)**

| Potential Annual Savings (GWh/yr) | | | |
|---|---|---|---|
| **Milestone year** | **Economic** | **Achievable** | |
| | | **Most Likely** | **Upper** |
| **2005/06** | 326 | 28 | 59 |
| **2010/11** | 397 | 84 | 146 |
| **2015/16** | 438 | 161 | 231 |

**Table 8c: Summary of Forecast Results – Commercial Sector, Interior**
**Potential Annual Electricity Savings (GWh/yr)**

| Potential Annual Savings (GWh/yr) | | | |
|---|---|---|---|
| Milestone year | Economic | Achievable | |
| | | Most Likely | Upper |
| **2005/06** | 352 | 31 | 64 |
| **2010/11** | 405 | 86 | 149 |
| **2015/16** | 444 | 162 | 233 |

**Figure 7: Graphic of Forecast Results – Commercial Sector, Total BC Hydro Service Area**
**Annual Electricity Consumption (GWh/yr)**




## *Base Year Electricity Use and Calibration*

In the base year of FY 2000/2001, BC Hydro's commercial sector consumed 12,739 GWh per year. Figure 8 shows that lighting is the major end use and accounts for 49% of electricity used in commercial buildings. (Commercial buildings account for 80% of the sector's electricity usage.) Heating, ventilating and air conditioning (HVAC) comprise the second-largest end use, accounting for 17% of total electricity use, followed by office equipment and plug loads (10%).

**Figure 8: Commercial Buildings, Total BC Hydro Service Area**
**Base Year Electricity Use By End Use**

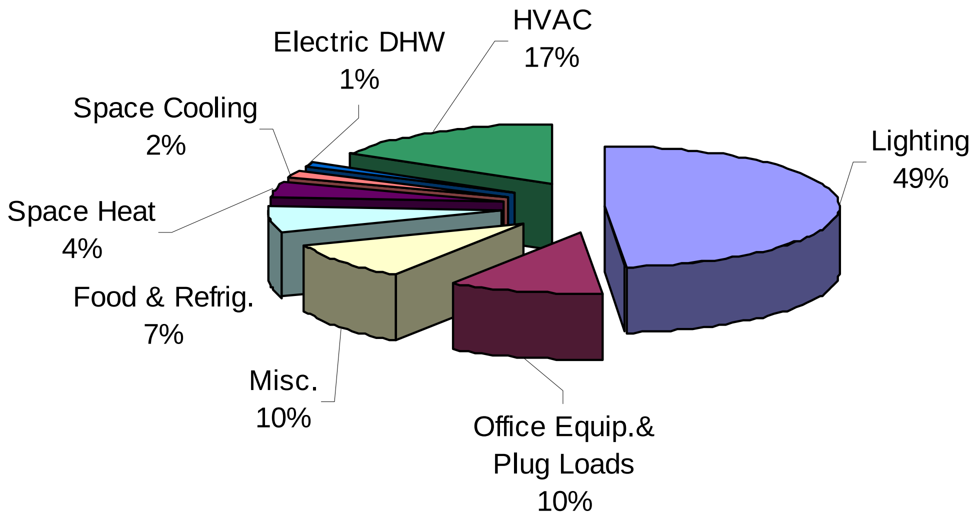
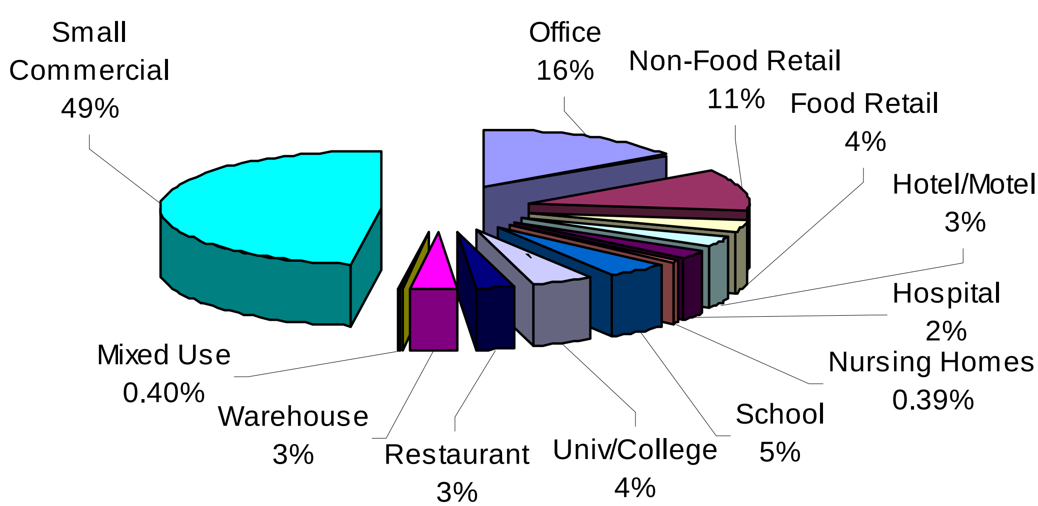



Figure 9 shows the distribution of base year electricity consumption by building segment. The office and non-food retail building segments account for the largest share of electricity use among the modelled building segments. The small commercial segment, which consists of the many small customers within each of the modelled building segments (e.g., office, hospital, etc.), accounts for 49% of the base year electricity used in commercial buildings.

**Figure 9: Commercial Buildings, Total BC Hydro Service Area**
**Base Year Electricity Use By Building Segment**



## *Reference Case*

With no new Power Smart initiatives but continuing expected rates of population and economic growth, the study estimated that electricity consumption in the commercial sector will grow from 12,739 GWh per year in 2000/01 to 14,314 GWh per year by 2005/06, to 16,185 GWh per year by 2010/11 and to 18,056 GWh per year by 2015/16. This represents an overall growth of about 42% in the period. It compares very closely with BC Hydro's own December 2000 forecast, which also includes consideration of the impacts of "natural conservation" – that is, conservation that is not stimulated by utility programs.

Natural conservation is expected to have the most impact on three end uses: lighting, space cooling and plug-in equipment. Marbek projects that natural conservation in existing buildings will result in approximately 50% of the remaining inefficient fluorescent lighting (T12 fluorescent tubes) being replaced with more efficient fluorescent lamps (T8 tubes) with electronic ballasts. Similarly, Marbek assumes that regulations on ozone-depleting substances will continue to drive cooling equipment replacements and that new cooling equipment will be more energy-efficient. The efficiency of new buildings will also improve over the period by using integrated design concepts. In contrast, office equipment plug loads in both existing and new buildings are expected to grow as a result of changes such as increased computer use per occupant, increased use of network computers and servers, and growth in other peripherals such as telephone network equipment.

## *Economic Potential Forecast*

If all the technologies that were defined as "economic" under the conditions of the Economic Potential Forecast were adopted, the Review estimates that electricity consumption in the commercial sector would grow to 14,984 GWh per year by FY 2015/16. Annual savings compared to the Reference Case are 3,072 GWh per year or about 17%. The Economic Potential annual savings in the remaining milestone years are 2,754 GWh per year in 2010/11 and 2,159 GWh per year in 2005/06. Efficient lighting accounts for 64% of total economic potential savings, while more efficient HVAC systems account for 11% of the total identified.

## *Achievable Potential Forecast*

The electricity savings opportunities that Marbek grouped into "Actions" are presented in Table 9 by Action and by milestone year, showing the different outcomes for the Most Likely and Upper scenarios. The most significant Achievable Savings opportunities came from lighting, small commercial building retrofit and design, high performance new buildings and HVAC use.

**Table 9: Commercial Sector, Total BC Hydro Service Area**
**Most Likely and Upper Achievable Savings, by Action and Milestone Year**

| Action | Annual Electrical Savings (GWh/yr), by Milestone Year | | | | | |
|---|---|---|---|---|---|---|
| | 2005/06 | | 2010/11 | | 2015/16 | |
| | Most Likely | Upper | Most Likely | Upper | Most Likely | Upper |
| C1 – Lighting | 95.8 | 174.3 | 283.3 | 426.4 | 510.5 | 634.2 |
| C2 – HVAC Retrofit | 4.5 | 10.3 | 20.6 | 53.4 | 54.0 | 92.4 |
| C3 – Heating and Cooling Retrofit | 1.0 | 2.1 | 4.2 | 10.5 | 8.5 | 19.0 |
| C4 – High Performance Large Com. Buildings | 14.6 | 31.1 | 58.9 | 110.5 | 129.9 | 245.1 |
| C5 – Small Commercial Retrofit and Design | 41.4 | 111.5 | 134.3 | 249.0 | 264.1 | 372.9 |
| C6 – Energy Star Computers and Electronic Equipment | 3.8 | 7.5 | 22.5 | 45.0 | 37.5 | 67.5 |
| C7 – Commercial Refrigeration Retrofit | 1.6 | 3.2 | 5.7 | 8.9 | 11.6 | 20.8 |
| C8 – Other Commercial Buildings | 15.0 | 30.0 | 30.0 | 60.0 | 60.0 | 90.0 |
| C9 – Non-Buildings | 12.9 | 25.8 | 25.8 | 51.6 | 51.6 | 77.4 |
| **Totals** | **190.5** | **395.8** | **585.4** | **1,015.2** | **1,127.7** | **1,619.3** |

## *Demand Impacts of Energy Efficiency Measures*

While the CPR 2002 did not focus on demand reduction, it did estimate the expected demand impacts of the estimated electric energy savings.

Compared to the Reference Case, demand savings in the Economic Potential Forecast are 314 MW in FY 2005/06, rising to 408 MW and 450 MW in, respectively, FYs 2010/11 and 2015/16. Achievable Potential demand savings in FY 2005/06 range from 29 MW (Most Likely) to 60 MW (Upper). By FY 2015/16 Achievable Potential demand savings range from 172 MW (Most Likely) to 247 MW (Upper). Projections for individual regions closely follow the pattern of the total service area. Table 10 summarizes the forecasts for BC Hydro's total service area, as well as for individual regions.

**Table 10: Commercial Sector, Total BC Hydro Service Area On-peak Demand Savings (MW)* for Economic and Achievable Forecasts vs. Reference Case by Service Region and Milestone Year**
(High-demand period, winter weekdays from 6 am to 10 pm, December and January)

| Service Region | Milestone Year | Average On-peak Demand Reference Case (MW) | Potential On-peak Demand Savings Relative to Reference Case | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Economic | | Achievable Most Likely | | Achievable Upper | |
| | | | MW | % | MW | % | MW | % |
| Total BC Hydro | Base Year | 1,961 | | | | | | |
| | 2005/06 | 2,180 | 314 | 14% | 29 | 1% | 60 | 3% |
| | 2010/11 | 2,438 | 408 | 17% | 88 | 4% | 153 | 6% |
| | 2015/16 | 2,699 | 450 | 17% | 172 | 6% | 247 | 9% |
| | | | | | | | | |
| Lower Mainland | Base Year | 1,290 | | | | | | |
| | 2005/06 | 1,442 | 211 | 15% | 19 | 1% | 40 | 3% |
| | 2010/11 | 1,622 | 286 | 18% | 58 | 4% | 102 | 6% |
| | 2015/16 | 1,806 | 318 | 18% | 115 | 6% | 165 | 9% |
| | | | | | | | | |
| Vancouver Island | Base Year | 327 | | | | | | |
| | 2005/06 | 358 | 49 | 14% | 5 | 1% | 10 | 3% |
| | 2010/11 | 394 | 61 | 15% | 14 | 4% | 25 | 6% |
| | 2015/16 | 430 | 66 | 15% | 27 | 6% | 39 | 9% |
| | | | | | | | | |
| Interior | Base Year | 343 | | | | | | |
| | 2005/06 | 380 | 54 | 14% | 5 | 1% | 10 | 3% |
| | 2010/11 | 422 | 61 | 15% | 15 | 4% | 26 | 6% |
| | 2015/16 | 463 | 66 | 14% | 30 | 6% | 42 | 9% |

*Includes line losses @ 7% (This includes distribution losses of 4% and area transmission losses of 3%).

It should be emphasized that the CPR 2002 is not a demand study. Rather the focus is on demand impacts of the electric energy efficiency measures contained in the Economic and Achievable Potential forecasts. Numerous other technologies and load control strategies could be used to reduce demand requirements. However, they are beyond the scope of this study.

## SUMMARY OF FINDINGS

The study confirms that significant cost-effective electricity efficiency improvements do exist in B.C.'s commercial sector. In the Most Likely and Upper Achievable scenarios, total electricity improvements in the commercial sector would provide, respectively, between 1,128 and 1,619 GWh per year of electricity savings by FY 2015/16, as well as demand savings of approximately 172 to 247 MW.

Within the large building segments that Marbek modelled in detail, savings potential is particularly significant in the office and retail segments, followed by schools and univer sities/colleges. Lighting, more efficient HVAC systems and new high-performance buildings account for nearly 60% of the identified Achievable Savings potential.

Readers are referred to a number of caveats throughout the full text of the individual sector reports.

# *The industrial sector*

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 such as food and beverage producers, clothing and textile makers, construction, electronic and other manufacturers.

For the purposes of this study, the industrial sector is defined to also include agriculture, fisheries, pipeline transmission and transportation. These operations use electricity in a way that is closer to that of other industrial users, since they use electricity primarily for motors, and moving products and supplies.

Willis Energy Services Ltd, of Vancouver, B.C. conducted the research, modelling and analysis of the industrial sector with assistance from BC Research Inc. of Vancouver, B.C.; CWA Engineers Inc., of Burnaby, B.C.; J & C Nyboer, of Surrey, B.C.; and Demand Side Energy Consultants, Inc. of Winnipeg, MB. Marbek Resource Consultants, of Ottawa, Ontario, provided analytic design and ensured that research methods and reporting in the industrial sector were consistent with those in other sectors.

## APPROACH

Willis Energy used the **ISTUM** computer model to analyze how the industrial sector uses electricity and to identify the potential for increased efficiency. ISTUM, the Intra-Sectoral Technology Use Model – Industry, was used in the 1991/1994 Conservation Potential Review, and has been used and further refined in a number of studies since then. Willis Energy, in collaboration with industry experts, reviewed and updated the process and equipment inventory contained in the ISTUM model, based on energy audits completed by BC Hydro and work that Willis has done for a number of B.C. companies.

ISTUM models the electricity used in each process for given subsectors and calculates the energy used as if all the facilities in the subsector were one large facility. The model is then used to estimate the amount of pumping, process, fan and other types of end-use electricity that is required to produce a product.

The subsectors modelled for the industrial sector using ISTUM were:

- Pulp and paper;
- Wood products;
- Chemical manufacturing;
- Metal mining;
- Coal mining; and
- Petroleum refining.

These subsectors account for almost 80% of the electricity that BC Hydro sold to its industrial customers in FY 2000/01.

The remaining industry types are highly diverse, ranging from greenhouses to small light manufacturing shops. Because of their diversity, the consultants modelled a category of "Other Industry" using a spreadsheet-based model, built on data from energy audits and the consultants' research files.

The five major steps in the general approach to the study are outlined in the Introduction under the title, Major Analytic Steps and Definitions. Specific procedures for the industrial sector were as follows:

**Modelling of Base Year –** The consultants compiled data on B.C.'s industrial sector from B.C. Statistics, BC Hydro's Load Forecasting Department, company websites and annual reports and various consultant reports. To account for the fact that some large energy users, especially in the pulp and paper sector, generate a portion of their own electricity, Willis estimated the amount of self-generated electricity and offset it from the consumption data. Using these information sources, Willis modelled the electricity use for the base year, FY 2000/2001, and compared it with BC Hydro's actual billing data. Comparing their calculated data with actual BC Hydro sales data, they found that the macro models produced a match within 3.8% of actual electricity sales.

**Reference case calculations –** Willis used forecasts of industrial activity provided by BC Hydro's Load Forecasting Department for the milestone years of 2005/06, 2010/11 and 2015/16. Using ISTUM and the spreadsheet model, Willis projected electricity growth for the milestone years against which to measure the impact of possible energy efficiency measures.

**Assessment of technical options –** The options assessed in order to estimate the economic and achievable potentials included technologies such as:

- Pump systems;
- Air displacement systems (fans);
- Compressed air systems;
- Material conveyance systems (such as conveyor belts and chains);
- Industrial refrigeration systems;
- Industrial lighting;
- Electric motors;
- Improvements to processes such as manufacturing, refining and mining; and
- Electrolysis.

**Estimation of demand impacts –** The consultants reviewed BC Hydro's daily and seasonal system demand patterns and, in consultation with BC Hydro personnel, identified the periods of highest (on-peak) electricity demand. The on-peak demand reduction impacts were then derived from the electricity savings for each end use and for the sector as a whole. End use savings that particularly contributed to the on-peak demand savings in the industrial sector include pumps and process equipment improvements (about 67% of most likely).

## RESULTS AND FINDINGS

Table 11 summarizes the results of the forecasts of annual electricity consumption and savings in the industrial sector by milestone year for BC Hydro's service area. Table 12 summarizes electricity consumption for individual regions. (Detailed regional breakdowns of this sector are not published in order to avoid presenting numbers that could be misinterpreted as applying to individual customers.) Figure 10 presents the consumption data for BC Hydro's service area in graphical form. A discussion of the results follows.

**Table 11: Forecast Summary – Industrial Sector, Total BC Hydro Service Area Annual Electricity Consumption* (GWh/yr)**

| Annual Electricity consumption (GWh/yr) Industrial Sector | | | | | | Potential Annual Savings (GWh/yr) | | |
|---|---|---|---|---|---|---|---|---|
| **Milestone Year** | **Base Year** | **Reference Case** | **Economic** | **Achievable** | | **Economic** | **Achievable** | |
| | | | | **Most Likely** | **Upper** | | **Most Likely** | **Upper** |
| **2000/01** | 19,753 | 19,753 | | | | | | |
| **2005/06** | | 19,162 | 16,250 | 18,415 | 17,973 | 2,912 | 747 | 1,189 |
| **2010/11** | | 19,045 | 13,943 | 16,894 | 15,987 | 5,102 | 2,151 | 3,058 |
| **2015/16** | | 17,821 | 12,156 | 14,447 | 13,483 | 5,665 | 3,374 | 4,338 |

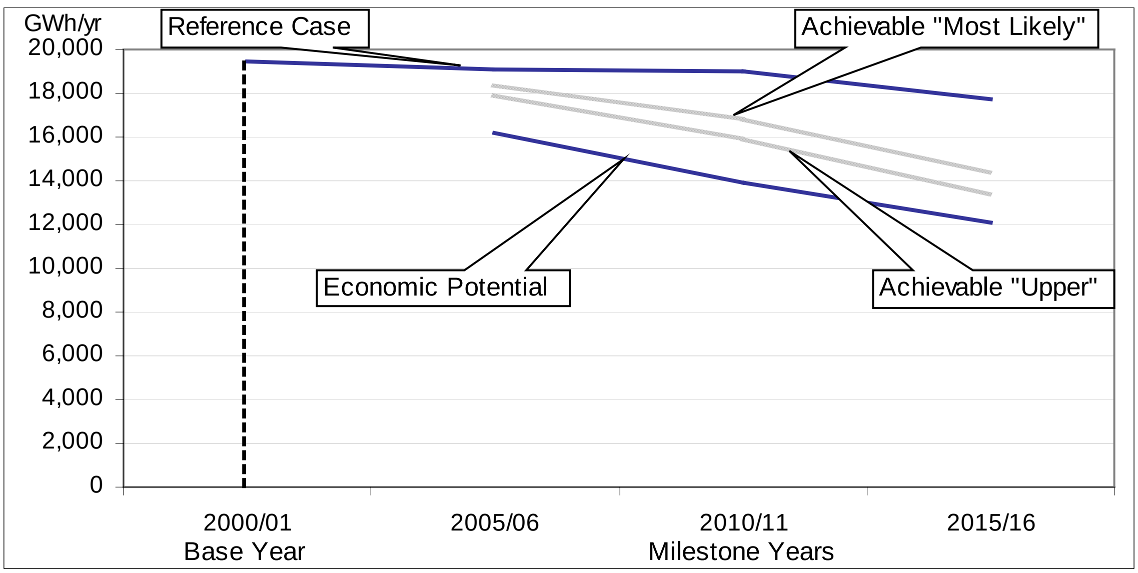
*Net of self-generated electricity

**Table 12: Forecast Summary – Industrial Sector, Annual Electricity Consumption* by Region and Milestone Year (GWh/yr)**

| Milestone Year | Lower Mainland | Vancouver Island | Interior | Total |
|---|---|---|---|---|
| **2000/01** | 5,127 | 5,209 | 9,417 | 19,753 |
| **2005/06** | 4,533 | 5,067 | 9,562 | 19,162 |
| **2010/11** | 4,626 | 4,623 | 9,796 | 19,045 |
| **2015/16** | 4,609 | 4,349 | 8,863 | 17,821 |

*Net of self-generated electricity

**Figure 10: Forecast Summary – Industrial Sector, Total Service BC Hydro Area Annual Electricity Consumption (GWh/yr)**




## *Base Year Electricity Use and Calibration*

In the base year of FY 2000/2001, BC Hydro's industrial sector consumed a total of 19, 753 GWh per year. Figure 11 shows that process equipment, including various types of machinery used directly in production processes, is the major end use and accounts for 44% of total industrial sector electricity use. Pumping systems are the second-largest end use, accounting for 23% of total electricity use, followed by air displacement systems (10%), materials conveyance (7%) and electrolysis (6%).

**Figure 11: Industrial Sector, Total BC Hydro Service Area**
**Base Year Electricity Use By End Use**

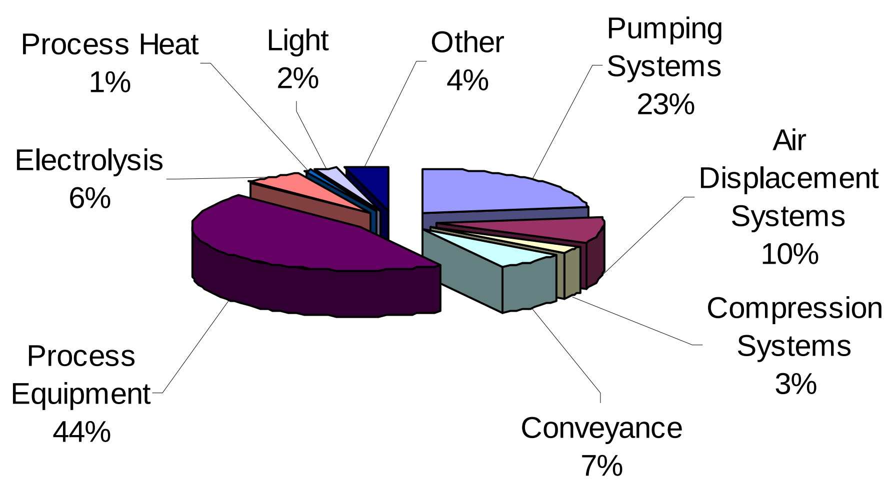
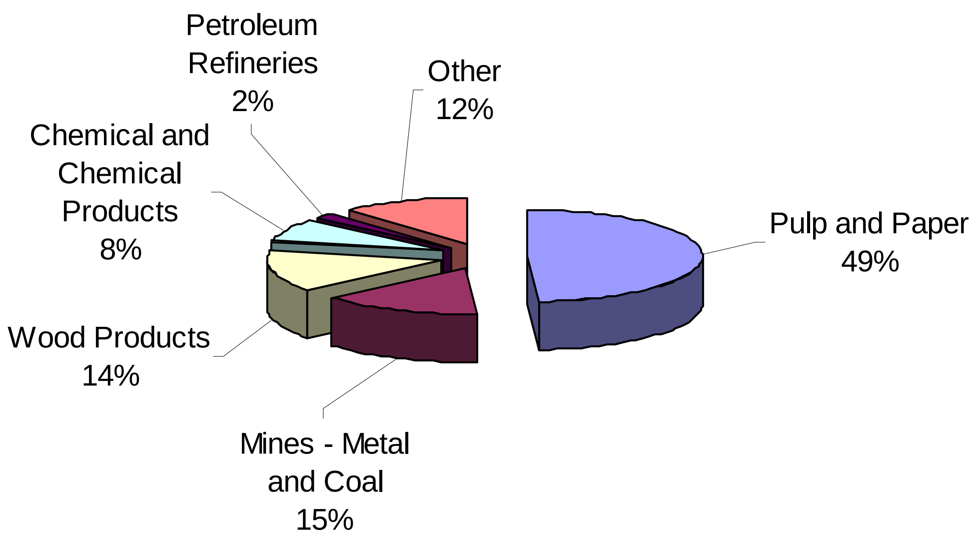



Figure 12 shows the distribution of base year electricity consumption by industrial sub-sector. As illustrated, the pulp and paper industry accounts for the largest share (49%) of industrial electricity use in the base year. Mining (15%), wood products (14%) and chemical products (8%) follow. The “Other” category accounts for 12% of the industrial electricity used in BC Hydro’s service area.

**Figure 12: Industrial Sector, Total BC Hydro Service Area**
**Base Year Electricity Use By Sub-Sector**




## *Reference Case*

In the absence of new Power Smart initiatives, the study estimated that industrial electricity consumption would be 19,162 GWh in 2005/06, 19,045 GWh in 2010/11 and 17,821 GWh in 2015/16. This represents an average annual growth rate of -0.56% over the forecast period. This differs from the BC Hydro reference forecast that grows at an average annual growth rate of 0.38%. It is acknowledged that the growth of industrial electrical consumption in British Columbia has been declining, reflecting British Columbia's general shift from a resource-based to a service-based economy. The declines in this reference case also reflect modelling assumptions including:

- The anticipated mix and quantity of future industrial products and sub-products;
- Future technological changes that impact the electrical intensity of industrial production; and
- The level of self-generation adopted by industry.

## *Economic Potential Forecast*

If all the technologies that were defined as "economic" under the conditions of the Economic Potential Forecast were adopted, the Review estimates that electricity consumption in the industrial sector would decline to 12,156 GWh per year by FY 2015/16. Annual savings compared to the Reference Case are 5,665 GWh per year or about 32%. The Economic Potential annual savings in the remaining milestone years are 2,912 GWh per year in 2005/06 and 5,102 GWh per year in 2010/11.

Most of the savings result from increased efficiency in pumping systems and process equipment, each of which represents 35% of the forecast potential savings. Adjustable speed drives allow pump motors, as well as other motors, to reduce their operating speed instead of closing output valves to adjust to changing needs; replacing conventional drives with adjustable ones provides significant electricity savings potential. In addition, inefficient pumps will likely be replaced with high-efficiency ones that are now available.

Two-thirds of the total potential savings are projected to occur in the pulp and paper industry, since it is both a major electricity user and a major user of pumping technology. The chemical and mining industries each account for about 10% of the total potential savings.

### *Achievable Potential Forecast*

The electricity savings opportunities that the consultants grouped into “Actions” are presented in Table 13 by Action and by milestone year, showing the different outcomes for the Most Likely and Upper scenarios. The most significant Achievable Savings opportunities came from pumping improvements and mechanical pulping. Mechanical pulping processes are extremely electricity-intensive and the pulp industry is actively looking for ways to reduce electricity use through methods such as more effective controls, process modifications and, ultimately, new systems that allow extensive heat recovery.

In addition, a significant potential exists for increased efficiency in steam cycle operations in pulp mills. As efficiency in other areas allows operators to divert steam from production processes and into electrical generation, the ability to self-generate increasing amounts of electricity grows.

**Table 13: Industrial Sector, Total BC Hydro Service Area**
**Summary of Achievable Savings, by Action and Milestone Year**

| Action | Annual Electricity Savings (GWh/yr), by Milestone Year | | | | | |
|---|---|---|---|---|---|---|
| | 2005/06 | | 2010/11 | | 2015/16 | |
| | Most Likely | Upper | Most Likely | Upper | Most Likely | Upper |
| I1 – Pump Improvement | 110 | 217 | 564 | 998 | 905 | 1,415 |
| I2 – Air Displacement Improvement | 24 | 37 | 69 | 110 | 114 | 171 |
| I3 – Compressed Air Improvement | 29 | 42 | 91 | 143 | 123 | 164 |
| I4 – Conveyance or Material Handling Improvement | 19 | 38 | 71 | 113 | 100 | 143 |
| I5 – Refrigeration and Cooling Improvement | 2 | 4 | 10 | 16 | 16 | 21 |
| I6 – Electric Motor Efficiency is not reported separately because motor efficiency improvements are included as part of the "system" efficiency improvements contained in Actions I1 through I5, above. | | | | | | |
| I7 – Industrial Lighting and Controls Improvement | 24 | 48 | 113 | 186 | 163 | 236 |
| I8 – Mechanical Pulping Improvement | 274 | 274 | 548 | 548 | 1,095 | 1,095 |
| I9 – Process Improvement | 33 | 65 | 187 | 304 | 247 | 382 |
| I10 – Steam Cycle Optimization | 218 | 437 | 428 | 524 | 504 | 542 |
| I11 – Industrial Indoor Air Quality | 14 | 28 | 69 | 117 | 107 | 169 |
| **Totals** | **747** | **1,190** | **2,150** | **3,059** | **3,374** | **4,338** |

Overall, Achievable savings by FY 2015/16 represent approximately 59% of the Economic Potential savings in the Most Likely scenario and 77% of the Economic Potential savings in the Upper scenario.

Estimating the likelihood of the industrial sector to adopt electrical efficiency projects is particularly complicated, because its motivation to change equipment or processes often comes from reasons other than cost reduction, such as productivity improvements, product quality, maintenance costs and legislative changes. In particular, process equipment is usually selected for its particular characteristics in a given process and changes made for energy efficiency reasons may be seen as unnecessarily risky.

## *Demand Impacts of Energy Efficiency Measures*

While the 2002 Conservation Potential Review did not focus on demand reduction, it did estimate the expected demand impacts of the estimated electric energy savings.

Compared to the Reference Case, demand savings in the Economic Potential Forecast are 380 MW in FY 2005/06, rising to 666 MW and 739 MW in, respectively, FYs 2010/11 and 2015/16. Achievable Potential demand savings in FY 2005/06 range from 97 MW (Most Likely) to 154 MW (Upper). By FY 2015/16, Achievable Potential demand savings range from 436 MW (Most Likely) to 559 MW (Upper).

Table 14 summarizes the demand implications of the Economic and Achievable Forecasts.

**Table 14: Industrial Sector, Total BC Hydro Service Area Demand Implications (MW)* for Economic and Achievable Forecasts vs. Reference Case by Milestone Year**

(High-demand period, winter weekdays from 6 am to 10 pm, December and January)

| Average On-peak Demand (MW) | | | | | | Potential On-peak Demand Savings (MW) | | |
|---|---|---|---|---|---|---|---|---|
| Milestone Year | Base Year | Reference Case | Economic | Achievable | | Economic | Achievable | |
| | | | | Most Likely | Upper | | Most Likely | Upper |
| 2000/01 | 2,542 | 2,542 | | | | | | |
| 2005/06 | | 2,503 | 2,123 | 2,406 | 2,349 | 380 | 97 | 154 |
| 2010/11 | | 2,488 | 1,823 | 2,211 | 2,095 | 666 | 277 | 394 |
| 2015/16 | | 2,331 | 1,591 | 1,895 | 1,771 | 739 | 436 | 559 |

*Includes line losses @ 7%. (This includes distribution losses of 4% and area transmission losses of 3%).

It should be emphasized that the CPR 2002 is not a demand study. Rather, the focus in this part of the Review is on demand impacts of the electric energy efficiency measures contained in the Economic and Achievable Potential forecasts. Numerous other technologies and load control strategies could be used to reduce demand requirements. However, they are beyond the scope of this study.

## SUMMARY OF FINDINGS

The study confirms that substantial cost-effective electricity efficiency improvements do exist in B.C.'s industrial sector. In the Most Likely and Upper Achievable scenarios, those efficiency improvements would provide, respectively, between 3,374 and 4,338 GWh per year of electricity savings by FY 2015/16, as well as demand savings of approximately 436 to 559 MW.

Savings potential is particularly significant in improvements to pump systems, mechanical pulping systems and steam plants, which together account for 74% of the Most Likely achievable savings. However, they will require a significant amount of specialized engineering and significant capital investment.

Readers are referred to a number of caveats throughout the full text of the individual sector reports.

# *Appendix: Glossary*

Following is a list of terms and definitions of terms used in this summary and in the full texts of the individual sector reports, as defined by BC Hydro.

(NOTE: Underlined expressions are defined elsewhere in the text of this Glossary.)

**Achievable Potential:** The achievable potential is the portion of the savings identified in the economic potential that could realistically be achieved within the study period.

**Avoided Cost:** The unit cost of acquiring the next resource to meet electricity demand. This is used as a measure for evaluating individual demand-side and supply-side options.

**BC Hydro Service Area:** That portion of the Province of B.C. which receives retail electricity service from BC Hydro. It excludes the area served by Aquila Networks Canada (previously known as West Kootenay Power and Utilicorp Networks Canada) and, for the purpose of this study, includes the city of New Westminister. Approximately 75-80% of B.C.'s electrical demand is in the BC Hydro service area.

**BC Hydro Service Regions:** The Conservation Potential Review 2002 presents its results, allocated to three service regions.

- Vancouver Island, including all of Vancouver Island plus the Gulf Islands, which get their electricity supply from Vancouver Island;
- the Lower Mainland, including the Lower Mainland of BC, the Fraser Valley as far east as Hope, the Sunshine Coast and Powell River; and
- the Interior including the remainder of BC Hydro's service area, the southern Interior minus the area served by the former West Kootenay Power, the central interior and the northern interior regions.

**Co-generation:** The simultaneous production of electrical or mechanical energy and useful heat energy from a single fuel source. As an example, several mills in the B.C. forest sector co-generate electricity and process steam from wood waste for use in a pulping process.

**Cost of Conserved Energy (CCE):** The cost of conserved energy refers to the annualized unit energy cost of a DSM measure and is used to determine its cost effective ness compared to additional electricity supply (as part of the Total Resource Cost Test). It is calculated as the annualized incremental cost (including annual O&M) of the DSM upgrade measure divided by the annual savings achieved, excluding any administrative or program costs to achieve full use of the technology or measure.

**Demand Impacts:** In the context of the Conservation Potential Review 2002, demand impacts refers to the average load reduction over the 6 am to 10 pm period during an average weekday in December and January that is anticipated to result from the various electricity saving technologies, programs or actions presented in the CPR 2002.

**Demand-Side Management (DSM):** Actions that modify customer demand for electricity. These actions can defer the requirement for new energy and capacity additions.

**Diversity:** Diversity is a relative measure of the likelihood that a series of connected loads will reach peak demand at the same time. A high diversity implies that the individual connected loads will reach their peak demand at different times while a low diversity implies that they will reach peak demand at the same time.

**Economic Efficiency:** Allocation of human and natural resources in a way that results in the greatest net economic benefit, regardless of how benefits and costs are distributed within society.

**Economic Potential:** The economic potential is an estimate of the reduction of electricity consumption, relative to the reference case, that would occur if all electricity consuming equipment were upgraded to the efficiency level that is cost effective as calculated using the cost of conserved energy (CCE).

**Electric Capacity:** The maximum electric power that a device or system is capable of producing or transferring. Electric capacity is measured in watts, kilowatts, megawatts etc.

**Electric Energy:** It is the cumulative amount of electricity produced or consumed over a period of time. Electric energy is measured in kilowatt-hours or gigawatt-hours.

**Electric Power:** The instantaneous rate that electrical energy is produced, transmitted or consumed. Electric Power is measured in watts, kilowatts, megawatts etc.

**Electrical Efficiency:** Is the ratio of the useful energy delivered by a system or end-use to the amount of electric energy supplied to it. It is a measure of how well electrical energy is translated into another useful form of energy.

**Electricity Conservation:** Activities by electricity users that result in a reduction of the electric energy used to provide electrical energy services. Electricity conservation can include a wide variety of behavioural or operational changes that result in energy savings. For the purpose of this study only energy savings achieved through hardwired or hardware installations are included.

**Electricity Intensity:** Is the ratio of the electrical energy consumed per application or end-use. Examples would include kilowatt-hours per square meter of lit office space per day or kilowatt-hours per tonne of aluminum produced. All else being equal, electricity intensity increases as electricity efficiency decreases.

**Emerging Technologies:** Emerging Technologies are new energy conserving technologies that are expected to be market ready in any of the years up to and including 2015. These include technologies which could be "fast-tracked" through targeted financial or technical support, to be close to being market within any of the years up to and including 2015.

**End-use:** An end-use recognizes the fact that electrical energy is of no value to a user without first being transformed, by a piece of equipment, into a service of economic value. For example, office lighting is an end-use, whereas electricity sold to the office tenant is of no value without the equipment (light fixtures, wiring, etc.) necessary to convert the electricity into visible light. End-use is often used interchangeably with energy service.

**Energy Service:** An amenity or service supplied jointly by energy and other components/equipment such as buildings, motors and lights. Examples of energy services include residential space heating, commercial refrigeration, aluminum smelting, and public transit. The same energy service can frequently be supplied with different mixes of equipment and energy.

**Financial Incentive:** Certain financial features in the utility's demand-side management programs designed to motivate customer participation. These may include features designed to reduce a customer's net cash outlay, pay-back period or cost of finance to participate.

**Fuel Substitution:** The ability to use a different fuel to produce the same energy service. For example, natural gas can be used for space heating instead of electricity.

**Gigawatt-hour (GWh):** One million kilowatt-hours.

**Independent Power Producer (IPP):** A privately owned electricity generating facility which is usually connected to a utility's transmission system to sell electricity.

**Kilowatt (kW):** One thousand watts. A basic unit of measurement of electric power. The amount of energy transferred at a rate of one kilowatt for one hour is a kilowatt-hour.

**Kilowatt-hour (kWh):** The basic unit of measurement of electric energy. One kilowatt-hour represents the power of one thousand watts for a period of one hour. A typical non-electrically heated home in B.C. uses about 10,000 kWh per year.

**Load:** Is the amount of electricity required by a device, customer or group of customers as measured by an electrical meter.

**Load Displacement:** The reduction of electricity requirements from existing utility customers through electricity conservation or through customer self-generation.

**Load Factor:** The ratio of the average load supplied during a given period to the maximum load occurring during the same period.

**Load Forecast:** Is an estimate of expected electricity requirements that have to be met by the electrical system in future years.

**Load Shape:** Is the variation in electrical load over time, usually hour-by-hour. A load shape can be for the system, a customer or an end use load over a set period of time such as a day or a year.

**Load Shifting:** Utility DSM program to move energy consumption from one period of time to another. Most often it is from periods of high electrical consumption to periods of low electrical consumption (i.e., from on-peak to off-peak).

**Megawatt (MW):** One thousand kilowatts.

**Natural Change in Electricity Intensity:** The future change in electricity intensity, which is expected to occur in the absence of utility demand-side management programs. In developing an estimate of natural change in electricity intensity, it is necessary to make an explicit assumption about the future prices of electricity and competing fuels.

**Peak Demand:** The maximum electric power required by a customer, device or system during a specified time period (e.g, day, month, year).

**Peak Clipping:** Utility DSM program used to reduce peak demand, without reducing demand at other times of the day or year.

**Power Smart:** Power Smart is BC Hydro's demand-side management initiative, which was originally launched in 1989. Power Smart includes a full range of DSM programs aimed at BC Hydro's residential, commercial and industrial customers.

**Rate (Average Rate):** Generically refers to a utility's rate structure. "Average Rate" specifically refers here to the overall average revenue per kilowatt-hour that the utility receives from a given class of customers (e.g. residential) covered by one or more tariffs.

**Rate Structure:** The formulas used by a utility to calculate charges for the use of electricity. For example, the present BC Hydro rate structure for residential customers consists of a basic monthly charge plus charges for the amount of electric energy used (i.e., cents/kWh). Other BC Hydro rates structures charge for energy at a rate per kilowatt-hour that depends on the level of consumption, while others may include charges for peak demand.

**Reference Case:** Is an estimate of the expected level of electricity consumption that would occur over the study period in the absence of any new Power Smart initiatives.

**Resource Planning:** The process of long-term planning of electricity generation and transmission facilities in order to reliably meet the forecast requirements of BC Hydro's domestic customers. It addresses regional supply requirements and can utilize both supply and demand side resources while recognizing economic, environmental and social impacts and risks.

**Resource Smart:** The name given to BC Hydro's strategy of improvements to existing power generation and transmission facilities to achieve supply-side efficiency through physical and operational modifications.

**Sector:** A group of customers having a common type of economic activity. BC Hydro divides its customers into three principal sectors: residential, commercial and industrial. Sectors are often divided into sub-sectors. For example, "offices" is a sub-sector of the commercial sector.

**Self-generation:** Generation of electricity by an industry or commercial enterprise whose principal product is not electricity. Self generation can either reduce the amount of electricity purchased from the utility or it may be sold to the utility as a supply-side resource.

**Sub-sector:** A classification of customers within a sector by common features. Residential sub-sectors are by type of home (single family, duplex, apartment, etc.). Commercial sub-sectors are generally by type of commercial service (office, retail, warehouse, etc.). Industrial sub-sectors are by product type (pulp and paper, solid wood products, chemicals, etc.).

**Tariff:** The tariff explicitly defines the rate and the terms and conditions of sale for electric power and energy between utility and customer. It includes the type of service, delivery point(s), limitations of obligations to serve, minimum charges, etc.

**Technical Efficiency:** The efficiency of a system, process or device in achieving a certain purpose. It is measured in terms of the physical inputs required to produce a given output.

**Total Resource Cost:** The total economic cost of acquiring energy resources. For DSM programs this includes costs incurred by the utility (DSM program administration, taxes and incentives) and by the customer (the cost of the DSM measure net of incentives).

**Total Resource Cost Test:** A benefit/cost test that compares the Total Resource Cost of electricity investment alternatives, including electricity conservation programs, to either the avoided cost of new electricity supply or to the market value of electricity.

**Utility Cost:** A cost that assumes that the utility's objective is to minimize utility revenue requirements. The costs include utility program costs, including incentive costs.

**Watt:** The basic unit of measurement of electric power.