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June 29, 2010

Via Email
Original via mail

Ms. Erica M. Hamilton
Commission Secretary
BC Utilities Commission
Sixth Floor, 900 Howe Street, Box 250
Vancouver, BC V6Z 2N3

Dear Ms. Hamilton:

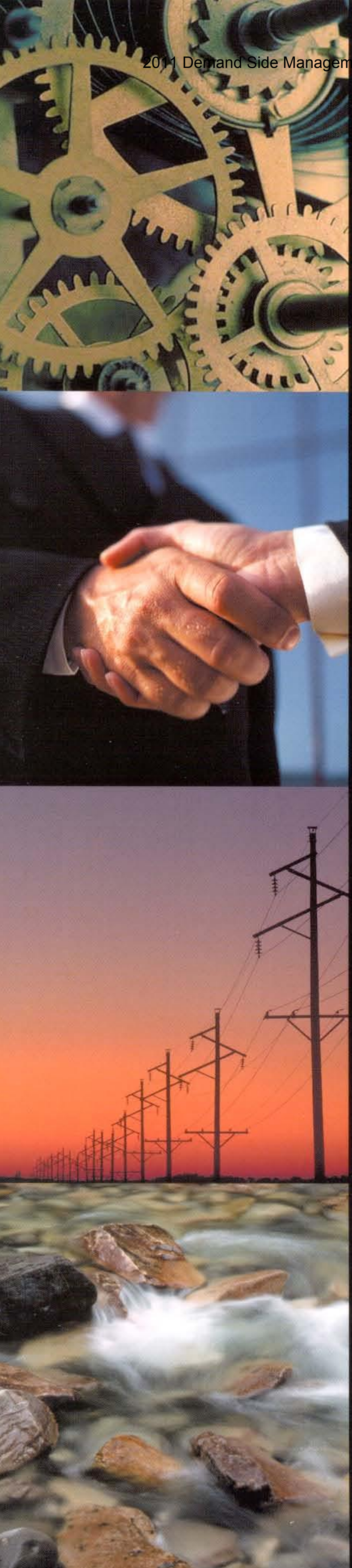
Re: ***FortisBC Inc. Application for Approval of the 2011 Capital Expenditure Plan – Project No. 3698603***

FortisBC provides the following erratum to its 2011 Capital Expenditure Plan Application.

1. **Appendix D (Conservation and Demand Potential Review) to the 2011 Demand Side Management Plan (Appendix 3 to the 2011 Capital Expenditure Plan)**
   Appendix D to the 2011 Demand Side Management Plan (Appendix 3) was incorrectly labeled as Appendix C. A replacement Appendix with the corrected header is attached.

Sincerely,

Dennis Swanson
Director, Regulatory Affairs



FortisBC

EES Consulting

Conservation and Demand Potential Review

Final Report
June 10, 2010

June 10, 2010

Mr. Keith Veerman, PE
Manager, Energy Efficiency
FortisBC Inc.
Suite 100, 1975 Springfield Road
Kelowna, British Columbia V1Y7V7

SUBJECT: 2010 Conservation and Demand Potential Assessment – Final Report

Dear Mr. Veerman:

Attached please find the FortisBC Conservation and Demand Potential Assessment Final Report.

We appreciate the effort by you and your staff to provide the background information and data necessary for a potential assessment. We have enjoyed working with you on this project.

Sincerely

Kevin L. Smit

Kevin Smit
Manager, Demand-Side Management

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Introduction

Objectives

The objective of this report is to describe the results of the FortisBC 2010 Conservation and Demand Potential Review (CDPR). This assessment provides estimates of energy and peak demand savings by sector for the period of 2011 - 2030. The assessment considered a wide range of conservation and demand resources that are reliable, available, and cost-effective. In addition, some emerging technologies, fuel switching, small scale generation, and behavioural measures were considered.

The conservation measures are based on sources such as the Ontario Power Authority, BC Hydro's 2007 Conservation Potential Assessment, and the Northwest Power and Conservation Council. The results provide estimates of peak demand and energy savings that will assist FortisBC in their future resource and program planning.

Background

FortisBC provides service to 110,000 customers in the province of British Columbia as well as 47,500 customers through wholesale supply to municipalities such as Summerland, Penticton, Kelowna, Grand Forks, and Nelson. Residential customers make up 87 percent of the total number of customers and nearly 40 percent of energy sales. Wholesale customers make up another 30 percent of energy, with the remaining 30 percent related to commercial, industrial and other retail classes. Energy sales for FortisBC are roughly 3.5 million MWh per year, with a winter peak demand of about 700 MW. The summer peak for the system is roughly 560 MW.

FortisBC owns generation from four hydro units collectively referred to as the Kootenay River Plants. Output from these plants is governed by a water coordination contract with BC Hydro, and other parties on the Kootenay River which predefines the amount of power that can be used at various times. Peak capacity for December 2009 for the Kootenay River Plants was 223.5 MW. Plant output reflects 47 percent of the 2009 energy requirement and 35 percent of the sum of the monthly capacity requirements. The remainder of FortisBC's power supply needs is met with power supply purchases, including a wholesale contract purchase of up to 200 MW per hour from BC Hydro. While FortisBC resources and contracts provide the majority of energy required by the utility, the system is constrained with respect to capacity.

The utility has made significant investments into its electrical infrastructure increasing its gross assets by more than 200% since 1997. Much of the investment was made to accommodate ongoing capacity constraints on the FortisBC transmission and distribution systems. In addition, customer peak electrical usage has been growing quicker in the summer than in the winter due in part to increased air conditioning load. From a government policy perspective, changes to the Utilities Commission Act and the introduction of the 2007 BC Energy Plan have also necessitated consideration in FortisBC's planning process.

The latest Resource Plan for FortisBC was filed with the BCUC in May of 2009. The *2007 BC Energy Plan* played a significant role in FortisBC's evaluation of potential sources for additional power, providing public policy guidance on directions that BC would like to take in making these types of decisions. Some of the specific policy measures outlined in the 2007 Capital Expenditure Plan include:

- Acquire 50 per cent incremental resource needs through conservation by 2020;
- Ensure a coordinated approach to conservation and efficiency is actively pursued in British Columbia; and
- Encourage utilities to pursue cost effective and competitive demand side management opportunities.

The report, *Energy Efficient Buildings Strategy: More Action, Less Energy* goes a step further by setting new targets specifically for buildings that support the goals of the BC Energy Plan. These targets include:

- Reduce average energy demand per home by 20 per cent by 2020
    - Low income retrofit incentives
    - SolarBC project
    - Net zero energy homes project
- Reduce energy demand in commercial buildings by nine per cent per square meter by 2020
- Complete energy conservation plans for all B.C. communities

In 2008, FortisBC enacted policy to pursue demand-side resources prior to supply-side options. While FortisBC realizes that demand-side resources alone may not be able to close the capacity gap, the utility and its customers could benefit from these resources by reducing the need for added capacity, securing low-risk resources at relatively low costs, and realizing environmental benefits such as reduced or avoided greenhouse gas emissions.

Report Organization

This report is organized as follows:

- Methodology for Conservation Potential Estimation
- Historic FortisBC Conservation Achievement
- End-Use Load Forecast
- Residential Energy Efficiency Savings Potential
- Residential Peak Demand Savings Potential
- Commercial Energy Efficiency Savings Potential

- Commercial Peak Demand Savings Potential
- Industrial Energy Efficiency Savings Potential
- Industrial Peak Demand Savings Potential
- Infrastructure and Irrigated Agriculture Conservation Potential
- Behaviour Measures
- Scenarios
- Combined CDM Potential Summary
- Program Implications
- Glossary
- Acronyms

Within each potential section, service territory data is defined, conservation measures identified, and estimated potential is summarized. Potential estimates are summarized according to supply curves, tables, figures, and in comparison to the end-use load forecast.

In addition to the main report, the appendices contain detailed information regarding potential estimates as well as supplementary information.

Methodology

This study is a comprehensive analysis that focuses mainly on a bottom-up approach where energy efficiency measures are applied specific end-uses, such as number of refrigerators, and assigned a specific kWh/year savings. This approach differs from "top-down" approaches where, in many cases, a percentage savings is assumed for each end-use. This section describes how conservation potential is estimated in this study as well as the specific considerations, vocabulary, and reasoning behind the methodologies described. First, the types of conservation potential are defined followed by the methodology for estimating those types of potential.

Types of Potential

In developing this potential study, several different types or levels of efficiency potential are identified: technical, economic, and achievable. Technical potential is the theoretical maximum efficiency in the service territory. Economic potential is a subset of the technical potential that has been screened for cost effectiveness through various benefit-cost tests. Beyond cost effectiveness, there are physical barriers, market conditions, and other economic constraints that reduce the total potential savings from an energy efficient device. When these factors are applied, the result is called the achievable potential.

- Technical – Amount of energy efficiency potential that is available regardless of cost or other constraints such as willingness to adopt measures. It represents the theoretical maximum amount of energy efficiency if these constraints are not considered.
- Economic – Amount of potential that passes an economic cost/benefit test; in British Columbia the total resource cost test (TRC) is used. This generally means that the present value of the benefits exceeds the present value of the measure costs over its lifetime. The TRC costs include the incremental cost of the measure regardless of who pays (utility or customer). In British Columbia the Ministry of Energy, Mines and Petroleum Resources ("Ministry") has mandated that the cost effectiveness of measures be calculated either at the individual level, in a bundle with other measures, or at a portfolio level.
- Achievable – Amount of potential that can be achieved through a given set of conditions. Achievable potential takes into account many of the realistic barriers to adopting energy efficiency measures. These barriers include the willingness of consumers to adopt a measure, the non-measure costs, and the physical limitations of ramping up a program over time. The level of achievable potential can increase or decrease depending on the given incentive level of the measure.
- Program Achievable – Amount of potential that can be achieved through programs. The program achievable excludes potential that is achieved through future code changes.

Data Requirements

The data required for estimating conservation potential falls into three categories: measure data, customer characteristic, and utility data. Figure 1 illustrates specific data included in each of these categories.

Figure 1
Overview of Potential Assessment Data Requirements

Energy Efficiency Measure Data

- kWh, kW savings, load shapes
- Costs - incremental, O&M, replacement
- Energy and non-energy benefits/costs
- Measure Life

Customer Characteristic Data

- Residential: single family, multifamily, manufactured
- Commercial: Floor area by building segment, population, employment
- Industrial: consumption by sub-sector
- Building characteristics: heating fuel, vintage, basement type, HVAC types
- Appliance saturation: refrigerators, lighting
- Commercial building square footage; total and by segment
- Current measure penetration rate

Utility Data

- Load forecast
- Avoided cost
- Discount rates
- Line losses
- Past energy efficiency program achievements

Energy Efficiency Measure Data

The characterization of efficiency measures includes measure savings (kWh), demand savings (kW), measure costs ($), and measure life (years). Other features such as measure load shape, operation and maintenance costs, and non-energy benefits are also important for measure definition. Next, the end-use conservation measures data is another piece central to conservation potential modeling. Three primary sources were referenced for conservation measure data that apply to characteristics in FortisBC's service territory: the 2007 BC Hydro Conservation Potential Review, the Northwest Power and Conservation Council's 6th Power Plan, and Ontario Power Authority measure databases. Annual savings for heating, cooling, and weatherization measures are adjusted to reflect the FortisBC climate zones.

The measure data from some or all of the resources listed above include adjustments from raw savings data for several factors. The effects of space heating interaction, for example, are included for all lighting and appliance measures where appropriate. For example, if a house is retrofitted with efficient lighting, the heat that was originally provided by the inefficient lighting will have to be made up by the heating system. This energy is netted out of the savings.

Customer Characteristic Data

Customer characteristics data are another important component of a potential study. One of the best ways to obtain these data is through original research, especially end-use surveys. An end-use survey may provide all the detailed housing and commercial building data requirements. Defining service territory data is often referred to as characterizing the baseline. For this analysis, FortisBC has completed end-use surveys for their residential and commercial customers. The results are used to guide which conservation measures are applicable as well as the corresponding saturation levels of those measures.

The building, appliance, and equipment data is obtained from the FortisBC customer surveys. Using FortisBC survey data, the end-use model forecasts saturations and building segmentation data over the planning period. The end-use model allows for the estimation of conservation potential over a period of time, rather than a snap-shot in time, as survey results show. Therefore, the estimation of growth rates and saturation levels over the time period becomes an integral piece to conservation potential.

Utility Data

The third category is utility data which include current and forecasted loads, growth rates, avoided cost information, and line losses. FortisBC provided a load forecast by sector with average annual growth of 1.4 percent (gross load) over the planning period 2011 through 2030. Line losses are assumed at 8.8 percent over the period. The load forecast provided includes historic conservation trends through utility programs and code and standard changes.

The inflation rate assumed is 2 percent annually with a utility nominal discount rate of 10 percent.

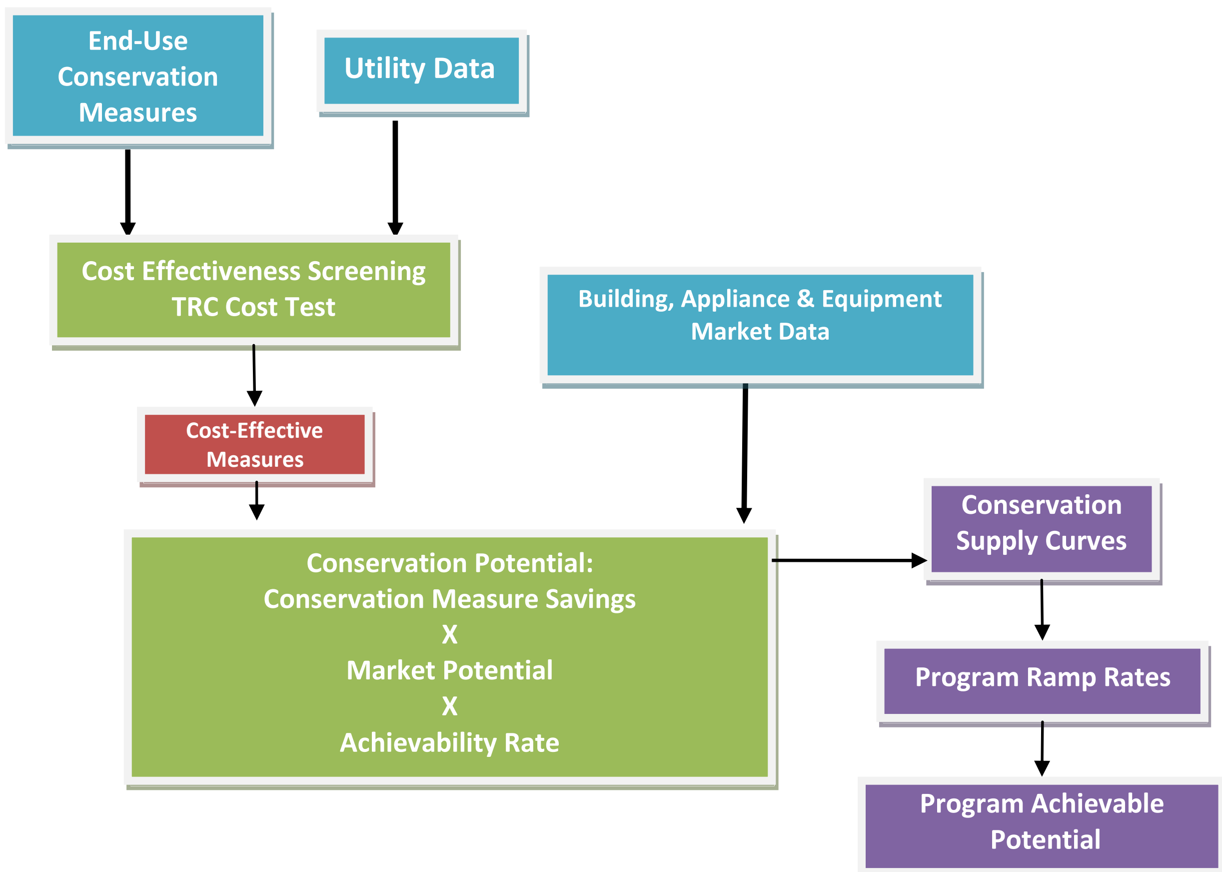
Energy Benefits

The avoided cost of electricity is the dollar value per MWh, of the conserved electricity, and accounts for the benefit value in cost effectiveness tests. In addition, avoided costs for transmission and distribution as well as peak summer and winter demand is also valued ($/kW). These energy benefits are often based on the cost of a generating resource, a forecast of market prices or an integrated resource planning process. For this study, BC Hydro’s long-term avoided costs are used to value energy, peak demand, and transmission and distribution savings. Avoided costs for energy measures are $154/MWh in levelized cost terms (2010 dollars). This energy value includes local and bulk transmission savings. Winter peak savings for demand measures with primarily capacity savings are valued at $190/kW-yr (2010 dollars). This value includes both avoided capacity and infrastructure costs such as transmission and distribution. Summer peak savings are not valued.

Basic Modeling Methodology

There are two general analytical approaches to estimating conservation potential: a bottom-up approach and a top-down approach. The bottom-up approach is the primary method used for this assessment and is illustrated by Figure 2. The key factor is the number of kWh saved annually from the installation of an individual energy efficient measure. The savings from each measure is multiplied by the total number of measures that could be installed over the life of the program. Savings from each individual measure is then aggregated to produce the total potential.

Figure 2
Conservation Potential Assessment Process



Estimating Technical Potential

The technical potential is the sum of all measure savings and possible applications of the measure across the service territory. Estimating the technical potential begins with determining a value for the energy efficiency measure savings. Then, the number of "applicable units" must be estimated. "Applicable units" refers to the number of units that could technically be installed in a service territory. This includes accounting for units that may already be in place. A sample formula for calculating technical potential for a residential measure is shown below:

Measure Savings = (Per Unit Savings) x (# of households) x (Applicability) x (1- Saturation)

The "Applicability" value is highly dependent on the measure and the housing stock. For example, a heat pump measure may only be applicable to single family homes with electric space heating equipment.

In addition, technical potential should consider the interaction and stacking effects of measures. For example, if a home installs insulation and a high efficiency heat pump, the total savings in the home is less than if each measure were installed individually (i.e., interaction). In addition, the measure-by-measure savings depend on which measure is installed first (i.e., stacking).

Total technical potential is often significantly more than the amount of economic and achievable potential. The difference between technical potential and achievable and or economic potential is due to number of measures in the technical potential that are not cost-effective, and the applicability or total amount of savings of those non-cost effective measures.

Estimating Economic Potential

Energy efficiency potential assessments estimate the amount of energy savings potential that is available and cost-effective. To find cost-effectiveness potential, energy efficiency measures must pass economic screening. In British Columbia, economic potential is defined using a total resource cost (TRC) test to screen measures for cost effectiveness. A total resource cost perspective considers all costs and benefits for each energy efficiency measure regardless of to whom they occur. Costs and benefits include, capital cost, O&M cost over the life of the measure, disposal costs, program administration costs, environmental benefits, distribution and transmission benefits, energy savings benefits, economic effects, and non-energy savings benefits. Appendix B describes the TRC test as it applies in British Columbia in more detail.

Another common cost-effectiveness test is the utility cost test (UCT) (also known as the program administrator cost test). This test considers only those costs and benefits that accrue to the utility. The drawback of this method is that it does not ensure that public resources are allocated in the most efficient manner. Energy efficiency measures with significant non-energy benefits, but smaller energy benefits may not pass the screening. Also, this test does not include all the costs of the measure but only those that accrue to the utility. FortisBC requested that UCT results be presented for each measure. In addition, participant cost tests (from the participant perspective) as well as rate-payer impact tests are also included. Appendix C describes these various cost-effectiveness tests in more detail.

Estimating Achievable Potential

Achievability criteria can be applied either to technical potential or to economic potential. There are several methods for accounting for achievability, in the Pacific Northwest, the NWPCC applies achievability criteria prior to the economic cost-effectiveness tests. Specifically, the NWPCC uses an 85% achievability factor for all measures and has published a white paper describing the basis for using this value[1]. This value indicates that over the course of a 20-year potential study, 85% of all technical potential can be achieved, regardless of how it is achieved.

There are many different types of achievability factors and many ways to apply them. In addition, the achievability can be evaluated through different scenarios (e.g., high, medium, low). Scenarios can be based on the level of incentives offered or other program design factors.

Model Output - Supply Curves

Each type of potential can be summarized by a supply curve where savings potential (MWh) is graphed against the levelized cost ($/MWh). Measure costs are standardized (levelized) allowing for the comparison of measures with different lives. The supply curve facilitates comparison or demand-side resources to supply-side resources and is often used in conjunction with Integrated Resource Plans (IRPs).

Levelized Cost

The levelized cost of the measure is the discounted present value cost of the measure annualized over its life divided by the annual energy savings. The equation below illustrates how the levelized cost is calculated.

$$Levelized\ Cost = \frac{r}{1-\frac{1}{(1+r)^{measure\ life}}} \times (capitalcost + program\ administration\ costs)$$

Where r is the interest rate.

Dividing the equation above by the annual savings (MWh) produces levelized cost in terms of dollars per MWh. This levelized cost calculation is the same as BC Hydro’s Cost of Conserved Energy (CCE).

Program Achievable Potential

The last step to estimating reasonably attainable conservation potential over the time period is to assign ramp rates to each measure. Ramp rates might be individual for each measure, or one type of ramping might apply to several similar measures. How quickly savings from a particular measure is ramped up over the period depends on several factors:

[1] “Achievable Savings: A Retrospective Look at the Northwest Power and Conservation Council’s Conservation Planning Assumptions.” August 2007. http://www.nwcouncil.org/library/2007/2007-13.htm.

- Availability of technology;
- Program readiness;
- Whether the measure is implemented before or at the end of building or unit life; and
- Changes in codes or standards.

Ramp rates are applied to achievable potential; the result is program achievable potential, or the amount of potential a utility could reasonably expect to obtain over the time period given best current knowledge.

Historic Conservation Achievement

Historic conservation achievements are examined to adjust the 2008 end-use consumption estimates as well as the baseline characteristics for potential estimation. FortisBC has been active in helping their customers become more energy efficiency through their PowerSense program since 1989. Previous programs have included residential, commercial, and industrial measures. Figure 3 illustrates historic conservation efforts from 1990 through 2008.

Figure 3
Historical Energy Efficiency Achievements

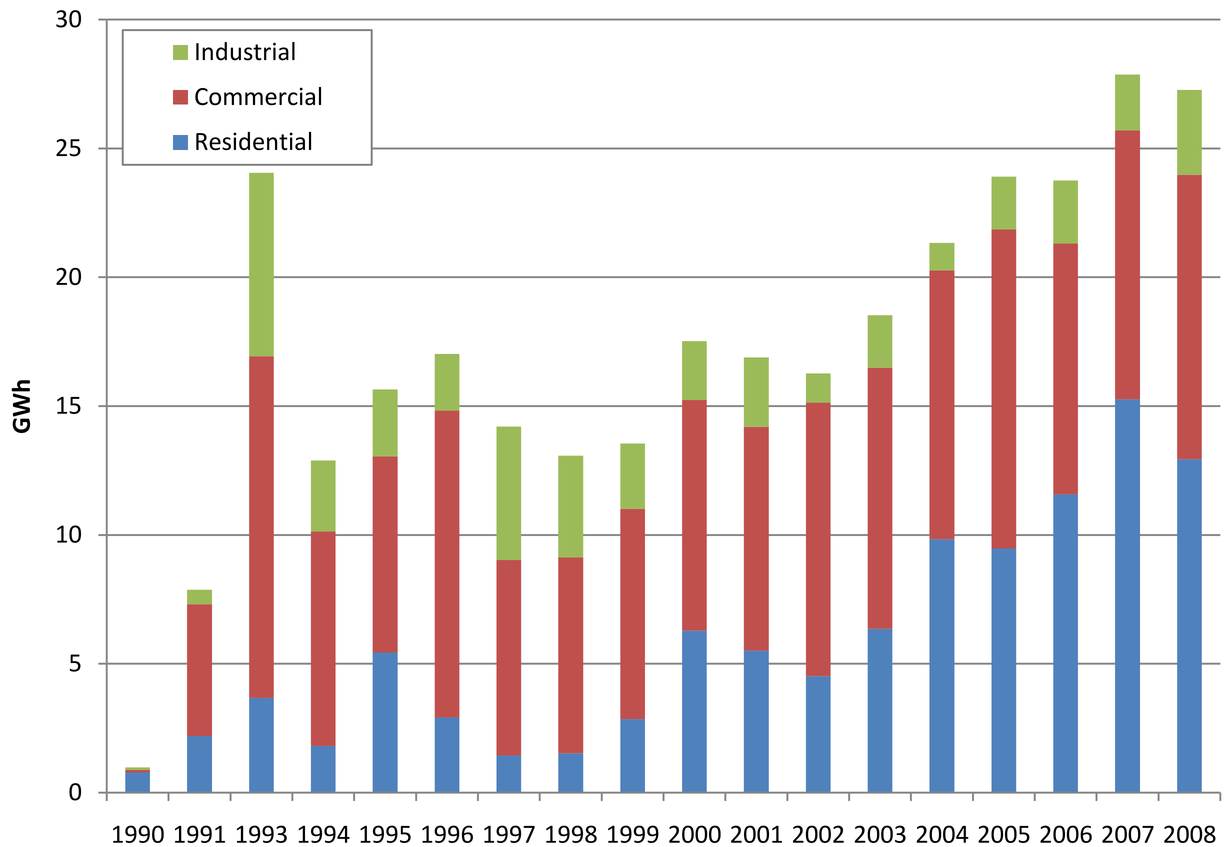
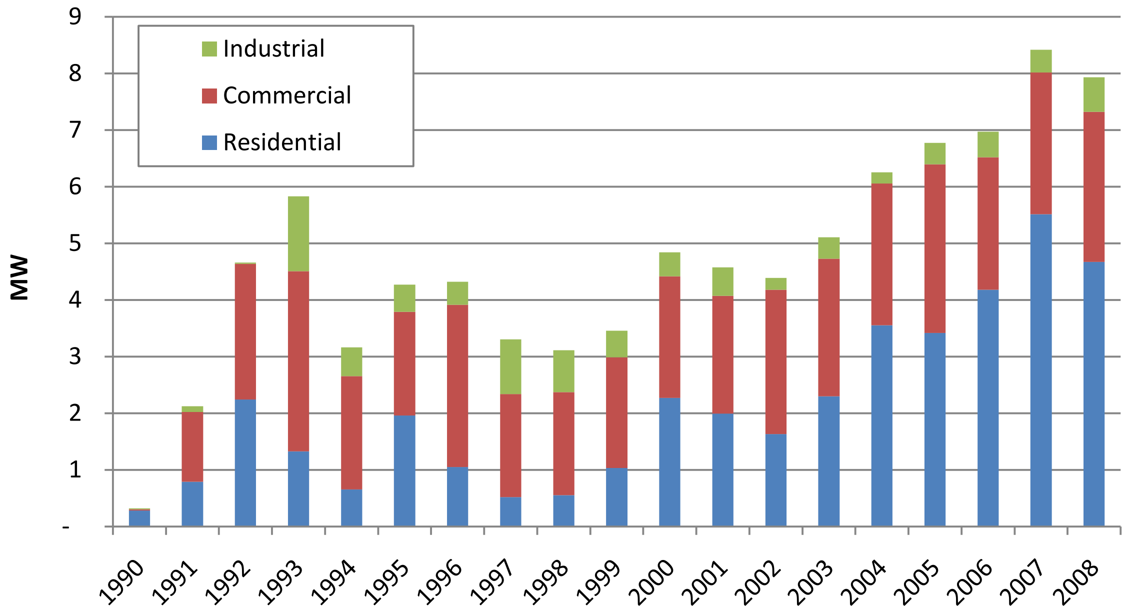


Figure 4 shows the associated demand savings for the energy savings in Figure 3.

Figure 4
Peak Demand Savings



The programs currently being utilized by FortisBC to acquire these savings are briefly described in the following sections.

Residential Incentives

LiveSmart BC - Provincial Program

To take advantage of FortisBC's energy efficiency incentives, some programs require that homeowners work through a government-run program called LiveSmart BC. This program coordinates utility, provincial, and federal promotions and has funding to operate through March 31, 2011. To take advantage of LiveSmart BC, homeowners must order an energy evaluation for their home. Some PowerSense rebates or loans are obtained through LiveSmart BC. These programs are identified in the descriptions below.

PowerSense

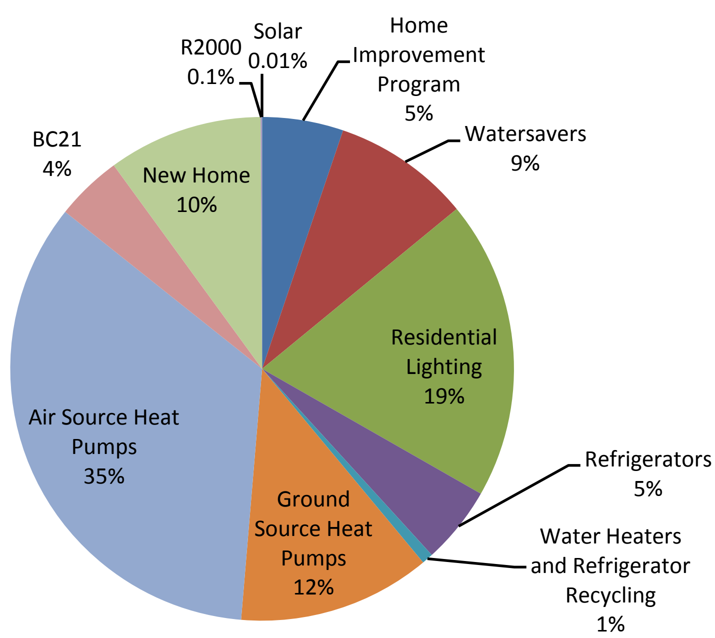
Residential energy efficiency programs include the following:

- **New Home Program (NHP)** – offers homeowners rebates on energy efficient windows, lighting, and technologies such as heat pumps for new construction projects.
- **Home Improvement Program (HIP)** – FortisBC offers several rebates for weatherization and heat pumps for electrically heated homes. Customers who receive rebates through the LiveSmart BC program are ineligible to receive rebates from the HIP.

- **Weatherization** – FortisBC offers rebates of $0.50 per square foot for windows, $0.05 per kWh savings for insulation upgrades.
- **Lighting** – Up to 10 free CFLs are available under the NHP and rebates of 50% the price of the bulb or up to $5/ bulb are available for retail sales.
- **Air Source Heat Pumps** – Customers can receive either a rebate or a low-interest loan for air source heat pumps for existing homes through the LiveSmart BC Program. The rebate amount is $0.05 per kWh savings (usually around $300per unit). The loan amount can be up to $5,000 over 10 years at 4.9%. Qualifying heat pumps must be EnergyStar rated for Canada. Incentives available through LiveSmart BC.
- **Ground Source Heat Pump** - Customers can receive either a rebate or a low-interest loan for ground source heat pumps for existing homes through the LiveSmart BC Program. The rebate amount is $0.05 per kWh savings(typically $900). The loan amount can be up to $5,000 over 10 years at 4.9%. System equipment design and installation must meet CSA Standards. Incentives available through LiveSmart BC.
- **Solar Hot Water Systems** – For new homes, a $1,000 Natural Resource Canada (NRCAN) rebate is available. Requires at least 6 square metres of South-facing roof space. A $300 rebate is available for existing homes with electric hot water heaters for the solar upgrade.

Figure 5 illustrates the share of historic energy savings by measure category. A significant share of historic savings is from heat pump installations.

Figure 5
Share of Residential Energy Efficiency Program Achievements 1990-2008



General Service Incentives

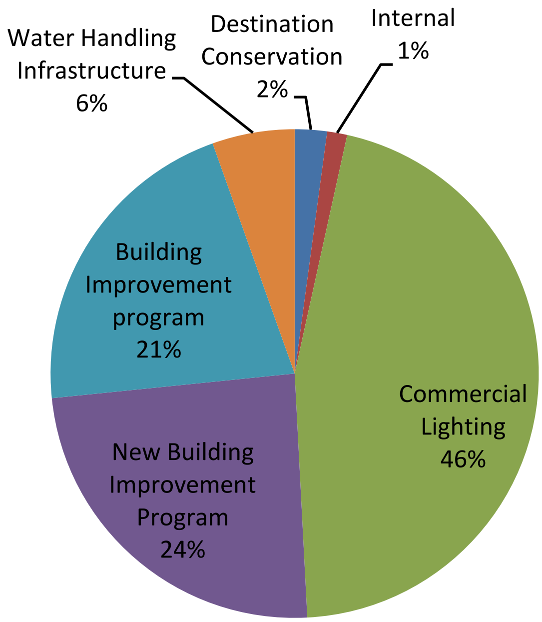
PowerSense

Commercial building energy efficiency programs include the following:

- **Lighting** – FortisBC provides rebates for compact fluorescent lighting, electronic ballasts, reflectorized luminaries, T8 fluorescents, LED and CFL exit lights, high density discharge lighting, and motion sensors or other lighting control systems.
- **New Building** – FortisBC offers a free initial assessment of new building design for energy efficiency. In cases where a more detailed assessment is required, FortisBC will cover 50% of the cost up to $5,000. Rebates are available for energy efficiency measures above the baseline construction standard.
- **Existing Buildings** – Qualified customers can take advantage of a free walk-through energy audit conducted by a qualified technical advisor to identify where conservation opportunities exist. If required, FortisBC will fund up to 50 percent, to a maximum of $5,000, of an approved consultant's fee to conduct a comprehensive energy study. Possible technologies include lighting, HVAC control systems or variable speed drives, water heating, refrigeration measures, building envelope, and motors.
- **Rebate structure –** General Service rebates are the lesser of:
    - Five cents per annual kWh saved;
    - 50% of installed retrofit cost;
        - 100% of incremental cost for new construction; or
    - Amount necessary to achieve a two-year payback.

Figure 6 illustrates the share of historic commercial energy efficiency achievements. Commercial lighting makes up almost half of historic achievement.

Figure 6
Share of Commercial Energy Efficiency Program Achievements 1990-2008



Industrial Incentives

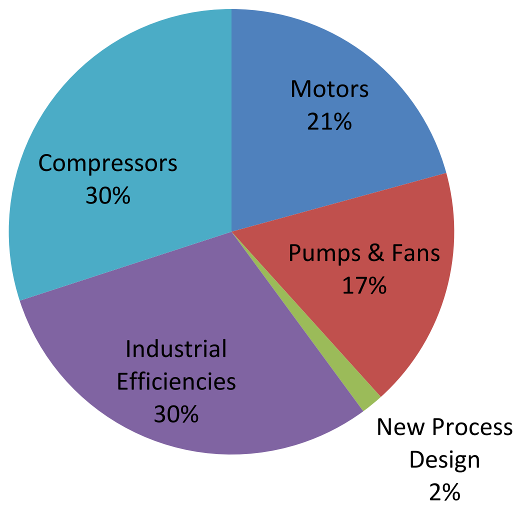
PowerSense

Industrial building energy efficiency programs include the following:

- **Walk Though Audit**– FortisBC offers a free walk through energy audit by a technical advisor to identify where potential energy savings opportunities exist. In cases where a more detailed assessment is required, FortisBC will cover 50% of the cost for an approved consultant. Energy efficiency measures may include motor upgrades, air compressor upgrades, process or non-process energy savings, pumps and fans, variable frequency drives, or other measures.
- **New Process Design** – A technical advisor or an approved consultant is available to assess new process design. Rebates are available for suggested technology upgrades for approved energy efficiency measures.
- **Rebate Structure** – same as General Service

Figure 7 illustrates the share of historic industrial energy efficiency savings.

Figure 7
Share of Industrial Energy Efficiency Achievements 1990-2008



Irrigation and Municipal Infrastructure

PowerSense

FortisBC offers audits or incentives up to 50% of an approved consultant's fee for energy audits in irrigation and municipal infrastructure. Financial incentives are available for identified projects 5 cents per kWh up to 50 percent of the incremental project cost or the amount required for a 2-year payback, whichever is less. The following areas are available for energy savings:

- Irrigation – Pumping systems can achieve increased energy efficiency through motor downsizes, upgrades, new gaskets, variable speed drives, digital control, or other equipment.

- Water and Waste Water Treatment – Annual capital improvement programs provide opportunities for energy efficiency upgrades that benefit ratepayers. FortisBC currently has agreements with each municipality to review energy efficiency potential each year.

- Traffic and Street Lighting – Similar to water and wastewater treatment agreements, energy efficiency is included in the annual capital improvement plan for city lighting. Due to successful past programs, virtually all traffic lights in FortisBC's service territory are already updated to LED technology.

Partner in Efficiency

FortisBC enters into a Partners in Efficiency (PIE) agreement with institutional, commercial, and industrial (ICI) customers such as schools, municipalities, hospitals, and other large commercial and industrial accounts. The PIE is a signed agreement that involves the following:

- Customer agreement to review their capital expenditure plan with FortisBC on an annual basis to identify key projects to improve energy use;
- FortisBC works with the customer to determine the economics for energy efficient upgrades to the project;
- Recommendations for improvements are presented with estimated costs, savings, applicable rebates;
- Rebates are presented upon project completion; and
- Monitoring and evaluation.

Summary

FortisBC has a strong history in energy efficiency achievement through its programs. FortisBC programs target energy efficiency across all customer classes including indirect customers. Energy efficiency programs target improvements from a whole-building or system perspective providing comprehensive efficiency upgrades. In addition, the Partner in Efficiency agreement continues energy efficiency conversations from year to year providing flexibility within each program for technology advancements.

End-Use Model

Introduction

This section summarizes the assumptions and results of the load forecast by end-use. End-use forecasts were prepared for commercial, residential, and industrial sectors. The end-use forecast includes all customers, both direct and indirect, that are served by FortisBC.

Residential End-Use Forecast - Energy

Methodology

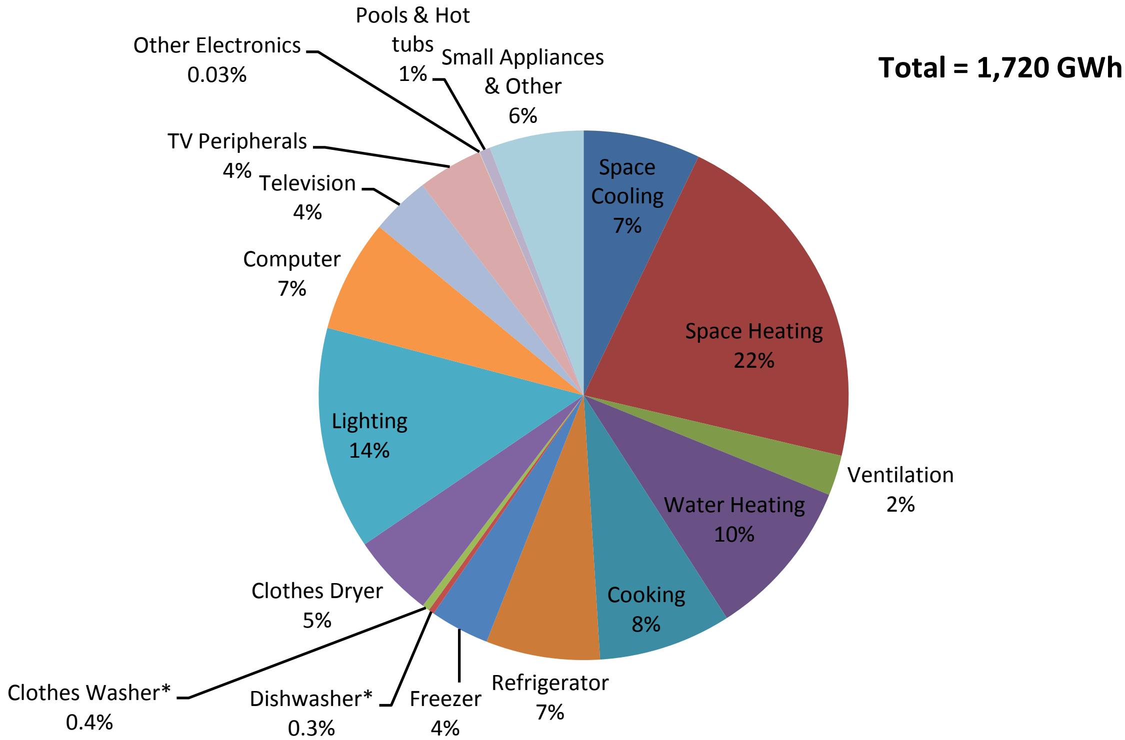
End-use consumption for residential customers was estimated based mainly on the 2009 Residential End-Use survey results. Appliance saturations, heating types and fuels as well as hours of use are used to define building characteristics. For instance, the number of refrigerators in single family homes built prior to 1976 was calculated from the survey data. Next, an average annual use was applied to the number of units. The result is energy consumption by appliance or end use.

Average use data was obtained from a combination of the BC Hydro 2007 Conservation Study as well as FortisBC's survey. The BC Hydro data is used to determine the average annual electricity use by building type, vintage, and heating fuel (i.e. single family, pre-1976, electrically heated). Average use from the FortisBC Survey is used to benchmark how well the BC Hydro data describes FortisBC customer energy consumption. Overall, the BC Hydro average use data results in average customer use by building type (single family, apartment, etc.) that is similar to the average use presented in the FortisBC survey (shown later in Table 1).

2008 Base Results

The first step was to define current end-use energy consumption for FortisBC customers. Figure 8 illustrates the share of energy consumption by end-use category. Total consumption is estimated at 1,720 GWh for 2008 (weather adjusted).

Figure 8
2008 Base Level End-Use Consumption - Residential



*Energy use is for motors etc. Use of hot water for these appliances is captured under Water Heating.

A comparison of average use by customer building type is presented in Table 1 below. The average use across all building types is within 5% of the average use collected by the 2009 survey. Variation in weather may account for some of the differences in average use.

Table 1
Average Customer Use Comparison

Building Type	End-Use Model kWh	FortisBC Survey kWh	% Difference	Units/ Customers
Single Family	13,424	13,057	-2.81%	94,431
Mobile Home	9,375	9,014	-4.01%	10,737
Apartment Condo	5,913	5,109	-15.74%	17,620
Townhouse, Duplex, Row	8,925	8,521	-4.74%	14,867
Total	11,661	11,234	-3.80%	137,655

Once the 2008 baseline is established, energy-consuming units and average use are forecasted through the end of the planning period. The results are then compared to the utility's load forecast. Building growth rates range from 0.27 to 5.64% for new construction over the period with demolition rates near 0.25% for existing homes. Existing mobile homes have slightly higher demolition rates (0.35%). Table 2 shows average annual growth rate by building type. Historic building permit data was used to distribute the total customer growth rate among building types. Building permits for apartments have increased significantly since 2004.

Table 2
Average Annual Net Growth Rate[1]
Number of Buildings

	Single Family	Mobile Home	Apartment	Row	Total
2009-2012	0.52%	0.27%	5.03%	0.41%	1.46%
2009-2020	0.50%	0.28%	5.22%	0.41%	1.46%
2009-2030	0.50%	0.28%	5.64%	0.43%	1.18%

(1) Includes demolition rates.

Appliance saturation data is estimated on a case-by-case basis. Some saturation rates such as heat types, refrigerators, freezers, and clothes washers do not change significantly over the period. On the other hand, saturations such as televisions, television peripherals, and other electronics were estimated to increase over the period. The saturation of central air conditioning as well as room or portable air conditioners is also projected to increase.

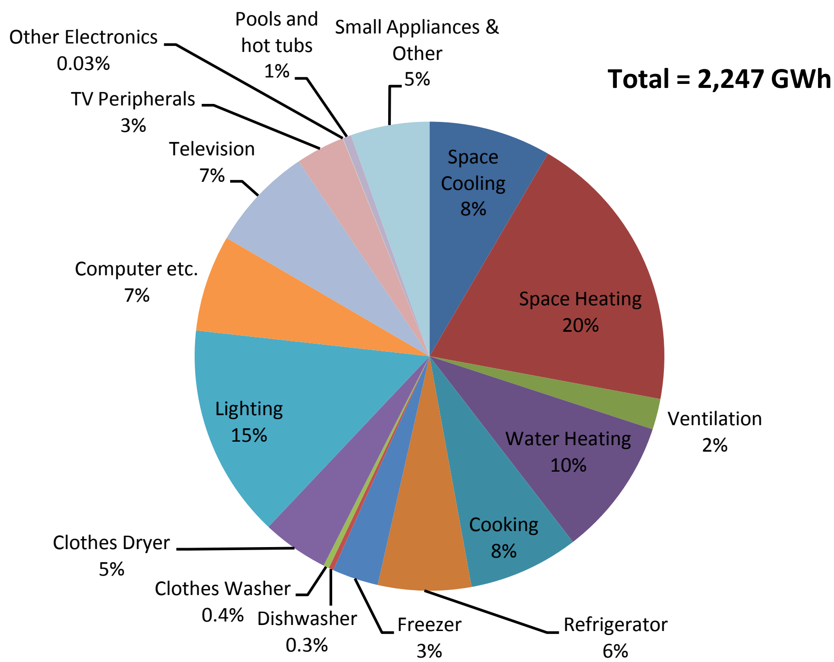
Table 3 compares the FortisBC forecast with the energy consumption estimated using end-use consumption and growth in residential building square footage. Because the FortisBC load forecast does not separate residential customer consumption from other classes within the wholesale forecast, the 2008 residential consumption from wholesale customers (Summerland, Nelson, Penticton, Kelowna, and Grand Forks) is projected at growth rates consistent with total wholesale sales growth.

Table 3
Residential Forecast Comparison - Energy

	FortisBC Load Forecast MWh	End-Use Model MWh	% Difference
2008	1,719,530	1,719,530	0.0%
2009	1,745,793	1,744,633	-0.1%
2010	1,772,466	1,771,657	0.0%
2011	1,783,712	1,800,177	0.9%
2012	1,807,542	1,822,257	0.8%
2013	1,831,541	1,844,574	0.7%
2014	1,855,710	1,866,484	0.6%
2015	1,880,701	1,888,620	0.4%
2016	1,906,346	1,910,985	0.2%
2017	1,932,249	1,933,580	0.1%
2018	1,957,970	1,956,408	-0.1%
2019	1,983,400	1,979,470	-0.2%
2020	2,008,728	2,002,769	-0.3%
2021	2,034,028	2,026,307	-0.4%
2022	2,059,050	2,050,086	-0.4%
2023	2,083,634	2,074,107	-0.5%
2024	2,107,779	2,098,374	-0.4%
2025	2,131,534	2,122,888	-0.4%
2026	2,154,780	2,147,651	-0.3%
2027	2,177,513	2,172,666	-0.2%
2028	2,199,772	2,197,989	-0.1%
2029	2,221,489	2,223,753	0.1%
2030	2,242,585	2,247,212	0.2%

Because house sizes and appliance saturation data changes over the period of the forecast, the share of end-use consumption also changes. Figure 9 illustrates the breakdown of energy consumption by end-use for 2030. Energy consumption by electronics has increased as well as lighting and space cooling energy consumption. In comparison, space heating and major appliances consume a smaller share of the total consumption.

Figure 9
2030 Residential Energy Consumption Breakdown



Residential End-Use Forecast – Peak Demand

Winter Peak Methodology

The winter peak demand forecast is estimated using the following inputs:

- FortisBC energy consumption by end use for each building type (single family, row or townhouse, apartment, and mobile home)
- BC Hydro coincident peak load by end-use and building type
- BC Hydro coincident peak demand for electric heat and annual kWh consumption[2]

Similar to FortisBC, BC Hydro's winter coincident peak occurs near either the 6:00 p.m. hour on a January or a December day. The peak is highly correlated with the coldest day of the year. Given this similarity, the relationship between energy demand by end use (kW) and total peak

[2] Effectively, load factors from BC Hydro's study are used to estimate FortisBC load factors using data from BC Hydro's Southern Interior region.

demand for each housing type is used to estimate FortisBC peak. The advantage of using BC Hydro data in this top-down approach is that behaviours and energy use for people in similar service territories are captured. These behaviours reveal the components of coincident peak demand in the residential sector. The disadvantage of this methodology is that the differences between FortisBC customers and BC Hydro customers are not fully represented. Examples of important differences include the higher penetration of CFLs among FortisBC customers. On the other hand, differences in building types across service territories are accounted for.

2008 Base Results

The methodology above results in an estimated peak of 427 MW from residential customers (including wholesale). For comparison, the total system peak for is estimated at 701 MW (weather adjusted). Figure 10 illustrates the breakdown of the coincident peak demand. Twelve percent of coincident peak demand is due to cooking, which can be expected given the assumption that the peak occurs at 6 p.m. Also, as expected, space heating and lighting make up the largest share of peak demand for residential customers.

Figure 10 shows winter peak demand estimates by end-use for 2008. Average annual growth in winter peak demand is approximately 0.9%, according to the FortisBC load forecast.

Figure 10
2008 Winter Peak Demand - Residential

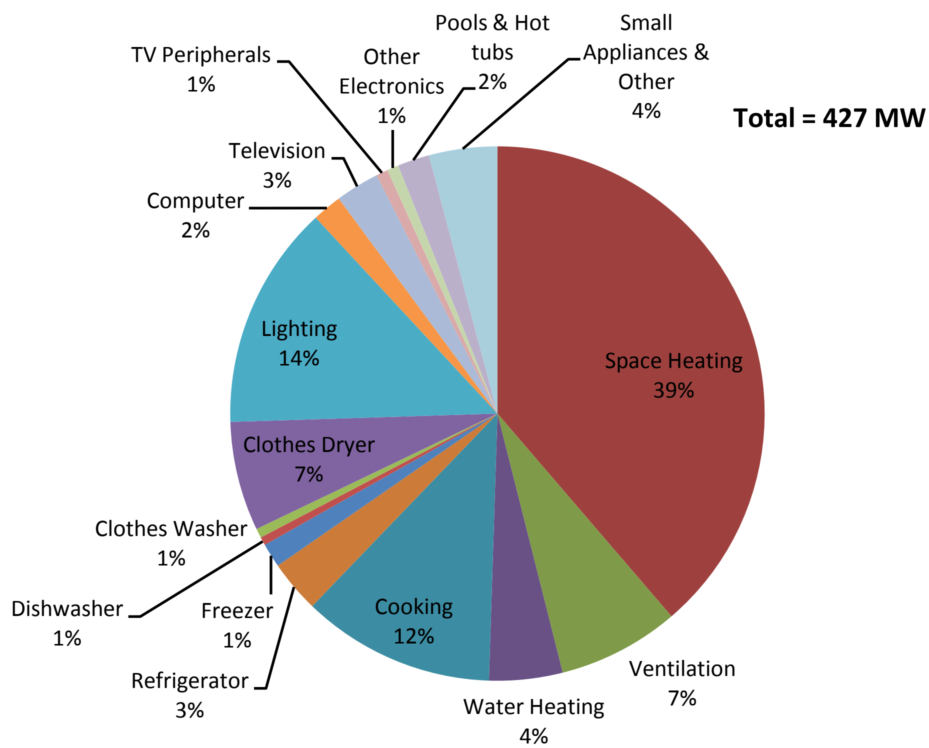
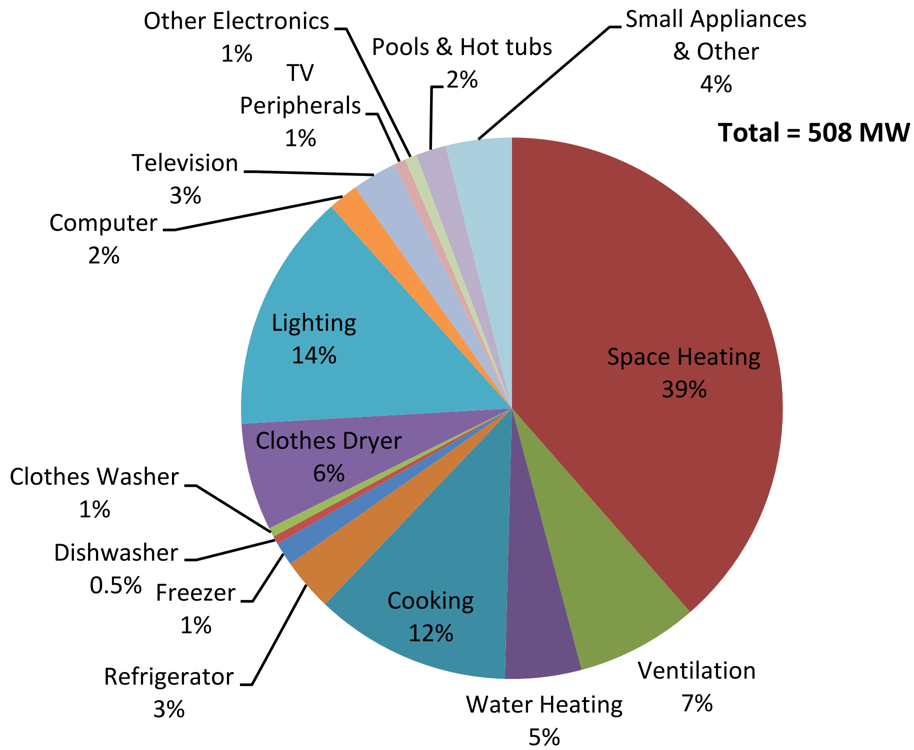


Figure 11 shows the forecast 2030 winter peak demand breakdown from the end-use model.

Figure 11
2030 Winter Peak Demand - Residential



Summer Peak Methodology

The summer peak demand forecast is estimated using the following inputs:

- FortisBC energy consumption by end use, and
- Summer peak load factor by end-use from statewide California load factors[3]

Load factors were adjusted to account for differences in weather between FortisBC and California based on population-weighted cooling degree days and maximum temperature. Load factors are applied to kWh consumption to produce kW demand. See calculation below for an example of how load factors are applied to energy to produce peak demand estimates.

$$\frac{kW_{peak}}{kWh_{annual}} \times kWh_{annual} = kW_{peak}$$

[3] Brown, Richard E. and Jonathan G. Koomey. "Electricity Use in California: Past Trends and Present Usage Patterns." Berkeley, CA: May 2002. Available at: <http://enduse.lbl.gov/info/LBNL-47992.pdf>

2008 Base Results

Figure 12 illustrates the breakdown of summer peak demand. The 2008 residential peak summer demand is estimated at 271 MW.

Figure 12
2008 Summer Peak Demand - Residential

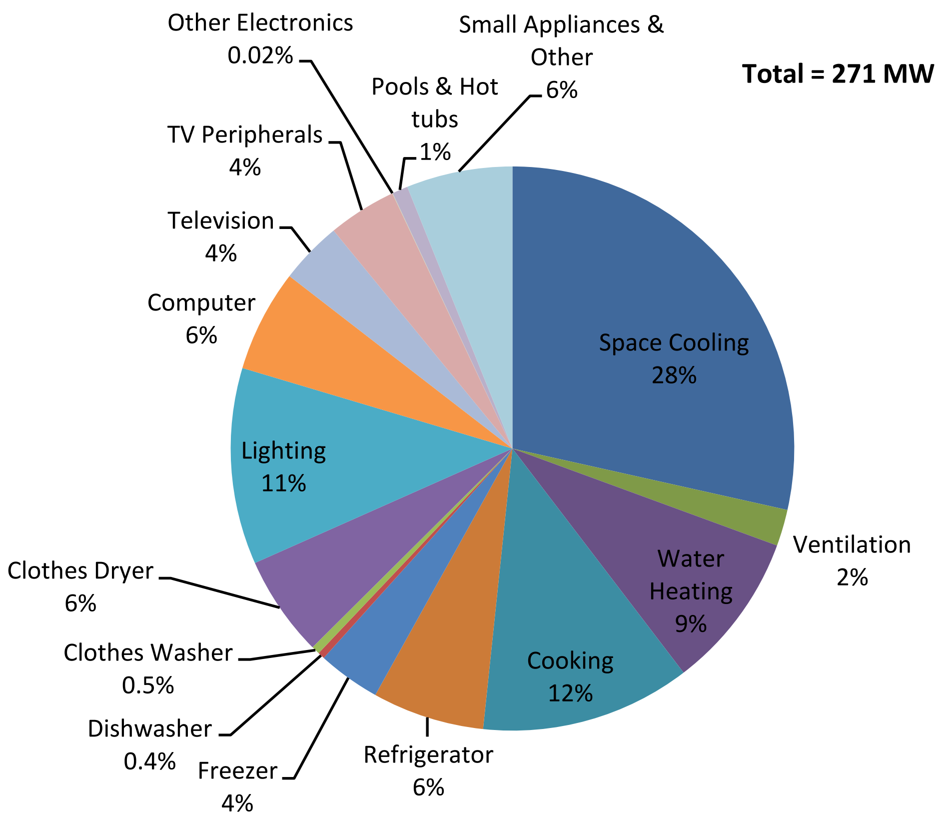
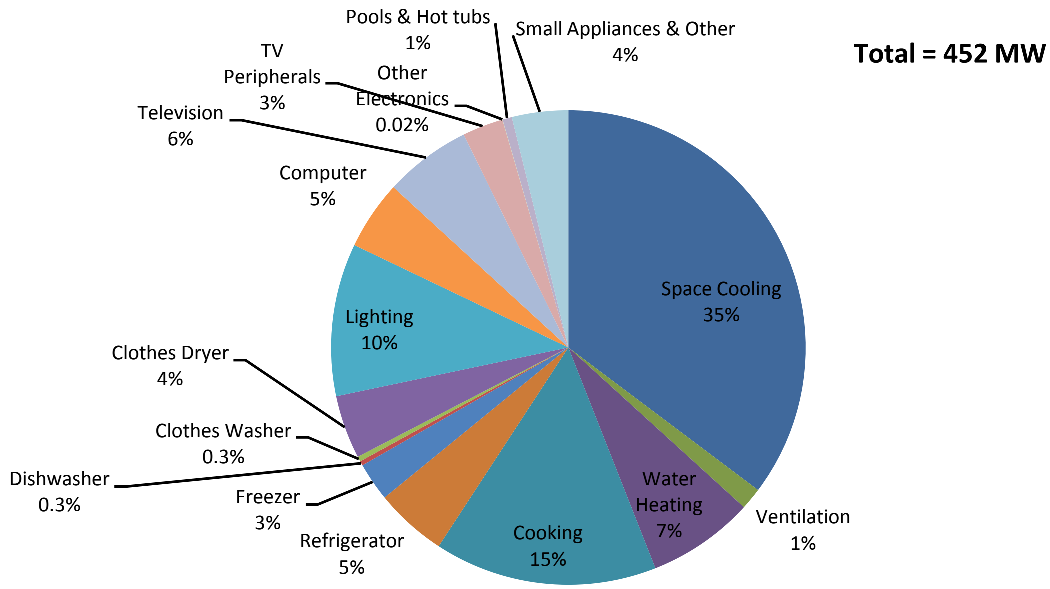


Figure 13 illustrates the forecast 2030 summer peak break down by end-use. Average annual growth in summer peak demand is 2.6%. The large growth rate can be attributed to significant growth in the penetration rate of air conditioning units and central AC.

Figure 13
2030 Summer Peak Breakdown by End-Use – Residential



Commercial End-Use Forecast - Energy

Methodology

The end-use forecast for commercial buildings was calculated according to the following steps:

1. Estimate the share of commercial buildings for each commercial building type (i.e. restaurant, office, retail etc) from FortisBC survey data;
2. Estimate the average square footage for each building type and benchmark against FortisBC survey data;
3. Utilize publicly available sources such as BC Hydro's conservation potential study (2007), FortisBC survey results, and the Northwest Power and Conservation Council for end-use intensity data (EUI data) in kWh/square foot;
4. Using the known number of commercial customers, estimate the number of customer per building so that the number of buildings can be estimated
5. Calibrate the number of buildings so that total end-use consumption matches weather adjusted 2008 load;
   a. EUI data is multiplied by estimated square foot data calculated using the number of buildings (calibrated) and average square footage by building type
6. Compare average customer use from end-use forecast model with average commercial consumption (actual or forecast data);
7. Forecast commercial square footage through 2030 by building type;

8. Forecast EUI for each end-use by building type;
9. Apply EUI to forecast of commercial floor space.

The equation form of this methodology is shown below:

$$\{2008\ \text{Load}\}_{\text{W.A.}} = \sum_{s=1}^{n=segments} \text{Buildings} \times \left(\% \frac{\text{Buildings}}{\text{Segment}}\right) \text{x} \left(\frac{\text{SqFt}}{\text{Building}}\right) \text{x(EUI)}$$

The 2008 weather adjusted load is equal to the sum of the load in each of the commercial building segments. The key calibration variable is the number of buildings per customer.

Assumptions

FortisBC survey data was used to estimate the share of buildings that are restaurants, offices, hospitals, etc. To estimate the breakdown of buildings the Commercial End Use Survey report is used.[4] Buildings were categorized as shown in Figure 14 below. The following assumptions were made to calculate the breakdown of buildings in Figure 14 below.

- Medium and light industrial buildings are excluded
- Other includes theatres, auditoriums, churches, museums, community and recreation centers and other buildings not in the major categories
- Mixed use commercial buildings were split between offices, retail, and restaurants based on the building function designated in the survey (i.e. personal services, retail trade, eating and drinking establishments etc)
- Three customers from industrial rate class schedules are included in commercial. These include UBC Okanagan, Selkirk College, and Trail Community Health (hospital).

[4] FortisBC Inc. *2009 Commercial End-Use Study*. Discovery Research. August 2009. Page 17.

Figure 14
Commercial Building Breakdown, Number of Buildings

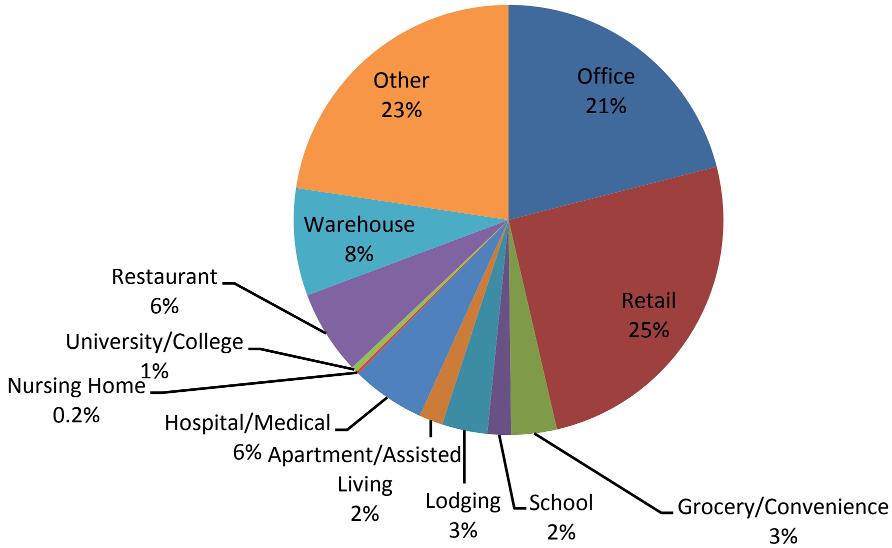


Table 4 defines the building types used in the analysis.

Table 4
Commercial Building Definitions

Building Category	Square Feet
Large Office	>100,000
Medium Office	50,000 to 100,000
Small Office	<50,000
Retail:	
Large Non-Food Retail	>100,000
Medium Non-Food Retail	50,000 to 100,000
Small Non-Food Retail	<50,000
Large Hotel	>100,000
Medium Hotel/Motel	50,000 to 100,000
Large School	>50,000
Medium School	25,000 to 50,000

EUI Data

The end-use forecast uses primarily EUI data from BC Hydro's 2007 study. The BC Hydro data corresponds to buildings in BC Hydro's "Southern Interior," or the climate zone most similar to FortisBC's climate. EUI data from the Northwest Power and Conservation Council was also considered but ultimately not incorporated since BC Hydro data is considered to better represent FortisBC data given that both territories are located in Canada and in similar climate zones. The table below shows FortisBC and BC Hydro EUI data by building type. Data from the NWPCC is also included for reference. The resulting average use per building is 192,017 kWh per year. Average use per customer is approximately 60,000 kWh per year.[5]

Table 5 compares EUI data by commercial building type.

Table 5
Building EUI Data, Annual kWh/Square Foot

	FortisBC End-Use Model	BC Hydro Southern Interior	NWPCC*
Large Office	22.0	22.0	16.4
Medium Office	18.5	18.5	15.4
Small Office	15.1	15.1	14.0
Large Retail	26.9	26.9	30.9
Medium Retail	24.5	24.5	15.2
Small Retail	18.9	18.9	12.9
Large Hotel	19.8	19.8	19.9
Medium Hotel/Motel	16.7	16.7	19.9
Large School	11.1	11.1	8.4
Medium School	8.7	8.7	8.4
Grocery/Convenience	58.3	58.3	53.7
Apartment/Assisted Living	13.4	13.4	19.9
Medical	27.7	27.7	17.8
Hospital	24.3	24.3	24.7
Nursing Home	13.4	13.4	19.9
University/College	17.7	17.7	17.9
Restaurant	66.1	66.1	41.6
Warehouse/Wholesale	16.4	16.4	5.8
Other	15.4	15.4	15.8

*For comparison purposes only.

Model Calibration

The next step is to calibrate the total number of commercial buildings so that the resulting total consumption matches the 2008 weather adjusted load. Then, the share of buildings can be applied to the total number of buildings for which FortisBC provides service. FortisBC has a total of 16,419 general service customers including both direct and indirect customers. However, many of these customers share buildings with one or more other customers or are not associated with buildings at all (such as railroad crossings). Since the total number of buildings is unknown, the commercial end-use forecast (total MWh) is calibrated to weather-adjusted 2008 actual energy consumption using the number of buildings variable. This methodology relies on accurate EUI data.

[5] FortisBC general service customers consumed an average of 59,000 kWh per year, lower than the forecast suggests. The difference could be attributed to wholesale general service customers having higher average use.

Table 6 shows the results of model calibration in terms of the number of buildings and square footage. In segments where the number of buildings is known the model uses fixed values; for the unknown segments, the number of building is estimated based on the *Commercial End-Use Survey*.

Table 6
FortisBC Commercial Building Square Footage

Building Type	Share of Buildings	Number of Buildings	Average Square Feet	Total Square Feet
Large Office	0.0%	5	NA	490,000
Medium Office	0.8%	41	50,000	2,068,492
Small Office	20.2%	1,089	4,000	4,355,504
Large Non-Food Retail	0.0%	-	NA	-
Medium Non-Food Retail	0.0%	5	NA	350,000
Small Non-Food Retail	25.4%	1,369	9,314	12,746,742
Large Hotel	0.0%	-	NA	-
Medium Hotel/Motel	3.4%	185	8,540	1,580,422
Large School	0.0%	-	NA	-
Medium School	1.8%	96	7,000	668,608
Grocery/Convenience	3.4%	185	9,300	1,721,069
Apartment/Assisted Living	1.8%	96	6,819	651,320
Medical	5.5%	298	6,000	1,790,915
Hospital	0.1%	14	88,500	1,540,000
Nursing Home	0.2%	12	5,800	69,249
University/College	0.4%	24	8,000	191,031
Restaurant/Tavern	6.3%	342	4,544	1,552,986
Warehouse/Wholesale	8.1%	436	9,339	4,069,836
Other	22.6%	1,221	14,200	17,335,456
Total	**100%**	**5,397**		**51,181,629**

Some of the above categories have sub categories by building size (Office, Non-Food Retail, Hotels etc.) FortisBC's customer surveys were used to determine what share of buildings fit into the size bins (shown in Table 4). According to the survey, the great majority of buildings are small to medium sized and less than 5% of all buildings with more than 50,000 square feet.

Results

EUI data (Table 5) is combined with commercial floor space data (Table 6) to produce kWh consumption by end use for each building type. Summed across building types, Figure 15 illustrates the kWh consumption by end-use for all building types. Total consumption is estimated at 1,033 GWh for 2008.

Figure 15
Commercial End Use Consumption, Base Year 2008

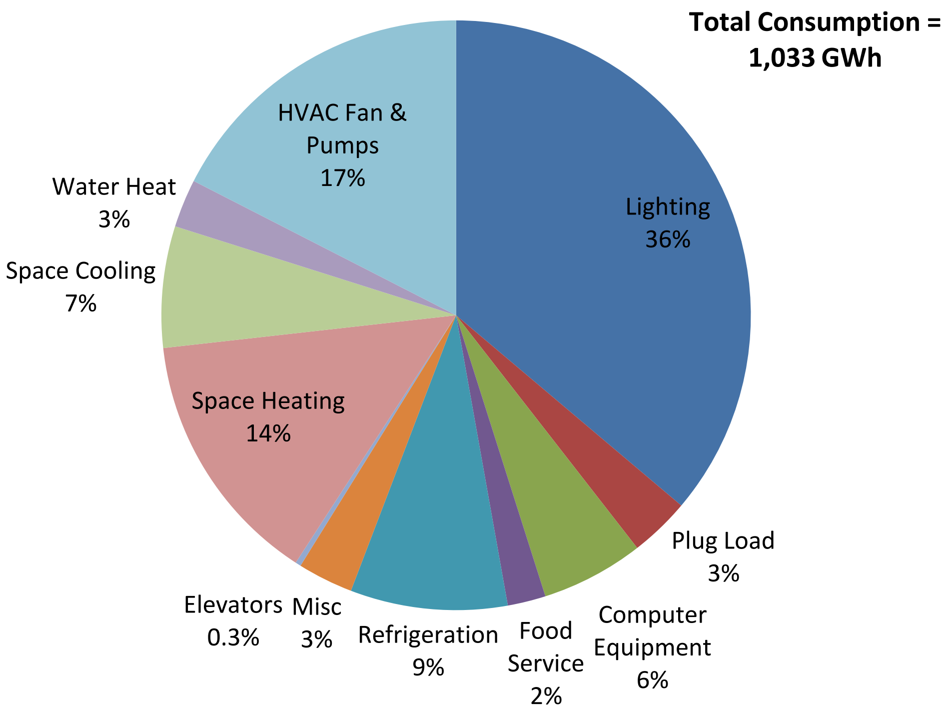
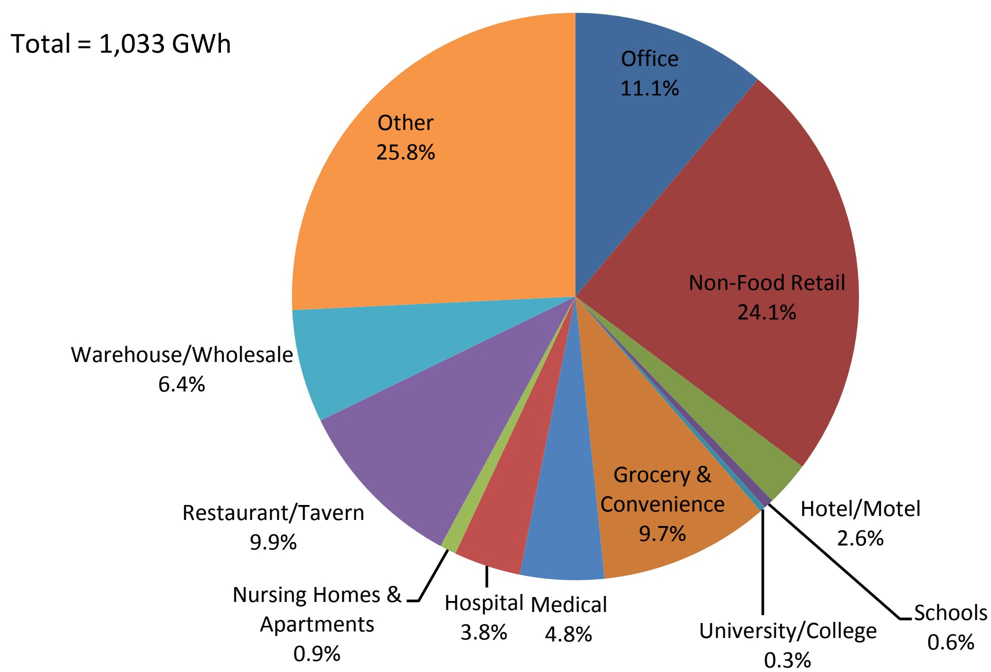


Figure 16 illustrates energy consumption by building type.

Figure 16
2008 Base Year End-Use Consumption by Building Type - Commercial



The total estimated use for 2008 is 1,033 GWh, or equal to 2008 weather-adjusted loads for commercial customers (plus the load from three commercial buildings classified under the industrial rate class).

Forecast

Average annual growth rates for building square footage were assigned by building type. Table 7 summarizes the growth rate assumptions which are based mainly on floor space growth rates in the Pacific Northwest as well as growth rates in BC Hydro's study.

Table 7
Building Growth Rates, Square Footage

Building Type	Building Growth Rates
Large Office	1.9%
Medium Office	1.3%
Small Office	1.7%
Large Retail	0.8%
Medium Retail	1.8%
Small Retail	1.8%
Large Hotel	1.3%
Medium Hotel/Motel	1.8%
Large School	0.9%
Medium School	1.2%
Grocery/Convenience	1.4%
Apartment/Assisted Living	2.6%
Medical	1.9%
Hospital	1.9%
Nursing Home	3.0%
University/College	1.3%
Restaurant	1.7%
Warehouse/Wholesale	3.2%
Other	1.9%

Table 8 compares the FortisBC forecast with the energy consumption estimated using end-use consumption and growth in commercial building square footage. Because the FortisBC load forecast does not separate commercial customers from other classes within the wholesale forecast, the 2008 commercial consumption from wholesale customers (Summerland, Nelson, Penticton, Kelowna, and Grand Forks) is projected at growth rates consistent with total wholesale sales growth.

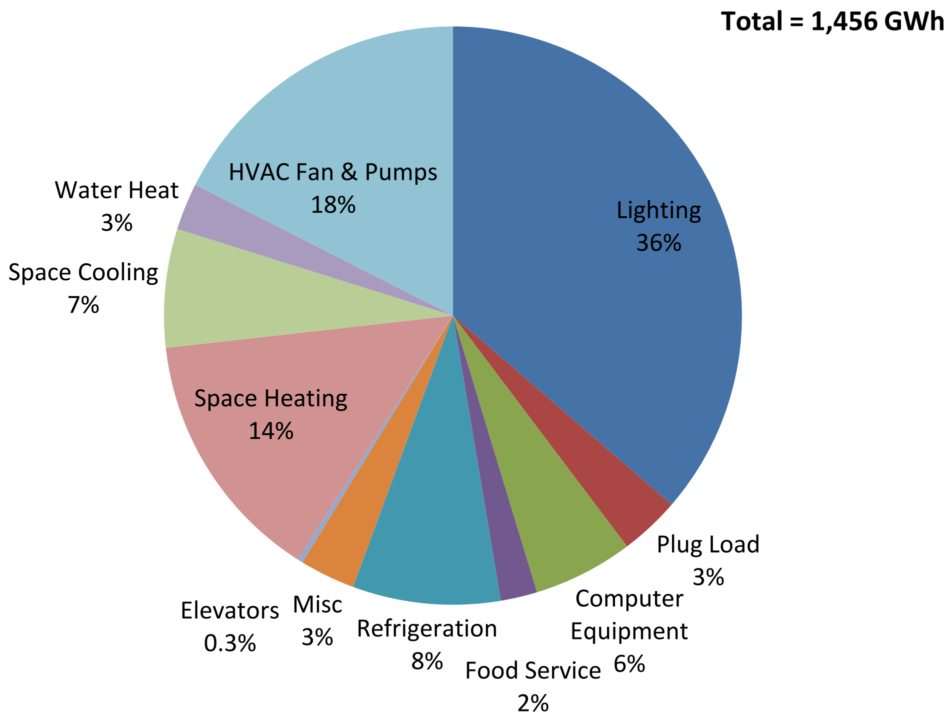
Table 8
Commercial Forecast Comparison - Energy

	FortisBC Load Forecast* MWh	End-Use Model MWh	% Difference
2008	1,033,440	1,033,440	0.0%
2009	1,036,928	1,036,896	0.0%
2010	1,061,161	1,060,909	0.0%
2011	1,086,944	1,086,469	0.0%
2012	1,114,152	1,113,455	-0.1%
2013	1,142,168	1,141,257	-0.1%
2014	1,166,264	1,165,182	-0.1%
2015	1,185,649	1,184,439	-0.1%
2016	1,203,756	1,202,432	-0.1%
2017	1,221,483	1,220,055	-0.1%
2018	1,239,774	1,238,246	-0.1%
2019	1,259,034	1,257,407	-0.1%
2020	1,278,251	1,276,533	-0.1%
2021	1,297,397	1,295,596	-0.1%
2022	1,316,781	1,314,905	-0.1%
2023	1,336,408	1,334,462	-0.1%
2024	1,355,875	1,353,869	-0.1%
2025	1,374,790	1,372,733	-0.1%
2026	1,393,482	1,391,384	-0.2%
2027	1,399,314	1,397,204	-0.2%
2028	1,419,208	1,417,064	-0.2%
2029	1,438,894	1,436,724	-0.2%
2030	1,458,361	1,456,175	-0.1%

*Excludes new DSM.

Figure 17 shows 2030 end-use consumption for the commercial sector.

Figure 17
2030 End-Use Consumption - Commercial



The EUI data for the buildings was forecasted to remain the same over the period. The EUI data were not adjusted to include energy efficiency or code changes. Change in future EUI or EUI for new buildings is accounted for in the conservation potential estimates. Energy efficiency potential due to code changes is later separated from potential available through utility programs.

Commercial End-Use Forecast – Demand

Methodology

The end-use forecast for energy was used together with load factors to estimate peak demand consumption for both the winter peak and the summer peak. The winter peak estimate is calculated by applying BC Hydro demand (kW) by end-use to FortisBC energy consumption across building types. The summer peak utilizes load factors from the Northwest Power and Conservation Council with some adjustments to account for FortisBC climate and other characteristics.

Winter Peak Demand

Figure 18 illustrates the breakdown of FortisBC winter peak by end-use. The winter peak usually occurs around the 6 p.m. hour in either December or January, depending on weather.

Using load factors and normalized annual energy, total commercial winter peak demand (normal) is estimated at 225 MW for 2008.

Figure 18
2008 Winter Peak Demand – Commercial

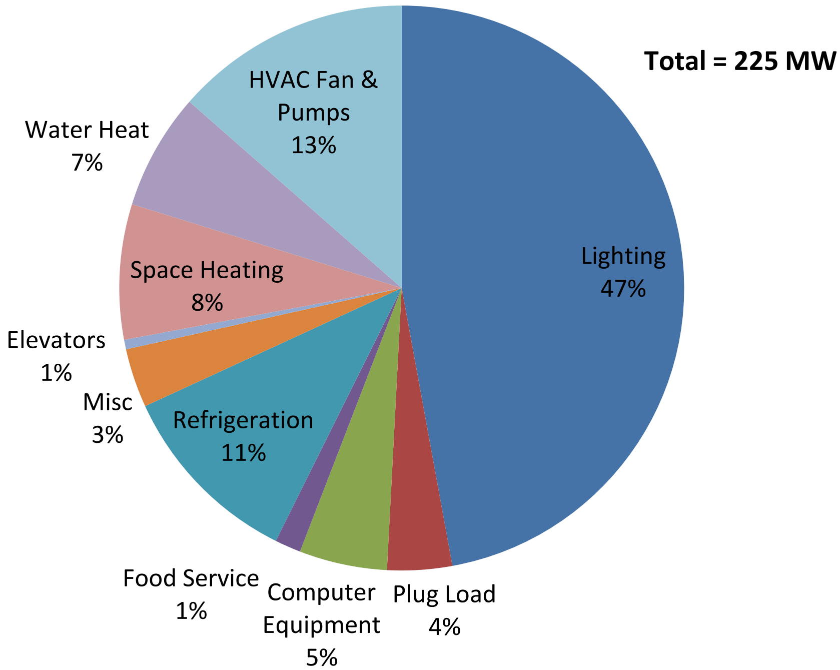
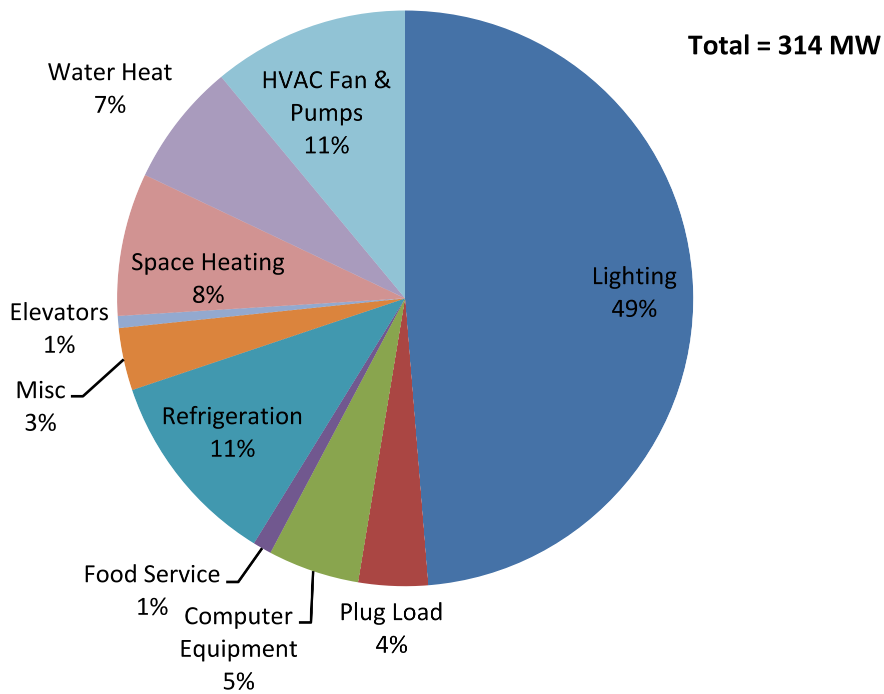


Figure 19 shows the forecasted winter peak breakdown in 2030. Average annual growth in peak demand is 1.8%. Because floor space growth rates varies across building types (See Table 7), the 2030 winter peak demand is slightly different from the 2008 winter peak demand profile.

Figure 19
2030 Winter Peak Demand – Commercial



The figure below shows the 2008 winter peak demand by end-use and customer type. Lighting is excluded in Figure 20 due to the large amount of consumption; however, lighting consumption by building type is shown in the subsequent figure. Figure 20 shows that the building types that contribute most to peak demand are small office, small retail, grocery, and other (see Table 9).

Figure 20
2008 Commercial Winter Peak Demand by Building Type and End-Use Excluding Lighting

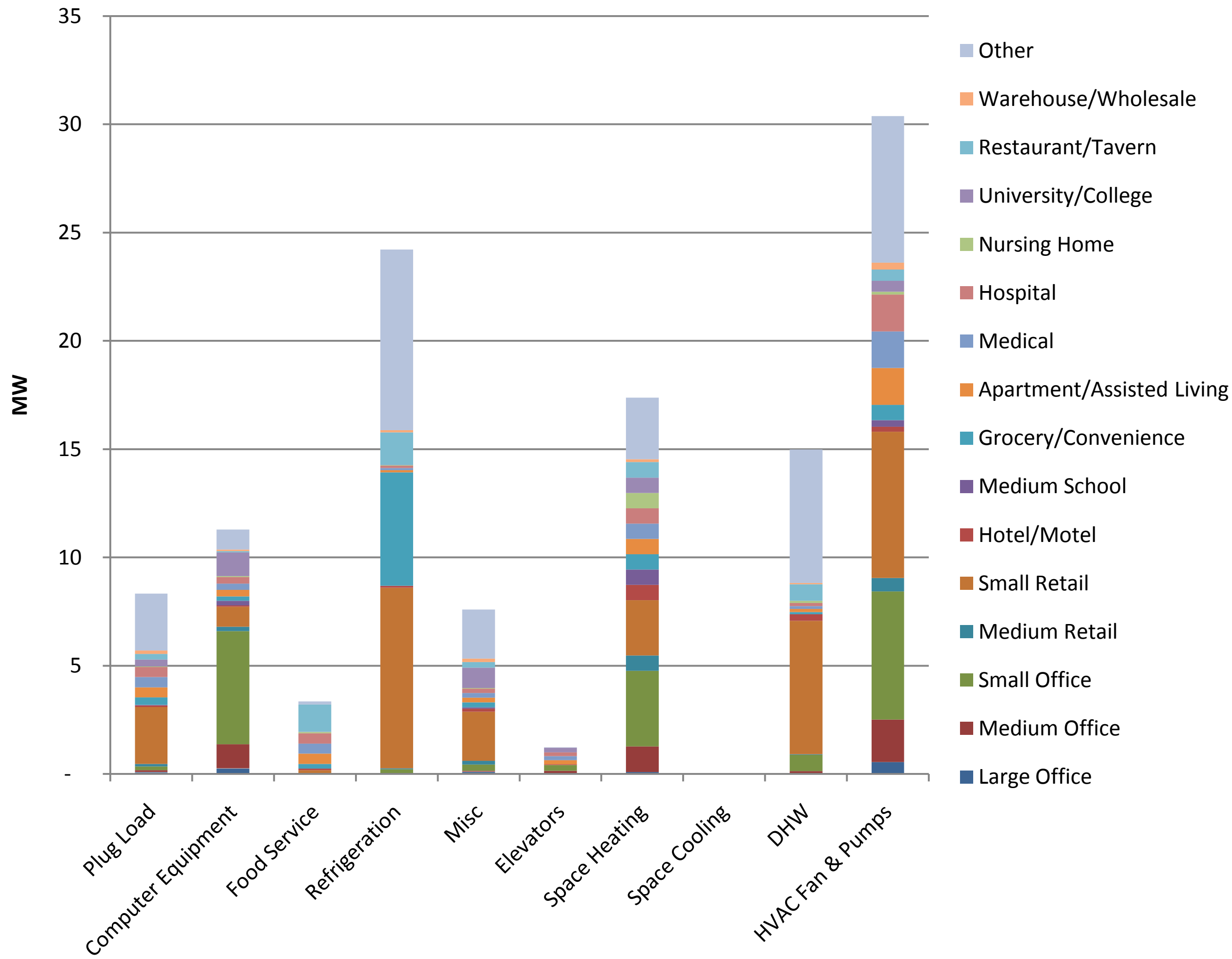
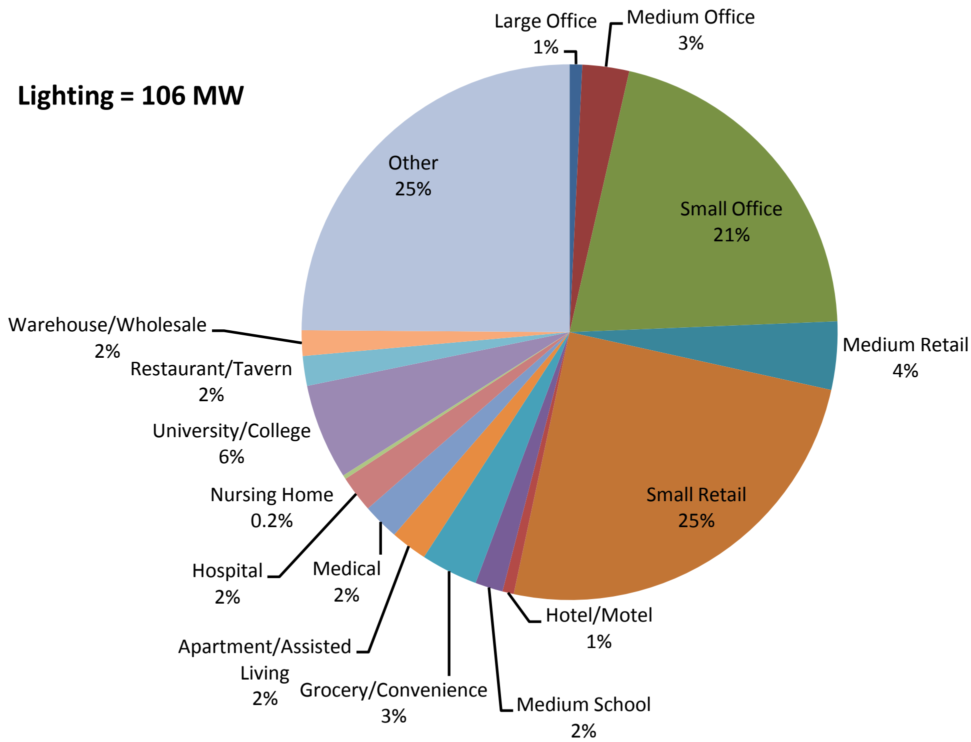


Table 9
2008 Commercial Winter Peak Demand, Top Four Building Types

	2008 Peak Demand, kW
Other	56
Small Retail	56
Small Office	38
Grocery/Convenience	11
All Commercial Buildings	225

Figure 21 shows that small office, small retail, and other building types contribute most significantly toward winter peak in terms of lighting consumption.

Figure 21
2008 Winter Commercial Peak Demand by Building Type – Lighting Only



Summer Peak Demand

Figure 22 illustrates the breakdown of FortisBC summer peak by end-use. The summer peak usually occurs in the late afternoon/early evening (around 5 P.M.) on July or August day, depending on weather. Total commercial summer peak demand is estimated at 193 MW for 2008.

Figure 22
2008 Summer Peak Demand - Commercial

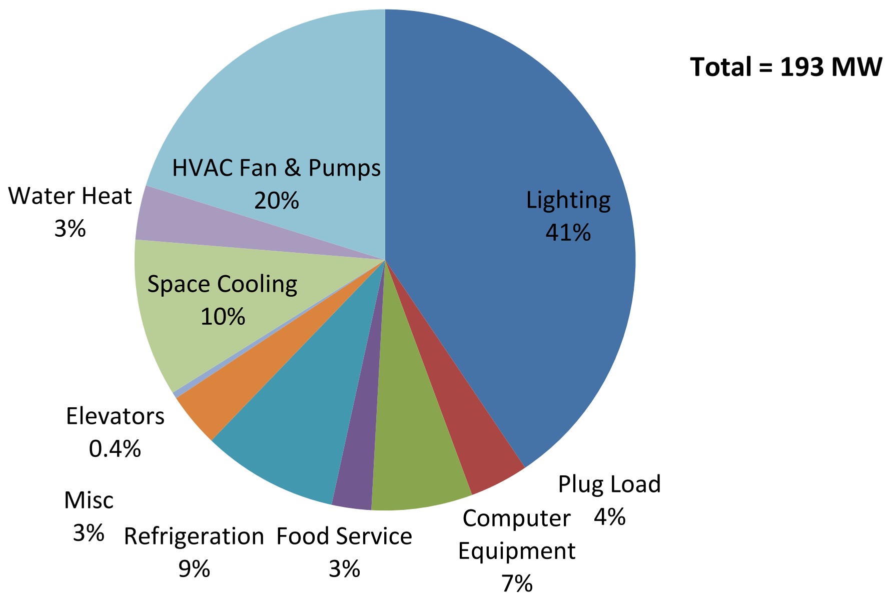


Figure 23 illustrates the forecasted summer peak demand for 2030. The average annual growth rate in peak demand is 1.4%.

Figure 23
2030 Summer Peak Demand - Commercial

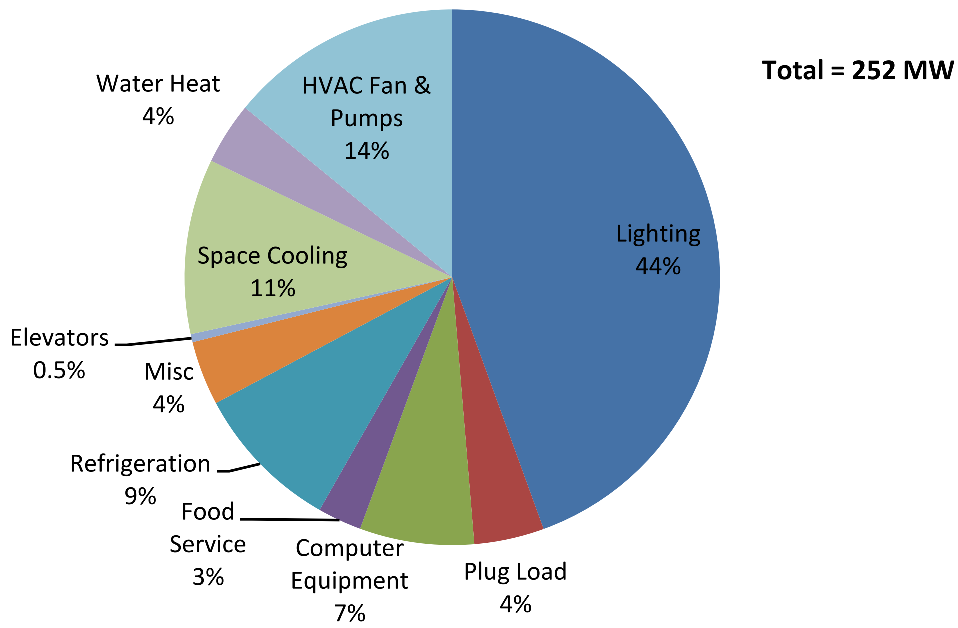


Figure 24 shows the 2008 summer peak demand by end-use and building type. Lighting is excluded in Figure 24 due to the large amount of consumption; however, lighting consumption by building type is shown in the subsequent figure. Figure 24 shows that the building types that contribute most to peak demand are small retail, grocery, restaurants, and other (see Table 10).

Figure 24
2008 Commercial Summer Peak Demand – by Building Type and End-Use Excluding Lighting

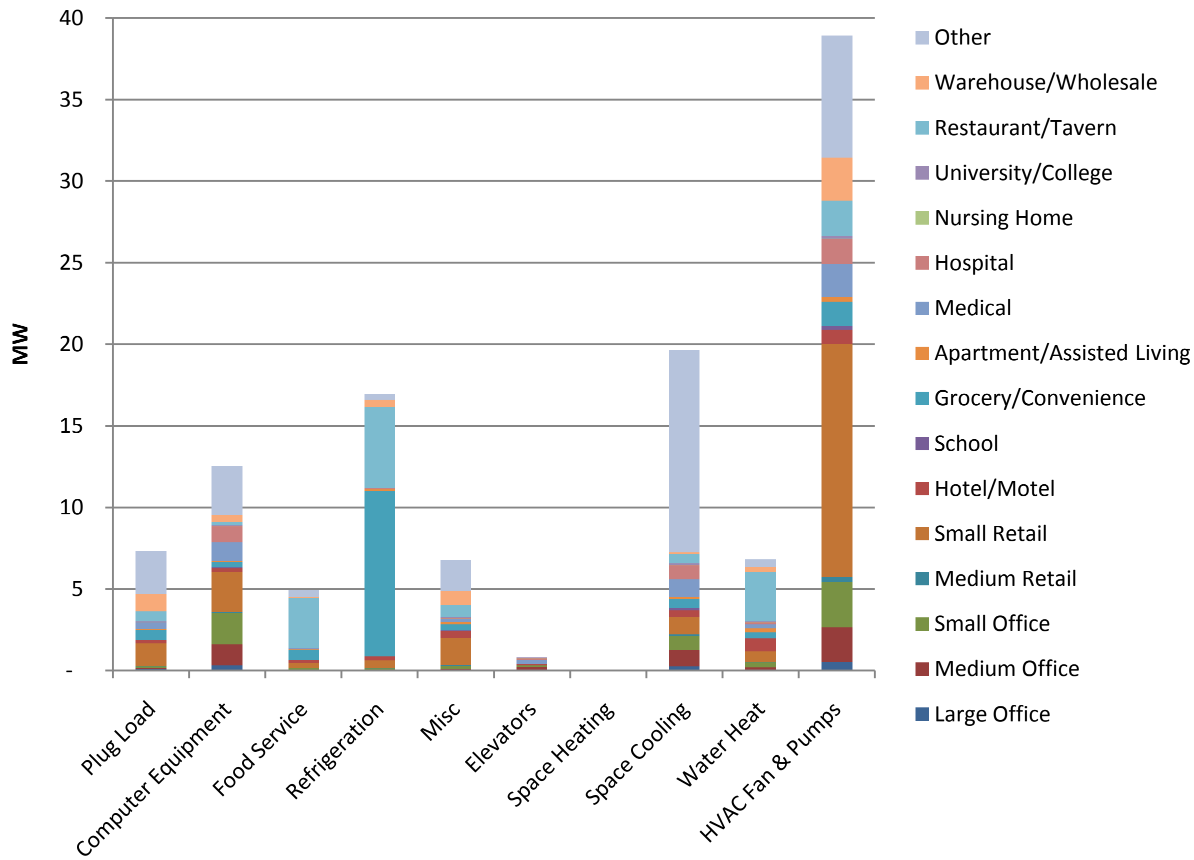
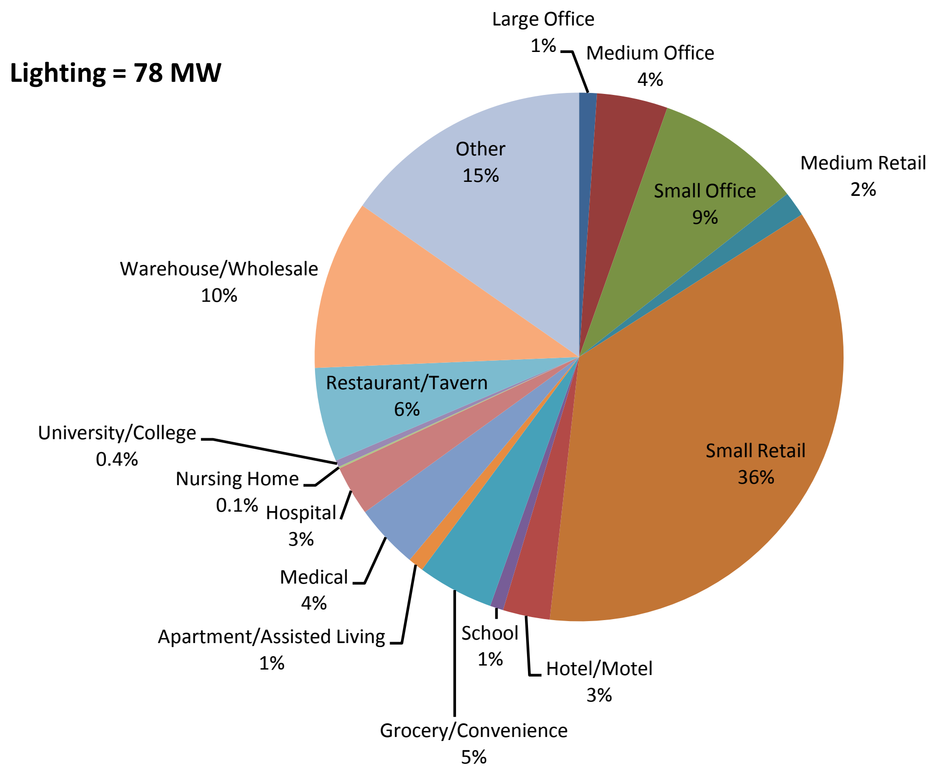


Table 10
2008 Commercial Summer Peak Demand, Top Four Building Types

	2008 Peak Demand, kW
Small Retail	50
Other	40
Restaurant/Tavern	20
Grocery/Convenience	18
All Commercial Buildings	193

Figure 25 shows that small retail, warehouse/wholesale, and other building types contribute most significantly toward summer peak in terms of lighting consumption.

Figure 25
2008 Summer Commercial Peak Demand by Building Type - Lighting



Industrial End-Use Forecast

Methodology

The base year for industrial sector consumption is calculated using the 2009 energy forecast for rate schedules 30, 31, and 33 and the Tolko sawmill (wholesale customer). As mentioned in the Commercial End-Use Forecast section, three customers were removed from the industrial rate class for conservation modeling purposes: UBC Okanagan, Selkirk College, and Trail Community Health. Some industrial customers are net metered; self-generation is not included in this forecast nor is it included in the FortisBC system forecast.

Customer consumption is grouped into classes according to the North America Industry Classification System (NAICS). Table 11 shows the industrial processes and annual kWh consumption for these customers.

Table 11
Industrial Sector Retail Sales by Segment, 2008

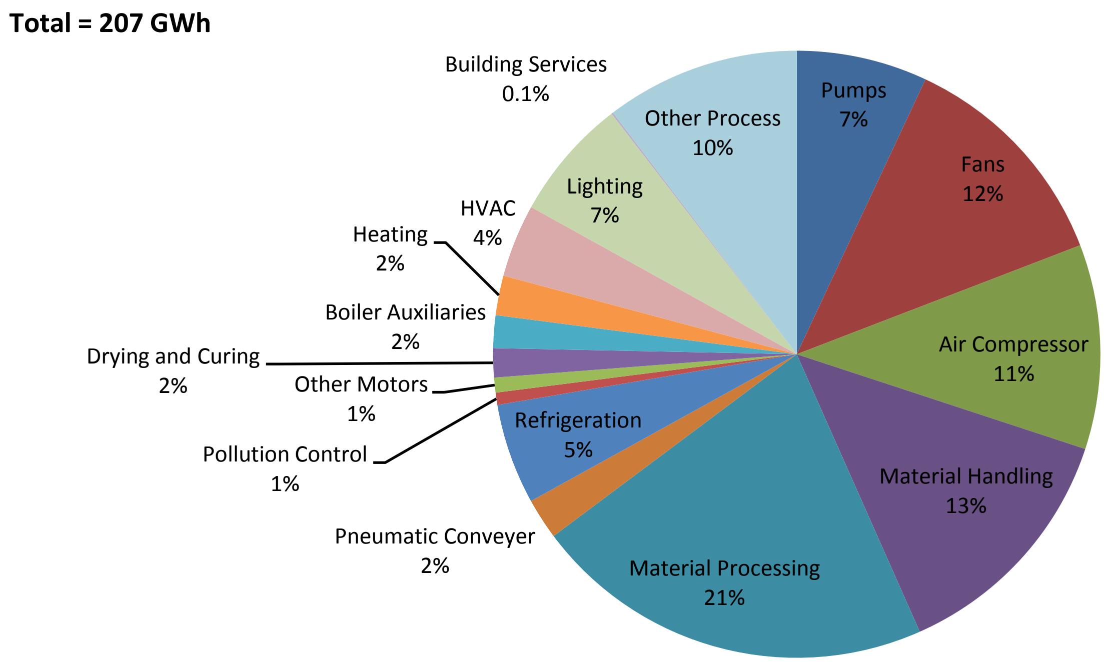
Industrial Process	Energy Consumption kWh
Wood products	90,054,330
Building Materials	53,000,000
Pulp and Paper	16,500,000
Food and Beverage	13,873,300
Miscellaneous	9,857,231
Mining	9,120,800
Fruit packers and storage	8,724,298
Other Manufacturing	3,621,000
Contractors & Construction	2,717,664
Total	207,468,623

Consumption within each industrial process was disaggregated into end-use by applying percentages from sources such as the BC Hydro Conservation Potential Assessment and the Northwest Power and Conservation Council. The result is a top-down methodology for classifying energy consumption by end-use.

2008 Industrial End-Use Consumption

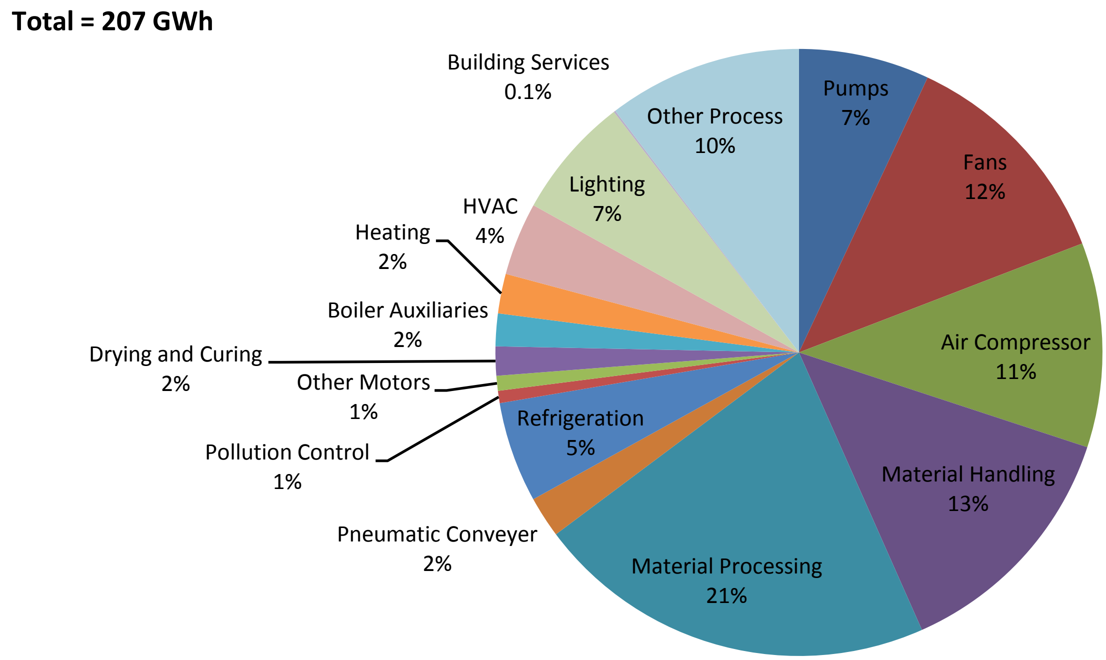
Using the methodology above, total sector consumption is split into several end-use categories. Figure 26 below shows the resulting break down for the base year. Total consumption is 207 GWh.

Figure 26
2008 End-Use Consumption - Industrial



Industrial loads are expected to remain flat over the planning period. Therefore the 2030 end-use breakdown will be identical as the 2008 break-down in terms of share and total consumption. See Figure 27.

Figure 27
2030 End-Use Consumption - Industrial



Peak Demand Forecasts

Winter and summer coincident peak demand for the industrial sector is estimated based on historical load factors by customer from FortisBC billing data as well as load factors for industries in California and British Columbia (BC Hydro). The methodology for forecasting peak demand by end use was first to calculate load factors for each type of industry (sawmill, pulp, manufacturing, etc). These load factors are applied to each end-use by industry. In cases where more details were known, such as refrigeration in food and beverage industries, specific load factors were used by end-use. The resulting summer and winter peak demand breakdowns are given in Figures 28 and 29. Since a 0% growth is assumed for the energy forecast, the 2030 peak demand breakdowns will be identical to Figures 28 and 29, and therefore are excluded from the report.

Figure 28
Industrial Winter Peak Demand

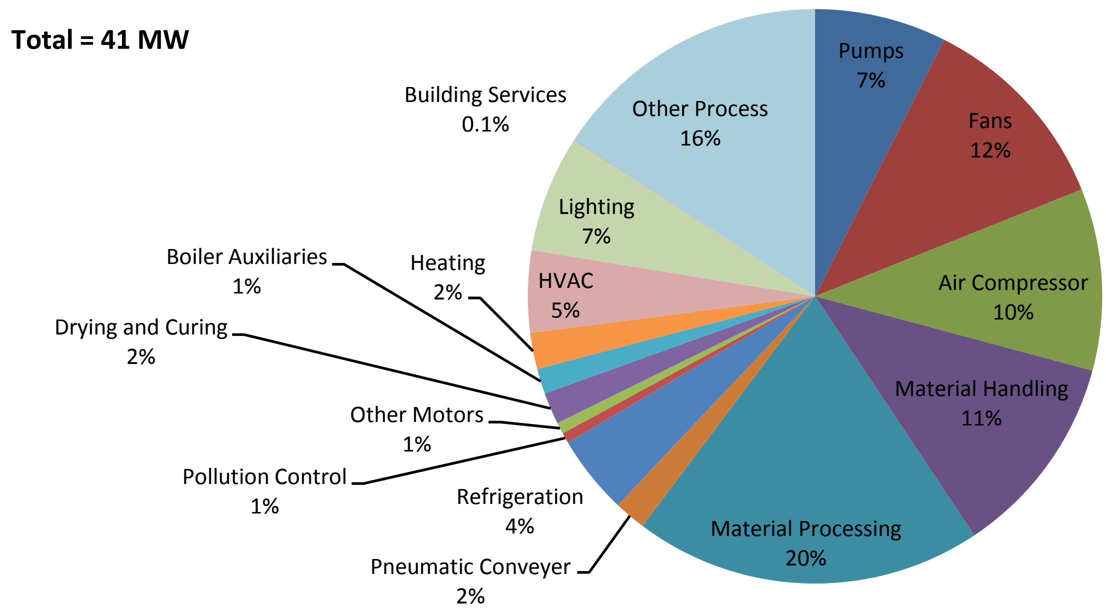
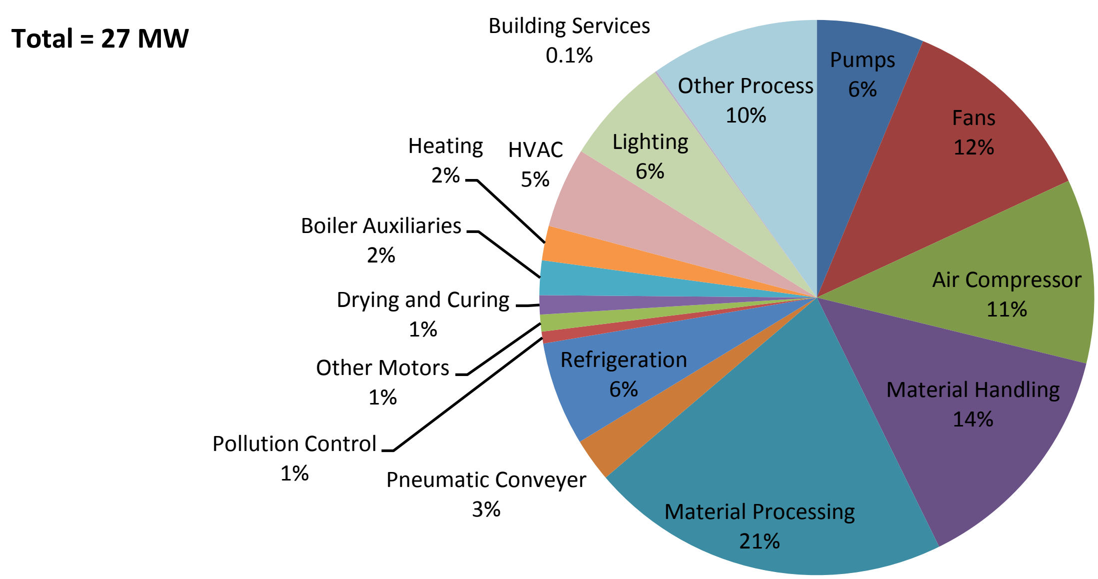


Figure 29
Industrial Summer Peak Demand



Total System

This section aggregates all sectors to compare the end-use forecasting models with the load data provided by FortisBC and its wholesale customers. First, Table 12 compares energy forecasts by sector. Irrigation and lighting sector consumption was not broken down due to lack of data. The end-use forecast model was calibrated to match normalized load data; therefore, there are no material differences in base year consumption.

Table 12
End-Use Model Comparison for 2008
(MWh)

	Residential	Commercial	Industrial	Lighting	Irrigation	Total
2008 Loads Provided by Utilities	1,719,530	1,033,440	207,469	13,538	52,071	3,026,047
2008 End-Use Model	1,719,530	1,033,440	207,469	13,538	52,071	3,026,047
% Difference	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 13 below compares the summer and winter peak demand forecasts. Load factors for Irrigation and lighting customers are assumed to produce the total peak. It was assumed that there is no irrigation during the winter peak and an 87% load factor for summer is used. It is assumed that lighting is not part of the summer peak demand.

Table 13
End-Use Model Comparison for 2008 (MW)

	Residential	Commercial	Industrial	Lighting	Irrigation	Total
Winter Peak						
Weather Adjusted Actual						701
2008 End-Use Model	427	225	47	3	4	706
% Difference						-0.7%
Summer Peak						
Weather Adjusted Actual						560
2008 End-Use Model	271	193	34	0	45	543
% Difference						3.0%

Residential Energy Savings Potential

Introduction

This section begins with a brief description of residential customer housing characteristics and appliance saturations. Next, energy efficiency measures are described followed by potential estimates calculated using the methodology described in the "Methodology" section. A couple of fuel switching measures, customer-owned renewable energy, and low-income measures are also addressed. The conservation potential results are presented as supply curves, tables, and compared to the end-use forecast.

Residential Customer Characteristics

FortisBC provides electric service directly to 95,282 customers and indirectly to an additional 42,373 customers through its wholesale customers. In 2009, FortisBC conducted a customer survey of both direct and indirect residential customers within their service territory. The surveys defined building characteristics and appliance saturations, type and age. These results are provided at an aggregate level as well as by sub region including West Kootenay, South Okanagan, and Central Okanagan.

Table 14 summarizes the key building characteristics for all FortisBC customers. Heat type, furnace age, insulation, window, and door characteristics were also defined for these buildings.

Table 14
Residential Building Characteristics

	Single Family	Mobile, Other	Apartment Condo	Duplex, Row, Townhouse
Building Type	**69%**	**8%**	**13%**	**11%**
Electric Heat	31%	27%	80%	42%
Gas Heat	57%	47%	18%	57%
Other Heat	12%	26%	2%	1%
Own Home	95%	92%	65%	82%
Before 1950	12%	0%	2%	1%
1950-1975	25%	25%	5%	14%
1976-1985	18%	31%	10%	19%
1986-1995	21%	21%	23%	28%
1996-2009	24%	22%	53%	32%
Full Basement	60%	2%	11%	46%
Partial Basement	12%	1%	2%	8%
Crawlspace	20%	26%	3%	27%
No Basement	8%	71%	85%	19%
Average Size (Sq Ft)	2,250	981	1,187	1,688

Table 15 summarizes key appliance saturations for FortisBC residential customers. The survey also identified the average age for the major appliances; these are shown below when provided for the main appliance.

Table 15
Residential Appliance Saturation

Cooking and Food	**Share**	**Average Age, Years**	**Electronics**	**Share**
Refrigerator Auto Defrost	90%	7.3	DVD	75%
Chest Freezer	52%	12.6	VCR	52%
Upright Freezer (not part of fridge)	21%	6.9	Digital Cable or Satellite TV	47%
Refrigerator Manual Defrost	20%	8.6	CRT TV <32 inches	61%
Microwave	87%		CRT TV >32 inches	24%
Electric Range (cook top + oven)	81%		LCD Flat Screen TV	38%
Electric Cook Top	11%	9.0	Laser Printer	15%
Gas Range (cook top + oven)	11%		Plasma flat screen TV	13%
Separate Electric Oven	10%		Rear projection TV	7%
Gas Cook Top	5%		Desktop Computer	69%
Cleaning			Inkjet printer	65%
Electric Clothes Dryer	92%	7.8	Laptop computer	49%
Automatic Dishwasher	82%	7.0	Fax	19%
Clothes Washer (top load)	64%	9.5	Audio entertainment video games	24%
Clothes Washer (front load)	35%	3.6	Surround System	32%
Gas Dryer	2%	8.7	Other	2%
Water Heating			**Miscellaneous**	
Gas Water Heater	50%	6.9	Jetted Bathtub	11%
Electric Water Heater	49%	6.6	Hot Tub (outdoor)	11%
AC			Swimming Pool (outdoor)	7%
Central Air Conditioning	50%	N/A	Indoor hot tub	2%
Window AC	16%		Separate workshop	18%
Portable AC	7%		Electric Car Block Heater	21%

Energy Efficiency Measures

Several measures for each end-use were analyzed to model energy efficiency potential. Measures were included where the data available supported cost and savings values. Many "non-traditional" measures such as shade trees or clothes lines have little solid basis for either cost or savings and so were excluded from this analysis. Future CPA work may include data collected from the many pilot programs currently being implemented in North America that seek to verify "non-traditional" measure cost and savings values. Non-traditional measures and/or new technologies may be viable and integral parts of program offerings, but because they are difficult to quantify, they are not used in this potential assessment. The table below summarizes the types of technology-based measures included in the analysis. While few categories are provided in the table, several permutations of each measure within these categories exist. There are over a hundred individual measures considered in the residential sector only.

Table 16
Residential Energy Efficiency Measure Categories

Appliances		Domestic Hot Water	
	Refrigerator and Freezer Recycling		Tank Upgrades
	Clothes Washers and Dryers		Low-Flow Showerheads
	Dishwashers		Low-Flow Faucet Aerators
	Refrigerators and Freezers		Heat Pump Water Heater
	Ovens and Ranges	Heating and Cooling	
	Microwave		Heat Pump Upgrades
Lighting			Heat Pump Conversions
	CFLs		Window and Portable Air Conditioning Upgrades
	LEDs		
Electronics			Electric Thermostats
	Televisions		ECM on Furnace Fans
	Computers and Monitors		Geothermal Heat Pumps
	Set Top Boxes	Weatherization	
	TV Peripherals		Windows
New Home Whole House Measure			Air Sealing
Electric Thermal Storage (ETS)			Insulation

Heat pump conversions are measures that take into account the incremental cost and energy savings from switching from some other electric heat source (like baseboard or forced air furnace) to heat pumps. Conversely, heat pump upgrade measures take into account the incremental cost and savings from upgrading from a less efficient heat pump to a more efficient model.

Electric Thermal Storage

Electric Thermal Storage (ETS) is a peak demand reduction measure evaluated alongside the energy efficiency resources in this section. Although there are no energy savings related to ETS, peak demand savings are evaluated assuming that ETS can be implemented with time-of-use rates (TOU) or some other customer incentive so that remote control or smart metering is not required. ETS is described in more detail below.

Thermal Storage, Room

Thermal storage systems heat enclosed ceramic bricks to as high as 1,650 degrees C during off-peak hours and slowly release the heat as needed during on-peak periods. While thermal storage has little or no energy benefits, it has the potential to shift almost the entire heating load to off-peak hours. If a unit is working exactly as installed, 100% of heating load can be curtailed during morning and evening winter peak. In practice, overrides and minimal on-peak usage make a 90% peak reduction possible. Lifetimes are 15-18 years and costs can be quite expensive ($5,000-$6,000 per house. A typical house would need three or four units ($1500 each). Steffes is the primary vendor in the region. Hayes Creek Electric reports good consumer acceptance of the technology and few problems, despite low participation in a Princeton, BC based program.

Thermal Storage, Central

Central thermal storage units are similar in savings and life to central systems. When applicable, they have a slightly lower cost. However, central thermal storage units also come with other retrofit concerns in addition to the substantial cost. Often houses require re-wiring and structural modifications to handle the weight of the units. Central thermal storage units require ducts through the house and are generally applicable to larger homes and new construction.

Emerging Technologies

Some emerging technology measures are included in the potential estimates. Measures such as heat pump water heaters and ductless heat pumps, which are not yet main stream but have equipment available in the market, have been included in the main potential assessment. In addition, whole house measures for new single family homes are included. These are known as EnerGuide80 and Energuide90[6] measures and include significant weatherization, energy efficient heating types and water heating. British Columbia plans to adopt EnerGuide80 standards as building codes by 2014.

EnerGuide90 homes are known as “near net zero” homes in British Columbia. While the technologies for these homes are available, programs for net zero homes are not yet mature. Net zero homes can be built for $10,000 to $30,000 more than the cost of a conventional home which can be recovered through savings on energy bills and increased value of the home. Currently, there are 1,697 homes in the southwestern United States, and at least fifteen demonstration projects are underway in Canada through CMHC.[7] EnerGuide90 homes are included in potential

[6] EnerGuide90 homes are also known as “near net zero” homes in British Columbia. Though these homes consume significantly less energy than standard or older homes; they do not attain net zero electricity consumption on an annual basis.

[7] http://www.netzeroliving.ca/#what_is_a_net_zero_homeHC's EQuilibrium initiative.

estimates; however, due to the emerging nature of the programs, achievability rates are set conservatively for this measure group (65 percent).

In addition to the emerging technology measures included in this analysis, there are a variety of technologies/measures that are undergoing research and development, and others that have yet to be identified that may come to fruition during the 20-year timeframe of this study.

- Phase change materials – building materials that store thermal energy during the day and release during the night
- Vacuum panel insulation – panels that achieve insulating levels up to 7 times greater than existing materials
- Green roofs – roofing systems capable of growing plants; primarily for multifamily apartment buildings
- Vacuum panel windows – two glass panels with a partial vacuum in between
- Integrated PV windows – windows that incorporate photovoltaic cells in the window
- Advanced LED lighting – LED's are included in the potential estimates in a limited manner, but significant advances could result in the displacement of CFLs
- Fiber optic lighting and light pipes – day lighting is distributed throughout buildings through fiber optic cable
- Solar absorption cooling – gas-fired absorption chillers are widely available, but these cooling systems use solar energy as the heat source.
- Evaporative cooling – evaporative cooling is becoming more widely available in hot, dry climates and may eventually have some application in FortisBC service area
- Home Automation (optimized home energy use) – Home Automation fully integrated with the smart grid will help to optimize energy consumption and peak demand beyond individual measure savings
- On-site generation (e.g., waste to energy, widespread PV, wind, fuel cell) – to obtain true net zero energy consumption, some on-site generation will likely be required.

At this point these measures/technologies are either unproven or too costly to be implemented as cost-effective conservation. However, it is likely that development will continue and some or all will be tested, verified, and included in future potential assessments.

Fuel Switching

In addition to the energy efficiency measures, one fuel switching measure category was analyzed in the residential sector. Due to the large share of demand from cooking during peak times, electric savings from the conversion of electric ranges (oven and stove top) to gas-fuelled ranges is examined. Also conversions from electric to gas-fuelled clothes dryers are analyzed. Approximately 92 percent of residential clothes dryers are electric. While these electric savings are quantified in this report, government policies preclude the electric utility from offering programs in this area.

Customer-Owned Renewable Energy

Several customer-owned renewable energy technologies were assessed for this conservation potential study. Customer-owned renewable energy measures include:

- Solar (photovoltaic);
- Wind turbines; and
- Solar hot water heating.

Micro hydro resources are sometimes included under the "customer-owned renewable energy" category. However, these resources are most commonly found as a supply-side resource rather than a demand side measure. Costs and annual generation for these projects vary significantly by site. In their study, BC Hydro notes that the main components of a micro hydro system include the pipeline, turbine, generator and controls. Generator costs vary from $2,000 to $3,000 per kW for small systems, but some systems are more complex and therefore cost more. The costs for installing pipelines and controllers are highly location dependent. Large components of micro hydro costs are site-specific, and this study does not attempt to develop a cost for these projects (similarly treated in the BC Hydro DSM study).

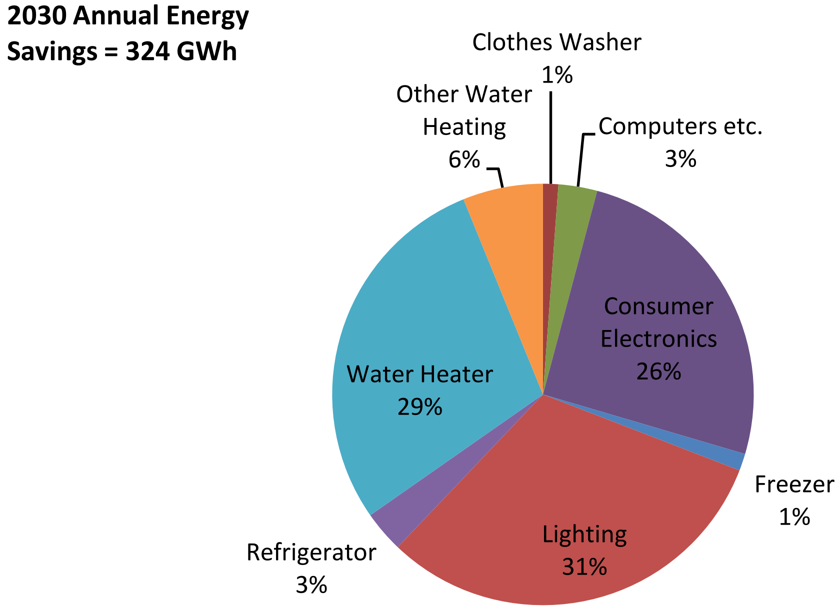
Potential Estimates

As described in the methodology section, end-use load forecast data and energy efficiency measures are combined to produce estimates of energy efficiency. In this analysis, energy efficiency potential is presented separately from the electric savings from fuel switching measures. The total economic and achievable potential is 479 GWh annually by 2030 or energy savings of 21 percent of 2030 forecasted residential load. In this section, economic and achievable potential are discussed followed by program achievable potential.

Appliances

Figure 30 illustrates the breakdown of economic and achievable energy efficiency potential for appliance measures. It is estimated that a total of 324 GWh of energy can be saved annually by 2030 through these measures. The potential estimates include measures that apply to both new and existing construction. Fuel switching measure potential is not included in the chart below but is discussed later in this section. The measure categories are described in further detail below.

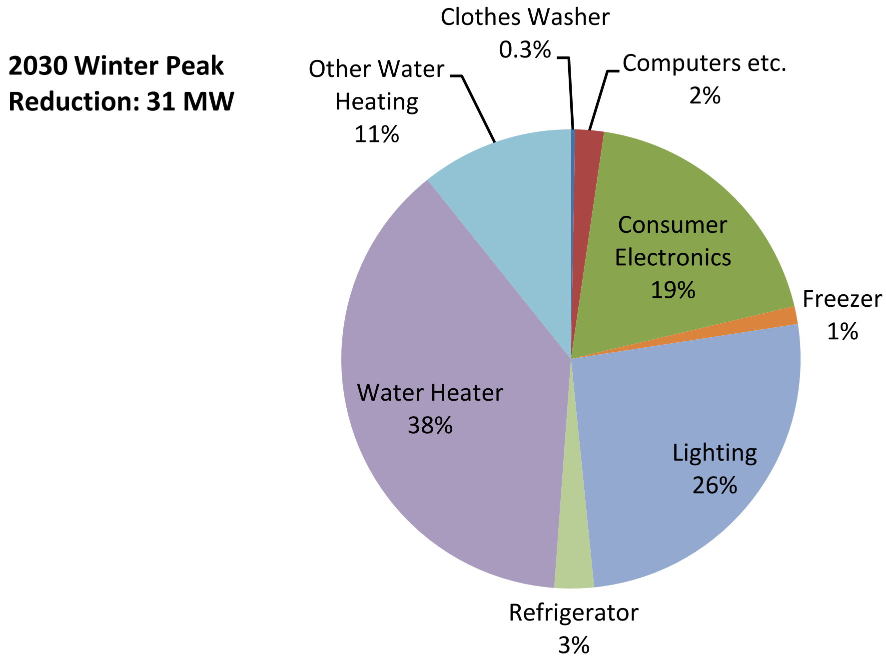
Figure 30
2030 Achievable Energy Savings Potential – Appliances



- **Clothes Washer** – Savings potential for 3 Tiers of clothes washer efficiency are applied to applicable units. The efficiency levels are: Tier 1is MEF (Modified Energy Factor) 2.0 to 2.19; Tier 2 is MEF 2.2 to 2.45; and Tier 3 is MEF 2.46 or greater.
- **Clothes Dryer** – Applies to electric clothes driers. Minimum efficiency level is EF (Energy Factor) 3.15. Due to high costs relative to energy savings, this measure does not pass TRC test, so it is excluded from chart above.
- **Computers** – Includes residential desktop computers and monitors.
- **Consumer Electronics** – Includes Energy Star Televisions and Set-Top Boxes.
- **Cooking** includes efficient microwave ovens and convection ovens. These measures do not pass the TRC so are not included in the chart above.
- **Dishwasher** measures have a minimum efficiency rating of EF 72. Does not pass TRC.
- **Freezers and Refrigerator** categories include both Energy Star rated appliance upgrades as well as retirement or recycling of old appliances.
- **Lighting** includes compact fluorescent light bulbs and fixtures.
- **Water Heaters** include upgraded efficiency as well as heat pump water heaters.
- **LED Lighting** – applies to whole house (new construction). Does not pass TRC.
- **Other Water Heating** measures include low-flow shower heads, bathroom and kitchen faucet aerators, and wastewater heat recovery systems in 2-storey, single family homes.

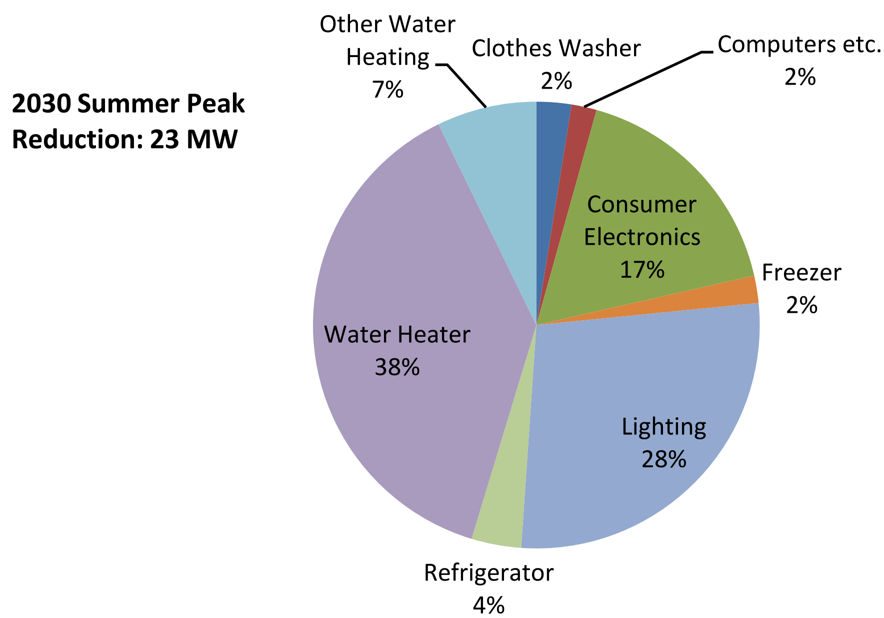
Winter peak reduction from these energy efficiency measures are shown in Figure 31. Peak energy savings are derived according to the timing of energy savings by measure.

Figure 31
Winter Peak Savings from Appliance Energy Efficiency Measures
Achievable Potential



Summer peak reduction from these energy efficiency measures are shown in Figure 32.

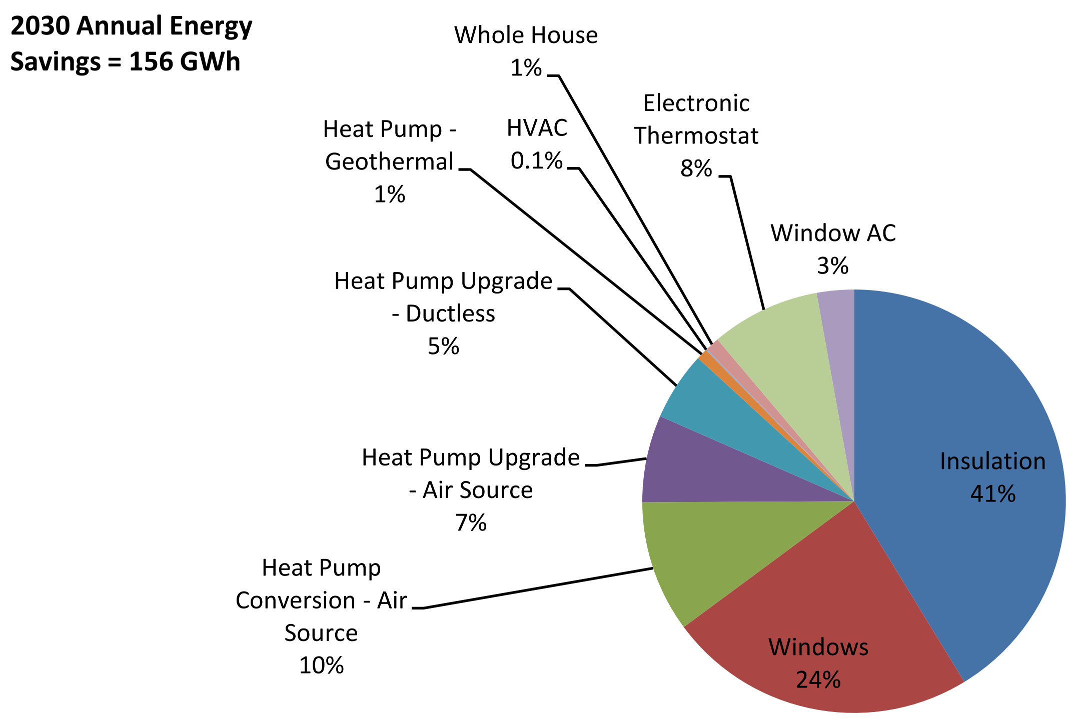
Figure 32
Summer Peak Savings from Appliance Energy Efficiency Measures
Achievable Potential



Space Conditioning

Figure 33 illustrates economic and achievable energy efficiency potential that is available annually by 2030. These space conditioning measures apply to electrically heated homes. The measure categories are described in more detail below.

Figure 33
2030 Achievable Potential from
Space Conditioning Energy Efficiency Measures



- **Insulation** – upgrades attic insulation to RSI-6.7, RSI-5.3, RSI-5.8 (R38, R30, R33) for single family, apartments and row, and manufactured houses respectively. Floor insulation is upgraded to RSI-5.3 (R30) for each building type and Wall insulation is upgraded to RSI 1.9 (R11).
- **Windows** – include upgrading single pane, double pane wood or aluminum frame to Energy Star rated windows. Also, an upgrade from U-Factor 1.7 to U-Factor 1.4 W/m^2 (0.30 to 0.25 $Btu/h{\cdot}ft^2{\cdot}°F$) windows in new and existing construction is included.
- **Heat Pump Conversion – Air Source** includes conversions from electric forced air furnace to heat pumps with ratings of HSPF 8.5/ SEER 14 or higher.
- **Heat Pump Upgrade – Air Source** applies to existing buildings with heat pumps of lower efficiency.
- **Heat Pump Upgrade – Ductless** applies to all housing types with baseboard or zonal heat.
- **Geothermal Heat Pumps** (ground source) - are cost-effective for existing single family homes.

- **HVAC** measures include ECM on furnace fans in homes with forced air furnaces, regardless of heating fuel, and air sealing in electrically heated homes.

Figure 34 shows the breakdown of winter peak savings potential from space conditioning energy efficiency measures.

Figure 34
Winter Peak Savings from Space Conditioning Energy Efficiency Measures Achievable Potential

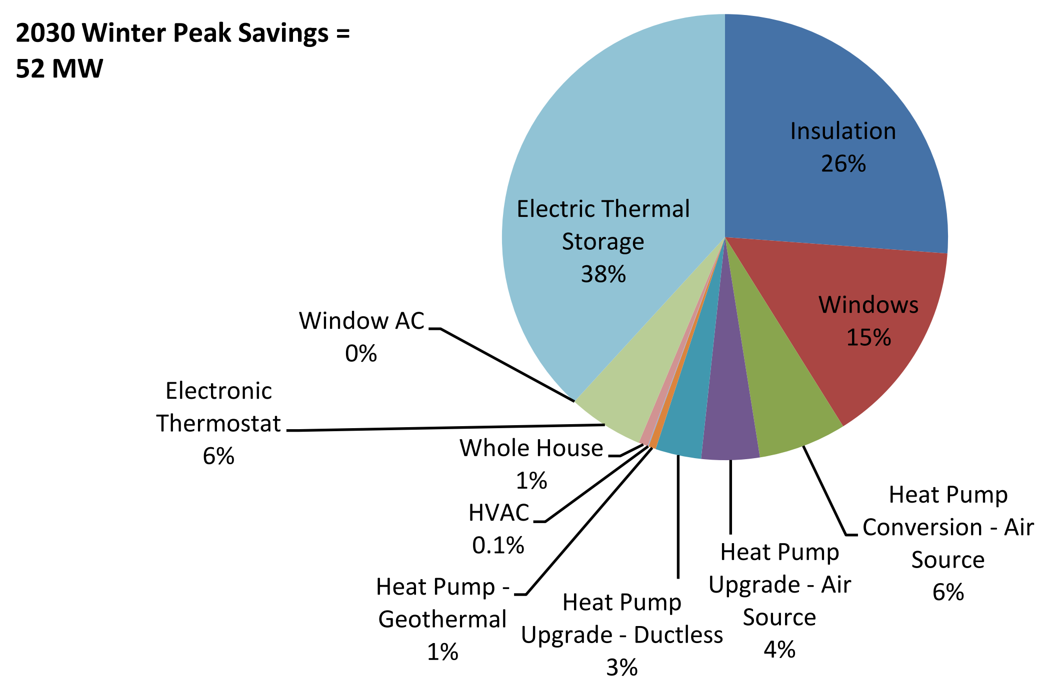
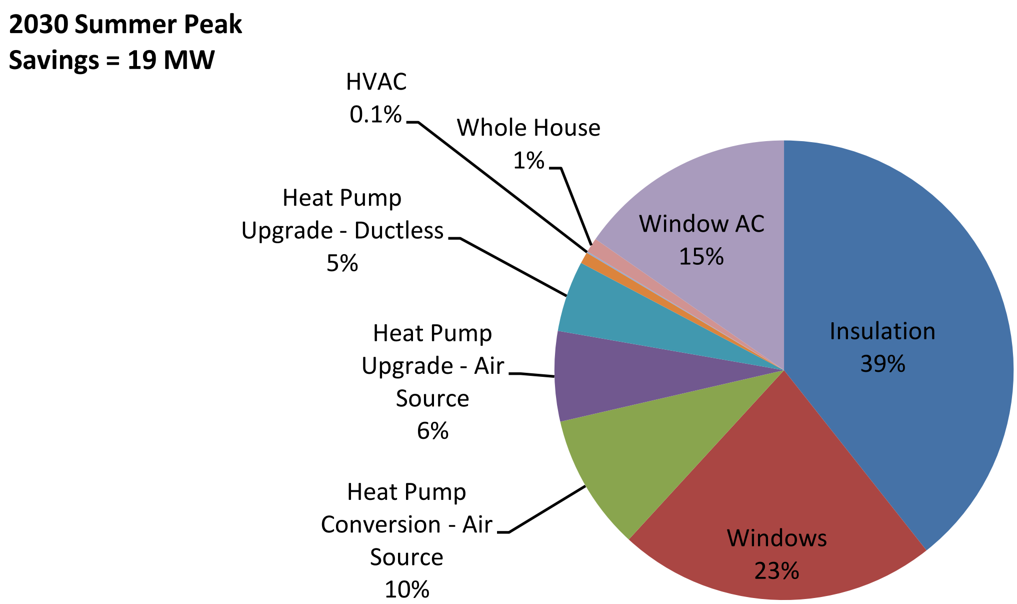


Figure 35 shows the breakdown of summer peak savings potential from space conditioning energy efficiency measures.

Figure 35
Summer Peak Savings from Space Conditioning Energy Efficiency Measures
Achievable Potential



A few other energy saving measures not quantified in this report include awnings and shade trees. Awnings and shade trees can reduce summer air conditioning load while maintaining the benefit of winter solar gain. These measures are difficult to quantify for a variety of reasons, in part because they can significantly interact with behaviour measures such as closing window blinds.

Low-Income Potential

The British Columbia Ministry of Energy, Mines and Petroleum Resources ("Ministry") amended the Public Utilities Commission Act (Bill 15-2008) to require public utilities to estimate cost-effective demand side resources (DSM) as part of their long term resource plan and to provide a plan to acquire those resources as a first priority over supply-side options. Under this mandate, the Ministry requires that residential energy efficiency measures be evaluated using several scenarios such as measure-by-measure TRC tests, grouped measure TRC tests, and low-income TRC tests. This last evaluation criterion allows low-income DSM programs to value additional benefit not accounted for in energy savings alone. As mandated by the government of British Columbia, an additional benefit of 30 percent is to be added to measures to evaluate cost-effectiveness for low income program measures.

According to Statistics Canada, 16.5 percent or approximately 27,000 households[8] in the FortisBC service territory are below the Low-Income Cut-Off (LICO). For this study, most of the residential measures analyzed pass the TRC test without the added benefit for low-income. No additional measures become cost effective when low income benefits are added to the TRC test.

Low-Income Programs

According to work prepared by FortisBC, low-income households have some key characteristics that suggest potential opportunities for energy efficiency improvements. Low-income customers that live in single family homes have a higher level of energy intensity per square foot than customers living in the same housing type who are not low-income, even though low-income customers' total consumption is, on average, less than that of non-low-income customers. In addition, specific product and end use comparisons highlight additional opportunities for improving energy efficiency in the homes of low-income customers. In addition, FortisBC found that CFL penetration in low-income houses is lower than the average penetration for the entire service territory. These characteristics indicate that there are significant barriers to energy efficiency adoption for low-income families. FortisBC is currently working on program design and mechanisms to address low-income barriers.

Fuel Switching

The electric range fuel switching measures analyzed in this analysis are cost effective in both new and existing construction. In existing buildings, the incremental capital cost is the installation of a gas line to the appliance, approximately $600.[9] In new homes, the incremental cost to install a gas line is estimated at $200. Incremental capital costs for gas ranges are $130[10].

In addition to fuel switching in cooking appliances, measures for fuel switching to natural gas dryers are also included in the analysis. According to FortisBC's customer survey, 92 percent of clothes dryers are electric. Gas line installation costs in new and existing homes is assumed to be the same as for the cooking appliance fuel switching measures discussed above. Incremental capital costs for gas clothes dryers are $93[11].

[8] Statistics Canada. "BC Progress Board Performance Indicator #22 Low Income Cut-Offs (LICO)." 2006.

[9] Terasen Gas estimates installation of gas lines to be in the $200 to $1,000 range. $600 is used as the average.

[10] FortisBC staff

[11] FortisBC staff

Table 17 summarizes electric energy savings potential for the two fuel switching measures discussed above.

Table 17
Fuel Switching Electric Savings Potential

Fuel Switching	Energy Savings GWh	Winter Peak Demand Savings MW	Summer Peak Demand Savings MW
Electric Range, New	10.3	12.0	11.3
Electric Range, Existing	5.8	6.8	6.4
Electric Clothes Dryer, New	4.9	7.3	4.1
Electric Clothes Dryer, Existing	38.8	8.2	4.7
Total	**59.9**	**34.2**	**26.5**

Customer-Owned Renewable Energy

Cost and savings data for renewable energy measures were primarily obtained from the BC Hydro study; however, the NWPCC data base was used to benchmark the cost and savings data.

Technical potential for solar is calculated assuming that 30 percent of single family and row houses and 45 percent of apartment buildings are applicable for solar PV and solar water heating (based on BC Hydro Southern Interior Climate zone). The availability of wind resources is expected to be low. The BC Hydro study assumes an achievability rate of 0.1 percent for residential customer-owned wind generation, and this rate is applied to FortisBC homes as well. Lastly, 45 percent of homes with electric water heaters are assumed to applicable for solar water heat.

At current costs, none of the above technologies are cost-effective. However, a second scenario was analyzed assuming cost declines estimated in the BC Hydro study. BC Hydro estimated that costs would decrease to 42 percent of their current level by 2013, 21 percent the current level by 2018, and 11 percent of the current level by 2023. Using this declining cost structure and ramp rates to define achievability, economic potential is estimated and shown in the last column of the Table 18. Once a measure is cost effective, the ramp rate begins at 1% of technical potential per year and escalates to 5 or 10 percent of technical potential annually. The effective achievability rates are between 25 and 50 percent depending on when the measure becomes cost-effective.

Table 18
Residential Customer-Owned Renewable Energy
$2009

	Annual Generation kWh	Capital Cost	Installation Cost	Annual O&M	Life	TRC BC Ratio	Technical Potential MWh	Economic Potential* MWh	Year Technology Becomes Cost-Effective
Residential 3 kW PV, Detached	3,300	$27,999	$6,461	$194	20	0.14	133,678	66,839	2023
Residential 15 kW PV, Apt	16,500	$83,997	$19,384	$582	20	0.24	152,136	76,068	2018
Residential Wind, 400 W	700	$1,185	$969	$0	15	0.44	95	80	2013
Solar Hot Water 5 m^3 collector	2,200	$5,923	$0	$1	20	0.6	84,522	71,843	2013

*Assumes decreasing cost trend

Costs

TRC measure costs, utility costs, and participant costs are calculated for the economic and achievable potential. For the utility cost calculation, it is assumed that utility incentives are 60% of the incremental measure cost and that program administration costs are 20% of the full incremental measure cost. Participants incur OM&R costs/benefits. Table 19 summarizes TRC costs as well as compares a weighted average of the TRC levelized cost with savings potential. All cost and savings potential data in the table are for economic and achievable quantities of energy efficiency potential obtainable over a 20-year period.

Table 19
Residential 20-Year Achievable Energy Efficiency Savings and Cost Summary
2009 Dollars

	Ramp Rate	Total Measure Cost ($1000s)	Winter Peak Savings MW	Summer Peak Savings MW	Average TRC Levelized Cost $/MWh	Weighted B/C Ratio	Savings Potential MWh
Appliances Total		**$86,352**	**31**	**23**	**$44.04**	**10.98**	**324**
Lighting	CFL Code Change	$19,797	7.9	6.2	$28.34	6.41	101.1
Water Heater	EmergTech	$41,910	11.7	8.6	$45.01	3.05	92.5
Consumer Electronics	Electronics	$0	5.8	3.9	$52.81	12.62	82.3
Other Water Heating	20YearEven	$1,288	3.3	1.6	$7.23	75.17	19.9
Refrigerator	20YearEven	$6,728	0.9	0.8	$58.70	3.76	10.3
Computers etc.	EmergTech	$3,624	0.6	0.4	$79.97	2.84	9.6
Freezer	15YearEven	$1,759	0.4	0.4	$49.13	3.28	4.2
Clothes Washer	15YearEven	$11,246	0.1	0.6	$305.41	2.81	3.8
Clothes Dryer	20YearEven	$0	0.0	0.0	$0.00	0.00	0.0
Cooking	20YearEven	$0	0.0	0.0	$0.00	0.00	0.0
Dishwasher	20YearEven	$0	0.0	0.0	$0.00	0.00	0.0
Lighting LED	EmergTech	$0	0.0	0.0	$0.00	0.00	0.0
Space Conditioning Total		**$168,311**	**52**	**19**	**$61.19**	**1.95**	**156**
Insulation	20YearEven	$43,982	13.5	7.6	$40.80	2.22	64.3
Windows	20YearEven	$34,967	7.7	4.3	$35.15	2.06	36.7
Heat Pump Conversion - Air Source	20YearEven	$19,039	3.3	1.8	$105.28	1.31	15.7
HVAC	20YearEven	$215	0.0	0.0	$126.98	1.43	13.0
Heat Pump Upgrade - Air Source	20YearEven	$7,197	2.2	1.2	$60.16	2.27	10.4
Heat Pump Upgrade - Ductless	EmergTech	$11,430	1.7	1.0	$121.35	1.22	8.2
Whole House	EnerGuide90	$4,357	0.4	0.2	$98.70	1.31	4.4
Electronic Thermostat	20YearEven	$10,404	2.8	0.0	$79.71	1.72	1.7
Heat Pump - Geothermal	EmergTech	$1,554	0.3	0.2	$101.84	1.71	1.3
Window AC	2011 Code Change	$582	0.0	2.9	$17.95	7.92	0.2
Electric Thermal Storage	20YearEven	$34,585	19.7	0.0	NA	1.23	0.0
Fuel Switching		**$46,327**	**13**	**9**	**$305.04**	**1.06**	**16**
Electric to Gas Clothes Dryer	NA	$24,287	6.6	3.8	$280.42	1.06	9.0
Electric to Gas Range	NA	$22,039	6.0	5.7	$337.72	1.07	6.8
Total		**300,989**	**95**	**51**	**$57.73**	**7.83**	**495**

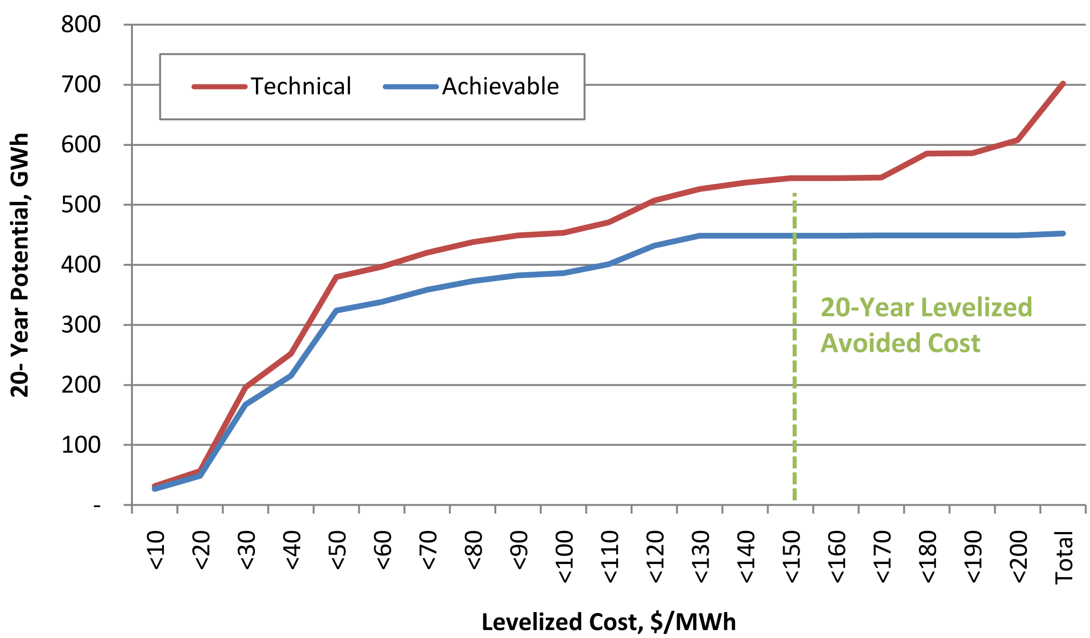
The definition of each column heading is listed below:

- **Ramp Rate** – reference to ramp rate used in estimating program achievable potential, discussed later.
- **Total Measure Cost** – incremental capital costs, O&M, replacement costs, and program administration costs. Costs are in thousands.
- **Winter Peak Savings –** MW peak savings associated with energy efficiency measure
- **Summer Peak Savings –** MW peak savings associated with energy efficiency measure
- **Average TRC Levelized Cost** – weighted average of levelized costs in measure category (weighted by share of measure category savings).
- **Weighted Benefit-Cost Ratio** – benefit-cost ratio for category weighted by the share of measure category savings.
- **Savings Potential** – Economic and achievable savings potential. Includes potential achieved through codes and standards.

Supply Curves

Energy efficiency resources are often summarized as supply curves. The supply curves in the figure below show how much energy efficiency (MWh) is available at different price levels. The x-axis shows measure levelized costs. These costs can be compared to supply side resources; however, unlike supply-side resources, the total quantity of the resource may not be available immediately. The curves in Figure 36 show the 20-year technical potential as well as the achievable potential. Note that the achievable potential in the figure includes potential that might be achieved through code and standard changes.

Figure 36
Residential Energy Efficiency Supply Curves



Program Achievable Potential

The previous section defined energy efficiency potential that is both economic and achievable through utility programs, codes, and standards. This section of the memo identifies potential that is both economic and achievable through utility programs only. Or, energy efficiency potential that is expected to be achieved through known code changes and product standards is not included in the following estimates.

In order to define utility program achievable potential, or "Program Achievable Potential," ramp rates are assigned by measure category to approximate the amount of energy efficiency potential that could be reasonably obtained through utility program efforts over the planning period. Figure 37 shows the Program Achievable Potential cumulatively by measure category and does not include fuel switching measures. The ramp rates used for program achievable potential can be found in Appendix D. Please reference Table 18 for measure category and applicable ramp rate names.

Figure 37
Residential Program Achievable Potential

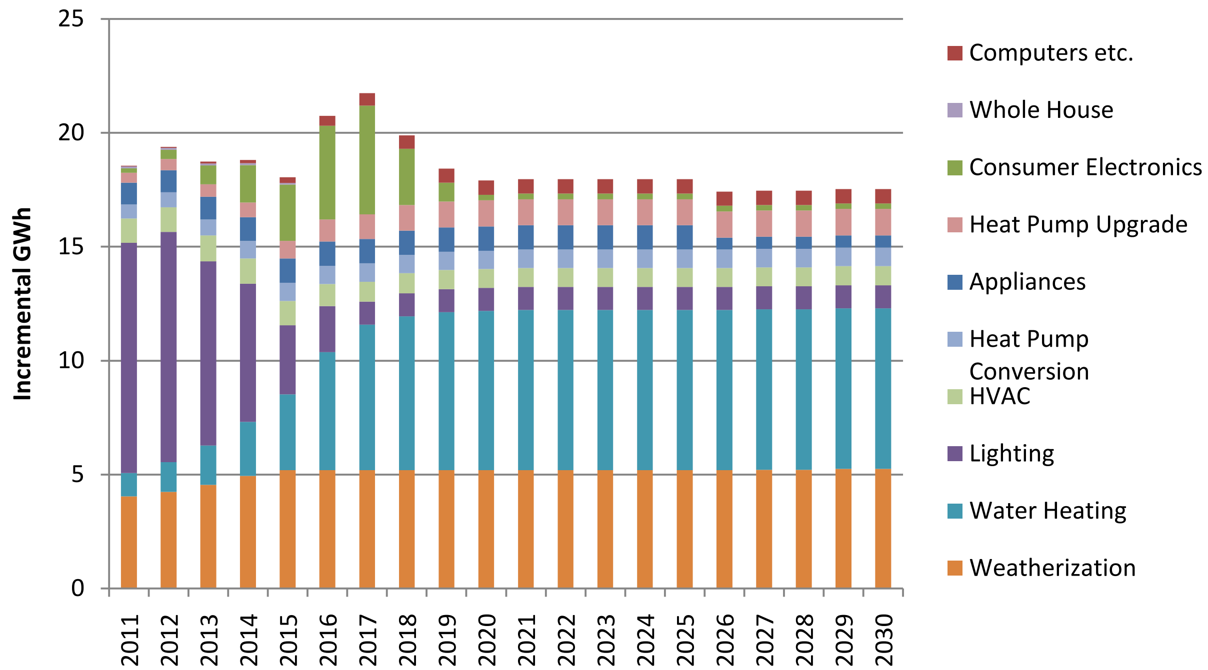


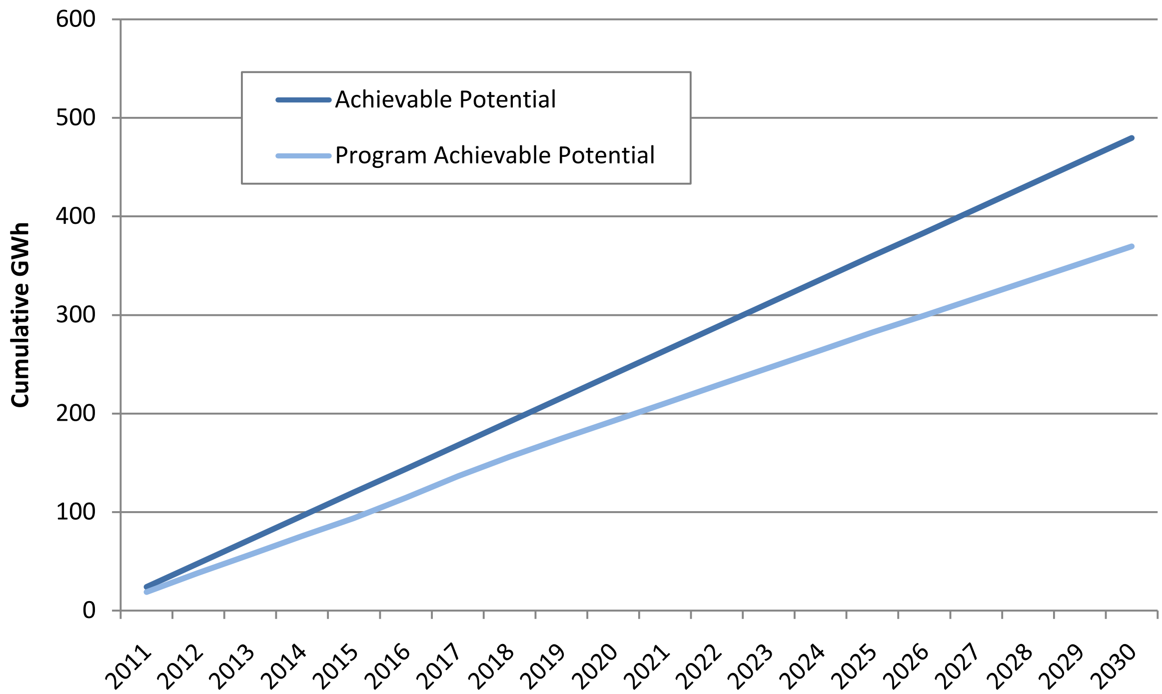
Table 20 shows measure category ramp rates and the associated larger measure category in Figure 37. The ramp rates dictate the pace (over time) that energy efficiency can be achieved. The infrastructure (e.g., availability of contractors) and cost (e.g., first cost, incentive levels) can affect the ramp rate, especially related to new technologies or measures that may take longer to become accepted in the marketplace.

Table 20
Measure Ramp Rates

Measure Category	Ramp Rate	Category in Figure 37
Lighting	CFL Code Change	Lighting
Water Heater	EmergTech	Water Heating
Consumer Electronics	Electronics	Consumer Electronics
Other Water Heating	20 Year	Water Heating
Refrigerator	20 Year	Appliances
Computers etc.	EmergTech	Computers etc.
Freezer	15 Year	Appliances
Clothes Washer	15 Year	Appliances
Dishwasher	20 Year	Appliances
Windows	20 Year	Weatherization
Insulation	20 Year	Weatherization
Heat Pump Conversion - Air Source	20 Year	Heat Pump Conversion
HVAC	20 Year	HVAC
Window AC	2011 Code Change	HVAC
Furnace Fan	2011 Code Change	HVAC
Heat Pump Upgrade - Air Source	20 Year	Heat Pump Upgrade
Heat Pump Upgrade - Ductless	EmergTech	Heat Pump Upgrade
Whole House	EnerGuide90/80	Whole House
Electronic Thermostat	20 Year	HVAC

Figure 38 compares Program Achievable Potential with total Achievable potential.[12] The difference between the curves in Figure 38 is the potential achieved through codes and standards for new building lighting. Figure 38 does not include savings from fuel switching. The residential code changes expected to occur during the 2011 – 2030 timeframe will result in an estimated 121 GWh of energy efficiency. See Appendix A for more information on residential code and standard changes.

Figure 38
Ramped Achievable[13] vs. Program Achievable Potential



[12] Note that all energy efficiency potential referenced in these paragraphs is cost-effective, or economic.

[13] Includes potential achieved through codes and standards and uses a constant ramp rate of 5 percent annually.

Summary

The following three tables compare the energy efficiency potential estimates with the end-use load forecast for the year 2030. The potential in the table below is both economic and achievable. Additional columns show the total savings potential including fuel switching measures.

Table 21
Comparison of End-Use Model and Achievable Energy Efficiency Potential (MWh)

End-Use	End-Use Model 2030 MWh	Total Achievable Potential	Total Potential as % of 2030 Forecast
Energy Efficiency			
Space Conditioning & Ventilation	675,066	153,995	23%
Water Heater	213,607	112,375	53%
Lighting	330,840	101,104	31%
Consumer Electronics	238,031	82,276	35%
Refrigerator	144,015	10,306	7%
Computers etc.	149,560	9,622	6%
Freezer	71,560	4,228	6%
Clothes Dryer	103,092	3,797	4%
Whole House Measures		1,679	NA
Dishwasher	7,377	0	0%
Clothes Washer	8,764	0	0%
Misc	134,833	0	0%
Total Energy Efficiency	**2,076,746**	**479,381**	**23%**
Fuel Switching			
Cooking	170,465	8,976	9%
Clothes Dryer	103,092	6,764	4%
Total Fuel Switching	**273,557**	**15,740**	**6%**
Total	**2,247,212**	**495,121**	**22%**

Table 22 compares estimated winter peak demand reduction to the disaggregated forecast from the end-use model.

Table 22
Comparison of End-Use Model and Achievable Winter Peak Savings Potential (MW)

End-Use	End-Use Model 2030 Winter MW	Total Achievable Potential	Total Potential as % of 2030 Forecast
Energy Efficiency			
Space Conditioning & Ventilation	233.0	51.2*	22%
Water Heater	23.2	15.0	65%
Lighting	72.6	7.9	11%
Consumer Electronics	20.7	5.8	28%
Refrigerator	15.9	0.9	5%
Computers etc.	9.2	0.6	7%
Freezer	7.1	0.4	6%
Clothes Dryer	32.5	0.1	0%
Dishwasher	2.5	0	0%
Whole House Measures		0	NA
Clothes Washer	2.8	-	0%
Misc	29.2	-	0%
Total Energy Efficiency MWh	**416**	**82**	**20%**
Fuel Switching			
Cooking	59.5	12.6	20%
Clothes Dryer	33	7	21%
Total Fuel Switching	**92**	**19**	**21%**
Total	**508**	**102**	**21%**

*Includes approximately 20 MW of electric thermal storage

Table 23 compares estimated summer peak demand reduction to the disaggregated forecast from the end-use model.

Table 23
Comparison of End-Use Model and Achievable Summer Peak Savings Potential (MW)

End-Use	End-Use Model 2030 Summer MW	Total Achievable Potential	Total Potential as % of 2030 Forecast
Energy Efficiency			
Space Conditioning & Ventilation	166.3	19.0	11%
Water Heater	32.9	10.2	31%
Lighting	47.0	6.2	13%
Consumer Electronics	39.5	3.9	10%
Refrigerator	22.2	0.8	4%
Clothes Dryer	19.5	0.6	3%
Freezer	11.9	0.5	4%
Computers etc.	21.3	0.4	2%
Whole House Measures		0.3	NA
Dishwasher	1.4	0	0%
Clothes Washer	1.6	0	0%
Misc	20.2	-	0%
Total Energy Efficiency	**384**	**42**	11%
Fuel Switching			
Cooking	68.7	9.4	19%
Clothes Dryer	19.5	4	14%
Total Fuel Switching	**88**	**13**	**15%**
Total	**452**	**55**	**12%**

Table 24 illustrates the 1, 5, 10, and 20 year energy efficiency potential that is achievable through utility programs.

Table 24
Residential Program Achievable Energy Efficiency Potential
GWh

Measure Category	Year 1	Year 5	Year 10	Year 20
Weatherization	4.0	23.0	48.9	101.0
Water Heating	1.0	9.8	42.0	112.4
Lighting	10.1	37.4	43.5	53.6
Consumer Electronics	0.2	5.6	18.0	20.4
Heat Pump Upgrade	0.4	2.9	8.3	19.8
Appliances	0.9	5.0	10.3	18.3
HVAC	1.1	5.4	9.8	18.2
Heat Pump Conversion	0.6	3.6	7.6	15.7
Computers etc.	0.02	0.5	3.4	9.6
Whole House	0.1	0.4	0.4	0.4
Total	**19**	**94**	**192**	**369**

Commercial Energy Efficiency Savings Potential

Introduction

FortisBC commercial customers consume approximately 34 percent of total load (both direct and indirect customers). This section of the report estimates the amount of energy efficiency potential available through these commercial customers. First customer characteristics are summarized using the end-use forecast developed in a previous section and the FortisBC Commercial Customer Survey completed in August 2009. Next, energy efficiency measures are defined followed by a summary of savings potential compared to the end-use load forecast.

Commercial Customer Characteristics

Figure 39 summarizes the distribution of building types for FortisBC commercial customers. Building type, heat type, and average building size are the key parameters used to define FortisBC's commercial sector. These parameters are developed and forecasted in the End-Use Consumption Forecast section.

Figure 39
Commercial Building Breakdown, Number of Buildings

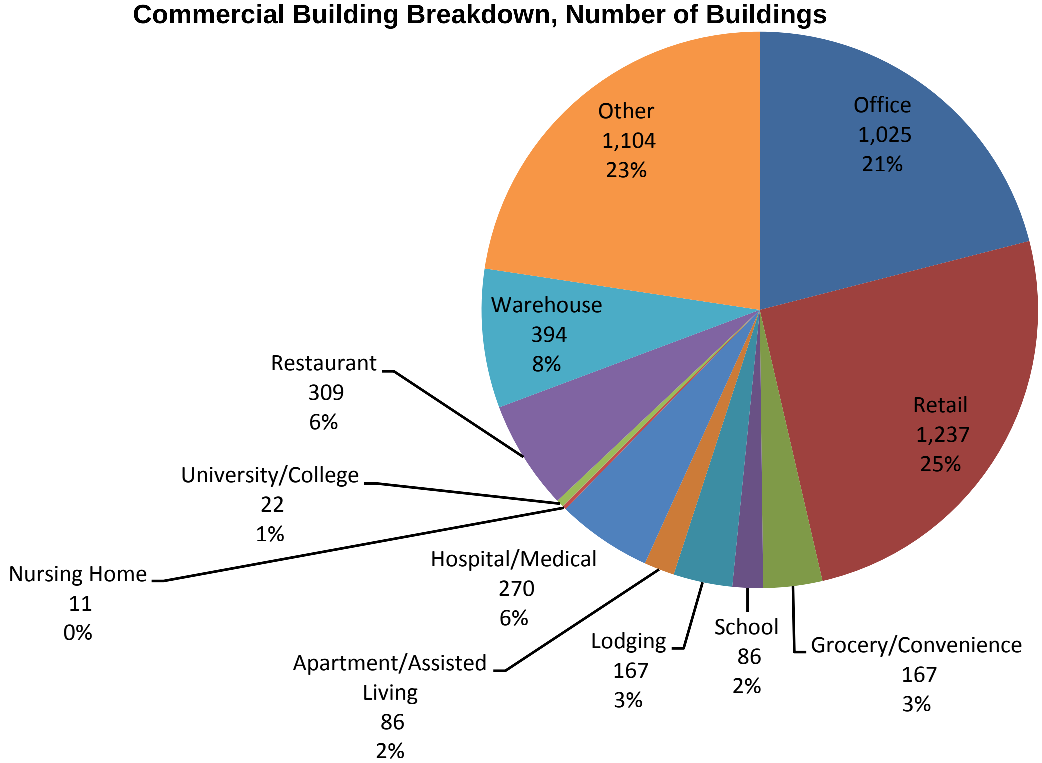


Table 25 illustrates the lighting types for commercial floor space. The percent share is of commercial square footage for each building type. Compact fluorescent lights (CFLs) are installed in up to 30 percent of commercial floor space for some building types.

Table 25
Commercial Building Lighting Characteristics

Building Type	No lighting	Linear fluorescent	Incandescent	CFL	Halogen, Quartz	High Pressure Sodium	Mercury Vapour	Metal Halide	Other
Large Office	1%	74%	16%	7%	2%	0%	0%	0%	0%
Medium Office	1%	74%	16%	7%	2%	0%	0%	0%	0%
Small Office	1%	74%	16%	7%	2%	0%	0%	0%	0%
Large Non-Food Retail	2%	65%	9%	6%	10%	2%	0%	5%	1%
Medium Non-Food Retail	2%	65%	9%	6%	10%	2%	0%	5%	1%
Small Non-Food Retail	2%	65%	9%	6%	10%	2%	0%	5%	1%
Large Hotel	1%	34%	27%	30%	6%	1%	0%	3%	0%
Medium Hotel/Motel	1%	34%	27%	30%	6%	1%	0%	3%	0%
Large School	1%	63%	23%	8%	4%	1%	0%	0%	0%
Medium School	1%	63%	23%	8%	4%	1%	0%	0%	0%
Grocery/Convenience	1%	34%	27%	30%	6%	1%	0%	3%	0%
Apartment/Assisted Living	1%	34%	27%	30%	6%	1%	0%	3%	0%
Medical	1%	63%	23%	8%	4%	1%	0%	0%	0%
Hospital	1%	63%	23%	8%	4%	1%	0%	0%	0%
Nursing Home	1%	34%	27%	30%	6%	1%	0%	3%	0%
University/College	1%	63%	23%	8%	4%	1%	0%	0%	0%
Restaurant/Tavern	1%	34%	27%	30%	6%	1%	0%	3%	0%
Warehouse/Wholesale	1%	62%	16%	4%	6%	3%	1%	9%	0%
Other	1%	74%	16%	7%	2%	0%	0%	0%	0%

Table 26 summarizes heating fuel shares among commercial buildings. Many of these buildings have more than one heating fuel and most are primarily heated by utility gas. These data are from the customer surveys completed in 2009.

Table 26
Commercial Building Heat Types

Building Type	Electricity	Natural Gas	Other	Natural Gas plus Supplemental fuel
Large Office	15%	79%	2%	81%
Medium Office	15%	79%	2%	81%
Small Office	15%	79%	2%	81%
Large Non-Food Retail	7%	81%	11%	92%
Medium Non-Food Retail	7%	81%	11%	92%
Small Non-Food Retail	7%	81%	11%	92%
Large Hotel	44%	38%	16%	54%
Medium Hotel/Motel	44%	38%	16%	54%
Large School	25%	65%	8%	73%
Medium School	25%	65%	8%	73%
Grocery/Convenience	25%	65%	8%	73%
Apartment/Assisted Living	25%	65%	8%	73%
Medical	25%	65%	8%	73%
Hospital	25%	65%	8%	73%
Nursing Home	25%	65%	8%	73%
University/College	25%	65%	8%	73%
Restaurant/Tavern	25%	65%	8%	73%
Warehouse/Wholesale	26%	62%	10%	72%
Other	35%	58%	4%	62%

Energy Efficiency Measures

Several measures for each end-use were analyzed to model energy efficiency potential. The table below summarizes the types of technology-based measures included in the analysis. While few categories are provided in the table, several permutations of each measure within these categories exist. In total, there are over 1,300 individual measures in the commercial sector.

Table 27
Commercial Energy Efficiency Measure Categories

Commercial Refrigeration	Water Treatment
Grocery Store Measures	Existing Building Lighting Upgrades
Pre-Rinse Spray Valve	New Building Lighting Upgrades
Cooking	Lighting Controls
Premium HVAC Equipment	Parking Lighting
Demand Control Ventilation	LED Street Lighting
ECM Motors in Variable Air Volume HVAC Systems	Window Upgrades
Continuous Optimization HVAC	Roof Insulation Upgrades
Package Roof Top Optimization & Repair	Network PC Power Management
Municipal Wastewater Treatment	Computer Servers

Emerging Technologies

Many of the emerging technologies identified in the Residential section also will have application in the commercial sector. These measures include advanced windows, green roofs, efficient lighting, solar air conditioning, on-site generation, and advanced controls (integrated with Smart Grid). However, the major advancements in the commercial sector are likely to come from the following general areas:

- Net zero or whole building measures,
- Efficient lighting, including LEDs, fibre optics,
- On-site generation; and
- Advanced controls.

Customer-Owned Renewable Energy

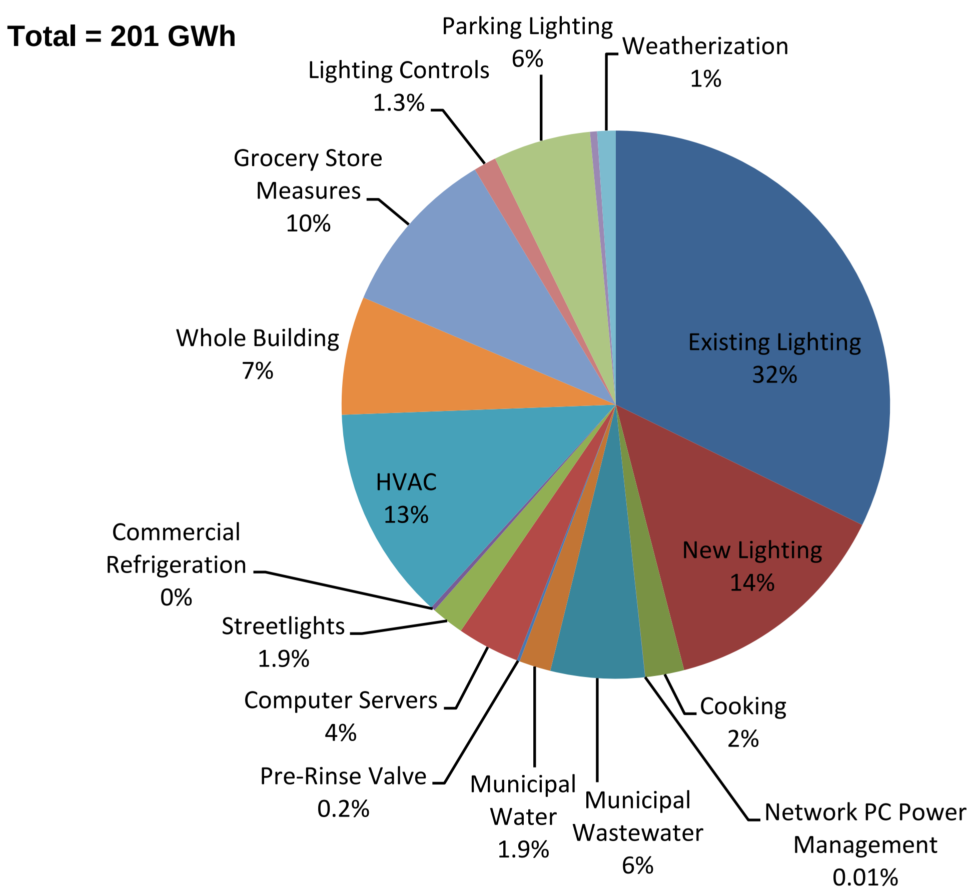
Solar PV on new and existing buildings is analyzed in this study. The measure data is from the BC Hydro 2007 study. Solar PV in commercial applications is generally sized at 100 kW. The Southern Interior of British Columbia has medium to high solar resources or approximately 4 kWh/m^2/day. The energy savings for renewable energies are reported separately from savings from energy efficiency measures. As reported in the Residential section, potential estimates for micro-hydro systems are not included.

Potential Estimates

As described in the methodology section, end-use load forecast data and energy efficiency measures are combined to produce estimates of energy efficiency. In this analysis, energy efficiency potential is presented separately from the electric savings from fuel switching measures. The total achievable potential is 201 GWh annually by 2030 or energy savings of 14% of 2030 forecasted commercial load. In this section, economic and achievable potential are discussed followed by program achievable potential.

Figure 40 illustrates the breakdown of energy efficiency potential that is both economic and achievable. The potential estimates include measures that apply to both new and existing construction. The measure categories are described in further detail below.

Figure 40
2030 Achievable Energy Savings Potential – Commercial

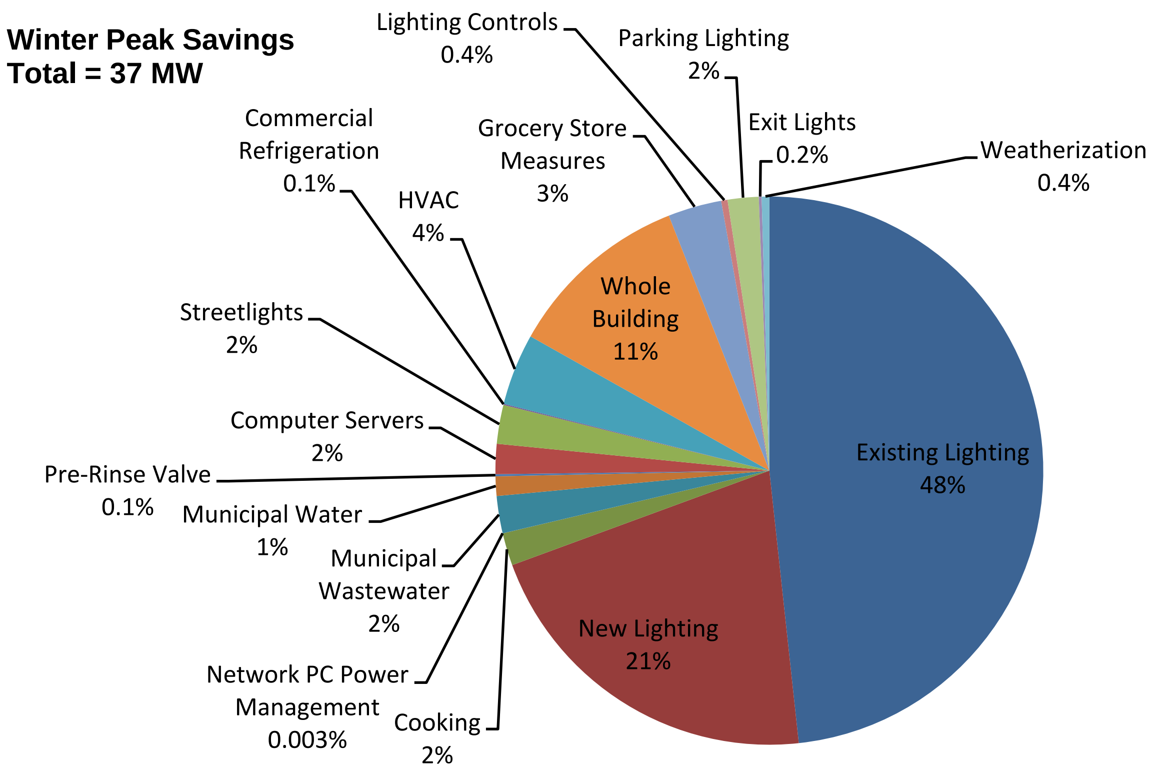


- Lighting – New and retrofit lighting for building interiors and exteriors
- Cooking – Hot food holding cabinet, steamers, and ovens.
- Network PC Power Management – Includes residential desktop computers and monitors.
- Municipal Water – optimization based on design capacity calculated as a rate per population. Includes both wastewater treatment and drinking water treatment.
- Pre-Rinse Spray Valve – includes high-efficiency, low-flow spray valves for food service applications.
- Computer Servers – applies to number of units calculated as a rate based on employment.
- Streetlights – street and roadway lighting.
- Commercial Refrigeration – applies to specific freezers, refrigerators, and ice-makers that are not included in the grocery store measure category.
- HVAC – includes premium HVAC equipment, controls commission HVAC, ECM on VAV boxes, package roof top optimization and repair, and demand control ventilation.
- Grocery Store Measures – refrigeration, fan, case lighting, compressors, visicoolers, compressors, anti-sweat controls, and motors.

- Weatherization – includes roof insulation and window upgrades
- Lighting Controls
- Parking Lighting
- Exit Lights

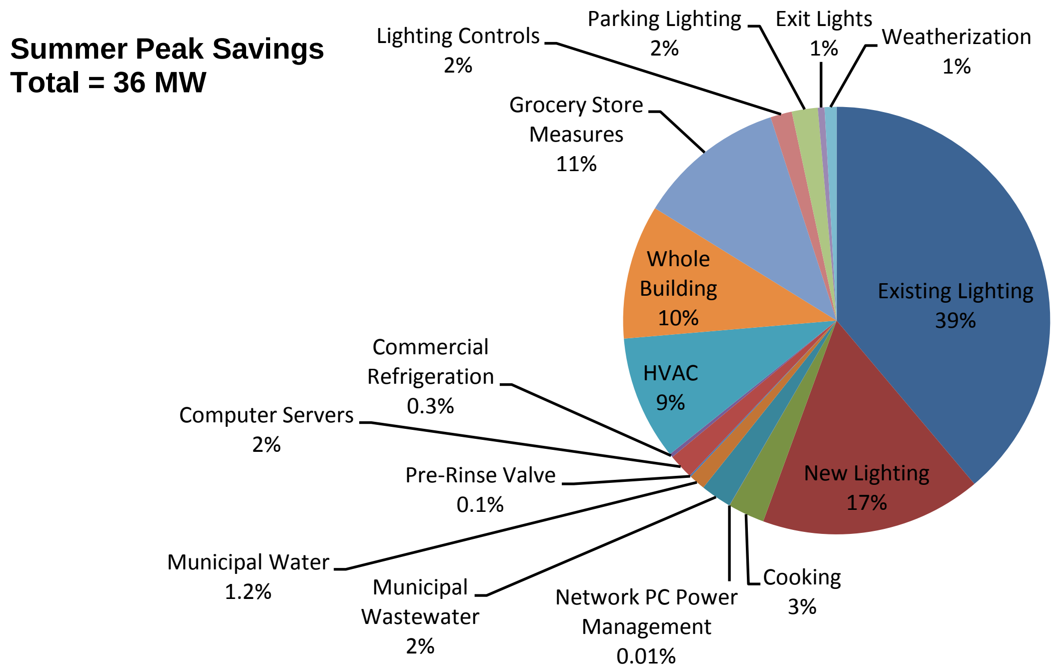
Winter peak reduction from these energy efficiency measures is shown in Figure 41.

Figure 41
Winter Peak Savings from Commercial Energy Efficiency Measures Achievable



Summer peak reduction from these energy efficiency measures is shown in Figure 42.

Figure 42
Summer Peak Savings from Commercial Energy Efficiency Measures Achievable



Customer-Owned Renewable Energy

Cost and savings data for renewable energy measures were primarily obtained from the BC Hydro study. Technical potential is calculated assuming that 30% existing commercial buildings have appropriate installation sites and 45% of new construction buildings have appropriate installation sites. The result is that 1,600 existing buildings and 1,300 new buildings might be appropriate for commercial PV units.

Commercial PV units do not pass the TRC at current costs; however, similar to residential, a second scenario is analyzed where costs are decreased over the planning period (consistent with cost decreases from the BC Hydro study). Costs are estimated at 42 percent of their current levels by 2013, 21 percent the current level by 2018, and 11 percent current levels by 2023. Solar PV is cost effective by 2018; therefore, achievable potential is ramped up from 1 percent annually to 8 percent over the remainder of the period. A total of 1,418 units are installed over the period 2018 through 2030. Table 28 summarizes the measure data and results of the analysis.

Table 28
Commercial Customer-Owned Renewable Energy

	Annual Generation kWh	Capital Cost	Installation Cost	Annual O&M	Life	TRC BC Ratio	Technical Potential MWh	Achievable Potential(1) MWh
Commercial PV Unit, 100 kW New and Existing Buildings	118,000	$430,756	$215,378	$6,461	20	0.26	341,439	167,305

(1) Achievable Potential is economic and achievable based on decreasing cost scenario.

Costs

TRC measure costs, utility costs, and participant costs are calculated for the economic and achievable potential. For the utility cost calculation, a proxy for utility incentives of 60% of the incremental measure cost is used and program administration costs of 20% of the incremental measure cost are assumed. Participants incur O&M costs/benefits. Table 29 summarizes these costs as well as compares a weighted average of the levelized cost with savings potential. All cost and savings potential data in the table are for economic and achievable quantities of energy efficiency potential.

Table 29
Cost Summary, $2009

Measure Category	Ramp Rate	Total Measure Cost ($1000s)	Winter Peak Savings MW	Summer Peak Savings MW	Average TRC Levelized Cost $/MWh	Weighted Benefit-Cost Ratio	Achievable Savings Potential MWh
Existing Lighting	15YearEven	$14,802	17.92	13.43	$22.59	4.05	64,776
New Lighting	New Lighting - Program	$9,481	7.84	5.79	$2.55	4.98	27,666
HVAC	HVAC - Code Change	$17,352	1.57	3.25	$68.17	3.32	25,443
Grocery Store Measures	20YearEven	$4,788	1.17	3.87	$36.67	5.49	20,135
Whole Building	20YearEven	$13,663	4.04	3.51	$87.83	2.45	14,028
Parking Lighting	20YearEven	$5,949	0.68	0.68	$82.10	2.10	11,554
Municipal Wastewater	15YearEven	$7,085	0.81	0.81	$6.60	2.33	11,153
Computer Servers	20YearEven	$1,763	0.66	0.66	$15.97	2.41	7,401
Cooking	20YearEven	$2,185	0.71	0.96	$4.93	4.04	4,606
Streetlights	20YearEven	$5,140	0.85	0.00	$8.09	1.11	3,898
Municipal Water	15YearEven	$3,920	0.43	0.43	$12.82	1.00	3,739
Lighting Controls	20YearEven	$775	0.14	0.56	$32.22	6.48	2,687
Weatherization	20YearEven	$1,862	0.17	0.31	$75.67	2.99	2,189
Exit Lights	10YearEven	$995	0.06	0.18	$141.90	1.09	839
Commercial Refrigeration	20YearEven	$608	0.02	0.10	$12.75	95.94	505
Pre-Rinse Valve	5YearEven	$75	0.04	0.04	$9.53	3.23	354
Network PC Power Management	20YearEven	$5	0.00	0.00	$9.84	4.18	23
Total		**$90,449**	**37.1**	**34.6**	**$34.14**	**3.97**	**200,995**
Solar PV, Customer Renewable(1)		**$44,918**			**$722.37**	**1.25(2)**	**167,305**

(1) Potential estimates and benefit-cost ratio assumes decreasing costs over planning period.
(2) Average benefit-cost ratio over planning period. Solar PV for commercial buildings is cost-effective beginning in 2018

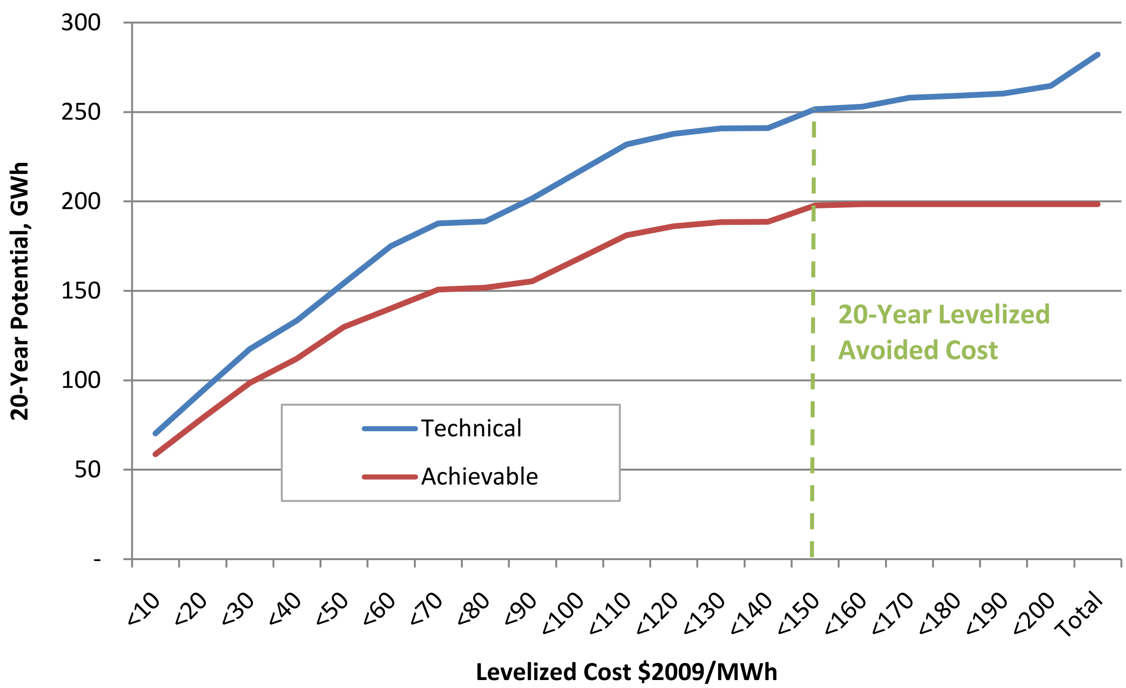
- **Ramp Rate** – reference to ramp rate used in estimating program achievable potential, discussed later.
- **Total Measure Cost** – incremental capital costs, O&M, replacement costs, and program administration costs. Costs are in thousands.
- **Winter Peak Savings –** MW peak savings associated with energy efficiency measure.

- **Summer Peak Savings –** MW peak savings associated with energy efficiency measure.
- **Average TRC Levelized Cost** – weighted average of levelized costs in measure category (weighted by share of measure category savings).
- **Weighted Benefit-Cost Ratio** – benefit-cost ratio for category weighted by the share of measure category savings.
- **Savings Potential** – Economic and achievable savings potential. Includes potential achieved through codes and standards.

Supply Curves

Energy efficiency resources are often summarized as supply curves. The supply curves in the figure below show how much energy efficiency (GWh) is available at different price levels. The x-axis shows measure levelized costs. These costs can be compared to supply side resources; however, unlike supply-side resources, the total quantity of the resource may not be available immediately. The curves in Figure 43 show the 20-year technical potential as well as the economic potential that can be reasonably obtained during that time period. Note that the economic and achievable potential in the figure includes potential that might be achieved through code and standard changes.

Figure 43
Commercial Energy Efficiency Supply Curves

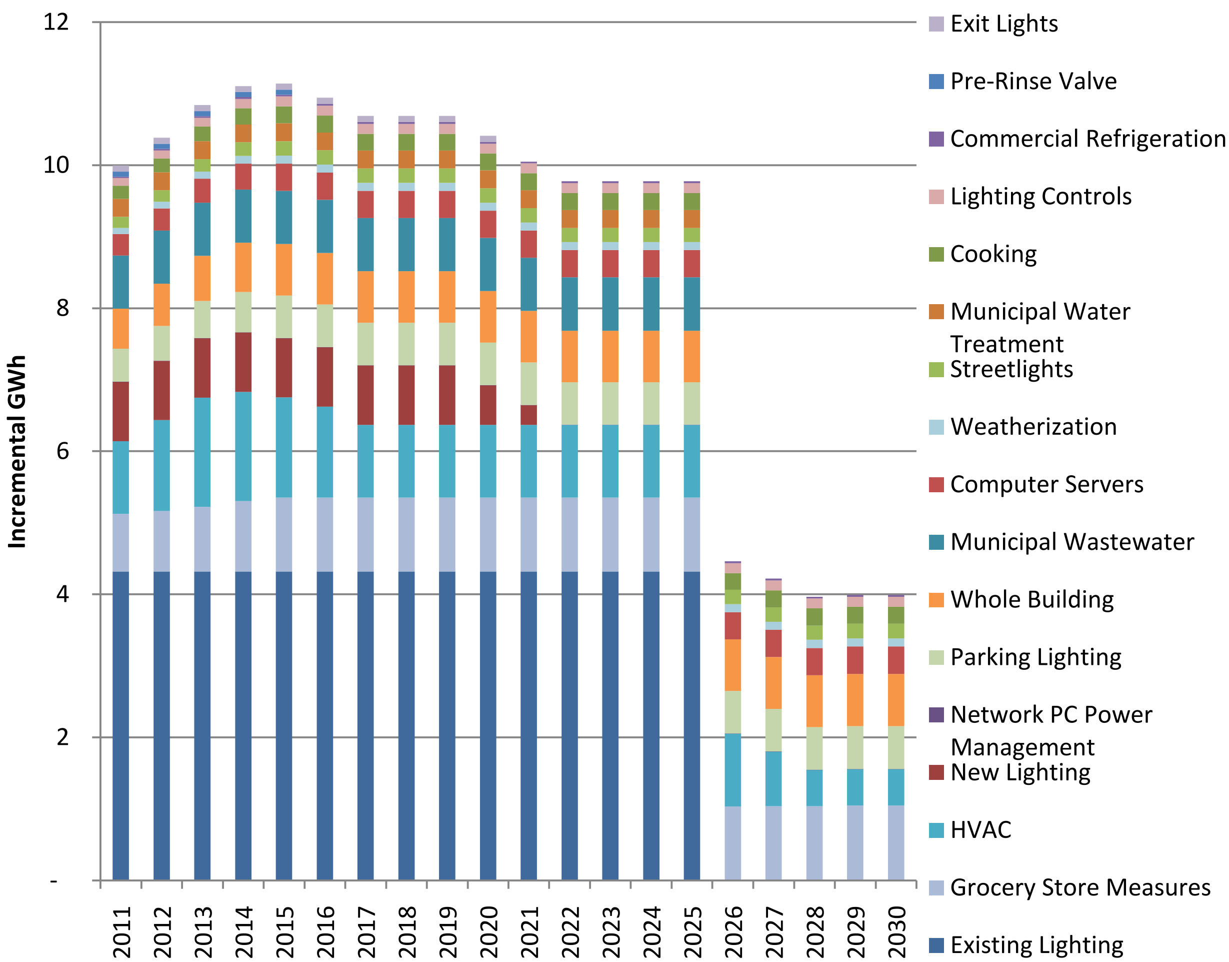


Program Achievable Potential

The previous section defined energy efficiency potential that is both economic and achievable through utility programs, codes, and standards. This section of the memo identifies potential that is both economic and achievable through utility programs only. Or, energy efficiency potential that is expected to be achieved through known code changes and product standards is not included in the following estimates.

In order to define utility program achievable potential, or "Program Achievable Potential," ramp rates are assigned by measure category to approximate the amount of energy efficiency potential that could be reasonably obtained through utility program efforts over the planning period. Figure 44 shows the Program Achievable Potential cumulatively by measure category.

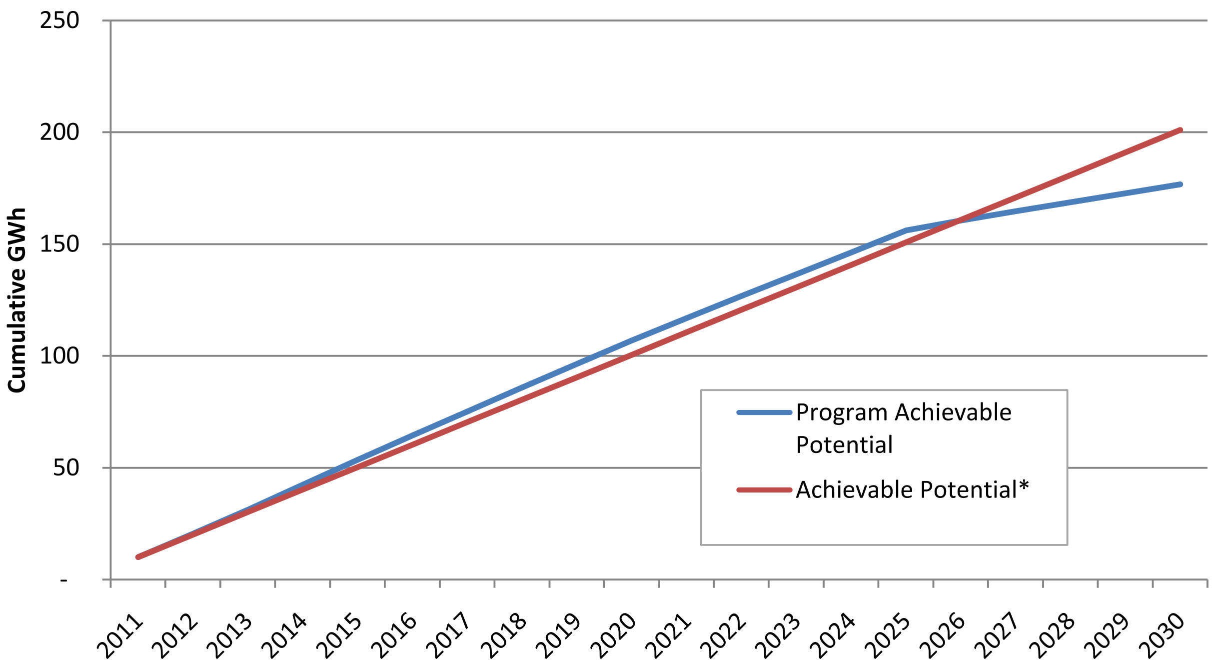
Figure 44
Commercial Program Achievable Potential[14]



[14] Excludes savings potential achieved through codes and standards.

Figure 45 compares Program Achievable Potential with total Achievable potential.[15] The difference between the curves in the out years (Figure 45) is the potential achieved through codes and standards for new building lighting and HVAC. Program Achievable Potential is higher than Achievable Potential for the first 15 years due to aggressive ramp rates for commercial lighting. The commercial code changes expected to occur during the 2011 – 2030 timeframe will result in an estimated 24 GWh of energy efficiency. See Appendix A for more details on code changes in the commercial sector.

Figure 45
Achievable vs. Program Achievable Potential



*Includes efficiency from codes and standards.

Summary

The following three tables compare the energy efficiency potential estimates with the end-use load forecast for the year 2030. When customer-owned renewable energy is added to the energy efficiency savings potential, FortisBC could achieve a 25 percent savings from their forecasted 2030 consumption in the commercial sector. Overall, energy efficiency potential can be used to meet 46 percent of load growth within the commercial sector.

[15] Note that all energy efficiency potential referenced in these paragraphs is cost-effective, or economic.

Table 30 compares the achievable energy efficiency potential to the forecast of 2030 load from the end-use model. The miscellaneous category includes municipal water and wastewater measures.

Table 30
Comparison End-Use Forecast with Conservation Potential Estimates

End-Use	End-Use Model 2030 Load MWh	Energy Efficiency Achievable Potential MWh	Percent of 2030 Load
Lighting	529,139	107,522	20%
HVAC	558,372	27,632	5%
Refrigeration	120,347	20,640	17%
Misc	45,224	14,892	33%
Whole Building		14,028	NA
Computer Equipment	81,467	7,424	9%
Food Service	29,816	4,606	15%
Streetlights	13,538	3,898	29%
Water Heat	38,333	354	1%
Elevators	4,374		0%
Plug Load	49,103		0%
Total	1,469,713	200,995	14%
Solar PV, Customer Renewable(1)		167,305	
Total	1,469,713	368,300	25%

(1) Assumes decreasing costs as noted in this section.

Table 31 illustrates the breakdown for winter peak savings. The energy efficiency potential estimated provides 12 percent winter peak savings.

Table 31
Comparison End-Use Forecast with Conservation Potential Estimates, 2030 Winter Peak

End-Use	End-Use Model Winter Peak MW	Energy Efficiency Achievable Potential Winter MW	% of 2030 Load
Lighting	153	26.6	17%
Whole Building		4.0	NA
HVAC	60	1.7	4%
Refrigeration	35	1.2	3%
Misc	11	1.2	11%
Streetlights	3	0.8	32%
Computer Equipment	16	0.7	4%
Food Service	3	0.7	22%
Water Heat	22	0.04	0%
Plug Load	12		0%
Elevators	2		0%
Total	316	37.1	12%

Table 32 illustrates the breakdown of summer peak savings. The energy efficiency potential estimated provides 14 percent summer peak savings.

Table 32
Comparison End-Use Forecast with Conservation Potential Estimates, 2030
Summer Peak

End-Use	End-Use Model Summer Peak MW	Energy Efficiency Achievable Potential Summer MW	% of 2030 Peak Demand
Lighting	111	20.6	19%
Refrigeration	23	4.0	17%
HVAC	63	3.6	7%
Whole Building		3.5	NA
Misc	10	1.2	13%
Food Service	7	1.0	14%
Computer Equipment	18	0.7	4%
Plug Load	11		0%
Water Heat	10	0.0	0%
Elevators	1		0%
Streetlights	0	0.0	0%
Total	252	34.6	14%

Table 33 illustrates the 1, 5, 10, and 20 year energy efficiency potential that is achievable through utility programs.

Table 33
Commercial Program Achievable Energy Efficiency Potential
GWh

Measure Category	1 Year	5 Year	10 Year	20 Year
Lighting	6.0	30.3	60.8	92.1
HVAC	1.0	6.7	12.1	20.5
Grocery Store Measures	0.8	4.6	9.8	20.1
Municipal	1.0	5.0	9.9	14.9
Whole Building	0.6	3.2	6.8	14.0
Computer Servers	0.3	1.7	3.6	7.4
Cooking	0.2	1.0	2.2	4.6
Weatherization	0.1	0.5	1.1	2.2
Commercial Refrigeration	0.02	0.1	0.2	0.5
Pre-Rinse Valve	0.07	0.4	0.4	0.4
Network PC Power Management	0.001	0.01	0.01	0.02
Total	**10.0**	**53.5**	**106.9**	**176.7**

Industrial Energy Efficiency Savings Potential

Introduction

This section describes the methodology, data, and energy efficiency measures used to estimate energy efficiency potential in the industrial sector. The methodology for potential estimation is a top-down approach, rather than the bottom-up approach used in the commercial and residential sectors. The results of the analysis are given as supply curves and detailed tables.

Industrial Customer Characteristics

The end-use model segments industrial load by both sector (paper, mining, fruit packing, etc) and end-use within those sectors (fans, pump, motors, etc). Consumption within each industrial process is disaggregated by applying percentages from sources such as the BC Hydro Conservation Potential Assessment and the Northwest Power and Conservation Council. The result is a top-down methodology for classifying energy consumption by end-use.

The base year for industrial sector consumption is calculated using the 2009 energy forecast for rate schedules 30, 31, and 33 and the Tolko sawmill (wholesale customer). Three customers were removed from the industrial rate class for conservation modeling purposes: UBC Okanagan, Selkirk College, and Trail Community Health. Net energy consumption was available only. Some industrial customers are net metered; self-generation is not included in this forecast nor is it included in the FortisBC system forecast.

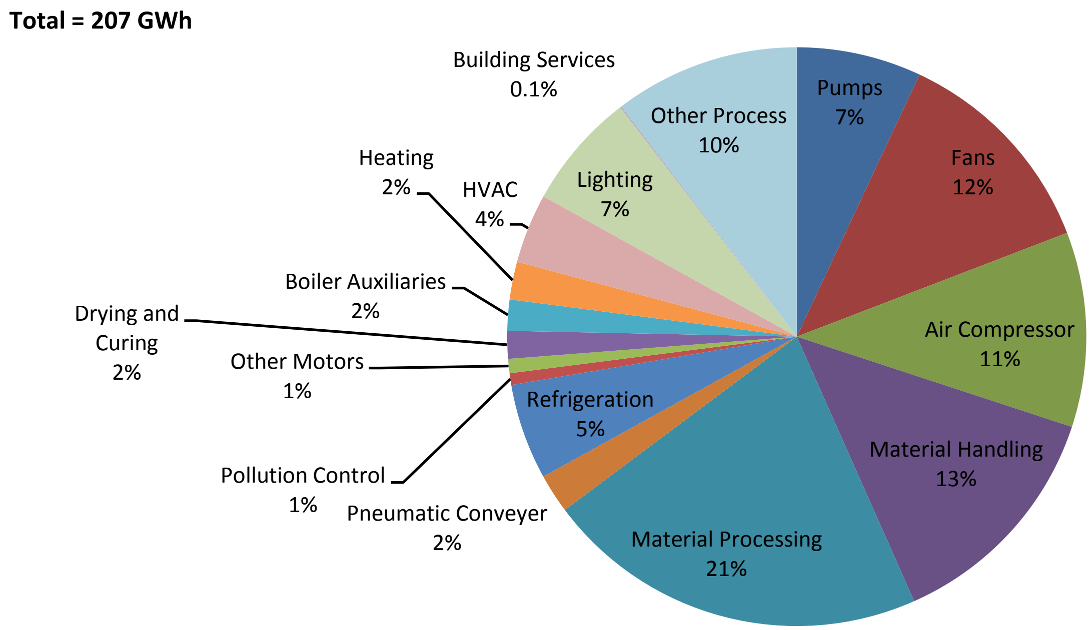
Customer consumption is grouped into classes according to the North America Industry Classification System (NAICS). Table 34 illustrates the industrial processes and annual kWh consumption for these customers. Note that the pulp and paper load is the net conservation of a major manufacture in the FortisBC service territory.

Table 34
Industrial Sector Consumption by Process, 2008

Industrial Process	Energy Consumption GWh
Wood products	90.1
Building Materials	53.0
Pulp and Paper and Paper	16.5
Food and Beverage	13.9
Miscellaneous	9.9
Mining	9.1
Fruit packers and storage	8.7
Other Manufacturing	3.6
Contractors & Construction	2.7
Total	207

Figure 46 shows the resulting break down of industrial electricity consumption for the base year. Total industrial consumption is 207 GWh and is expected to remain flat over the planning period. Therefore the 2030 end-use breakdown will be identical as the 2008 break-down in terms of share and total consumption.

Figure 46
Industrial End-Uses



Energy Benefits

The avoided cost of electricity is the dollar value per MWh, of the conserved electricity, and accounts for the benefit value in cost effectiveness tests. These energy benefits are based on the cost of a generating resource, a forecast of market prices or an integrated resource planning process. As mandated by the British Columbia Ministry of Energy, BC Hydro's avoided costs are used to value energy, peak demand, and transmission and distribution savings.

Modeling Methodology

The methodology used to calculate industrial potential differs from the approach in the residential and commercial sectors. There are two general analytical approaches to estimating conservation potential: a bottom-up approach, and a top-down approach.

The bottom-up approach is the method used in the residential and commercial sectors. The key factor is the number of kWh saved annually from the installation of an individual energy efficient measure. The savings from each measure is multiplied by the total number of expected installations over the life of the program. Each individual total measure savings is then summed and aggregated to total potential.

The top-down approach starts with the load forecast over the study period. These load forecasts are then disaggregated by end-use. Energy savings by measure, end-use, program, or sector are then expressed as a percent of the total energy consumption. For example, pumps are a common component of manufacturing and industrial operations whose improved performance has the potential to save energy. With improved pumps, a certain percentage of the disaggregated pump load can be saved. Savings from each end-use is summed and aggregated to total potential.

Energy Efficiency Measures

There are several classes of industrial measures: cross-industry systems, industry-specific processes and whole plant optimization.

Cross-Industry

Cross-industry measures are improvements of common industrial components found in most manufacturing and industrial settings. These are widespread equipment like fans, pumps, motors, lighting, etc. Cross-industry measures are listed in Table 35 followed by a brief description of major improvements in each measure type.

Table 35
Cross-Industry Measures

Measure Type	Conservation Measure
Belts	Synchronous Belts
Compressed Air	Air Compressor Demand Reduction
	Air Compressor Equipment
	Air Compressor Optimization
Lighting	High Bay Lighting 1-Shift, 2-Shift, or 3-Shift
	Efficient Lighting 1-Shift, 2-Shift, or 3-Shift
	Lighting Controls
Motors	Motors: Rewind 20-50 HP, 51-100 HP, 101-200 HP
Fans	Efficient Centrifugal Fan
	Fan Energy Management
	Fan Equipment Upgrade
	Fan System Optimization
Pumps	Pump Energy Management
	Pump Equipment Upgrade
	Pump System Optimization
Transformers	Transformers-Retrofit

- **Belts** - V-Belts are commonly used to drive industrial processes. By replacing the pulley sheaves with synchronous belt pulleys and installing synchronous belts onto the end use (e.g., fans or pumps), an efficiency gain of 3%-5% can be achieved from reduced slippage and friction.[16]

[16] Northwest Power and Conservation Council. *System Optimization Measures Guide*. 6th Power Plan. March 23, 2009

- **Compressed Air** - The primary measure is retrofit of air compressors. Modern models have built-in adjustable speed drive (ASD) can achieve 40% savings over conventional fixed speed compressors. Additionally, better distribution systems and end-use improvements (use blowers in place of compressors) also contribute to savings.

- **Lighting** - In lighting, there are two main categories of measure savings: major lighting retrofits and replacement of high bay lighting. Lighting retrofits are most applicable to pulp and paper subsector and involves replacing low-efficiency mercury vapor lighting and installation of lighting control. These tend to be in large and older facilities. Replacement of high bay lighting includes changing metal halide bulbs with fluorescent T5 high-output lighting.

- **Motors** - Motors efficiency improvement is fairly straightforward and is already occurring in the FortisBC service territory. There are several difference classes of motors separated by horsepower, but each replaces standard efficiency motors with premium-efficiency motors.

- **Fans** - Savings from industrial fans come from the optimization of fan operation and retrofit with more efficient models. Operation and maintenance improvements include changing filters, maintaining belts (tension, alignment), repair duct leaks, lube bearings and maintain dampers. Additionally, fan retrofits include more efficient timers, adjustable speed drives, and low friction ducts. [17]

- **Pumps** - Pump savings come from both retrofit of pumps in addition to improved operation and maintenance of those currently in operation. New equipment includes replacement of pump at time of major repair or shutdown, proper sizing of trim impeller and control valve. Better maintenance includes coupling alignment, lubrication, seal maintenance, and vibration analysis.

[17] Northwest Power and Conservation Council. *System Optimization Measures Guide*. 6th Power Plan. March 23, 2009

Industry-Specific

Industry-specific processes are improvements of specialized manufacturing components or processes. Like cross-industry measures, it is an improvement of a single technology or process. Common examples are refrigeration in the food service and fruit storage industries and material handling performance improvements. Cross-industry measures are show in Table 36.

Table 36
Industry-Specific Measures

Measure Industry	Conservation Measure
Hi-Tech	Clean Room: Change Filter Strategy
Hi-Tech	Clean Room: Clean Room HVAC
Hi-Tech	Clean Room: Chiller Optimize
Food Processing	Food: Cooling and Storage
Food Storage	Food: Refrigeration Storage Tune-up
Food Storage	Fruit Storage Refer Retrofit
Food Storage	CA Retrofit -- CO2 Scrub
Food Storage	CA Retrofit -- Membrane
Food Storage	Fruit Storage Tune-up
Material Handling	Material Handling2
Material Handling	Material Handling VFD2
Mining Process	Grinding Optimization, Improved Flotation Cells
Paper	Paper: Efficient Pulp Screen
Paper	Paper: Premium Fan
Paper	Paper: Material Handling
Paper	Paper: Large Material Handling
Paper	Paper: Premium Control Large Material
Wood	Wood: Replace Pneumatic Conveyor

Whole plant optimization measures are improvement of whole systems rather than discrete equipment upgrades used in cross-industry systems and industry-specific processes. This accounts for interactive effects in industrial technologies. Such measures require a much more tailored approach that includes: demand-side assessment; proper design, sizing, and/or reconfigurations to match supply to demand; system "commissioning;" sustainable O&M; and supporting management practices.[18] The savings and approach to plant optimization is categorized in a tiered system based the review of numerous case studies and regional program data: Plant Energy Management (First Tier), Energy Project Management (Second Tier), Integrated Plant Energy Management (Third Tier).

[18] Northwest Power and Conservation Council. *System Optimization Measures Guide*. 6th Power Plan. March 23, 2009

Estimating Technical Potential

The technical potential is the sum of savings from all industrial measures and each industrial sub-sector. It represents the amount of energy efficiency potential that is available regardless of cost or other constraints such as willingness to adopt measures.

Estimating the technical potential begins with determining the amount of energy consumed for each end-use (e.g. pumps, fans, motors, etc) in each industrial subsector (paper, wood, mining, etc). Data for this step was calculated in the end-use model. For example, in the wood products industry, 11% of load (10,266,194 kWh/yr) is used for drying fans. Table 37 illustrates an example of end-uses for wood manufacturing. All other industries (mining, construction, fruit packing, etc) have a different associated top-down savings percentage for each component of disaggregated load. An applicability value determines the amount of the end-use load eligible for measure savings. The applicability value is highly dependent on the measure and the industrial sector. For example, certain motors sizes are only applicable to select industries.

Table 37
End-Use Disaggregation Example, Wood Products

	Share	GWh
Drying Fans	11%	10.3
Air Compressor	13%	12.0
Material Handling	23%	20.7
Material Processing	29%	26.1
Pneumatic Conveyor	5%	4.5
Pollution Control	1%	0.9
Boiler Auxiliaries	4%	3.6
Heating	3%	2.7
HVAC	2%	2.1
Lighting	6%	5.6
Other Process	2%	1.5
Total		**90**

Estimating Achievable Potential

Achievable efficiency is the amount of energy savings potential that is achievable and cost-effective. To find cost-effectiveness potential, energy efficiency measures must pass economic screening. In British Columbia, economic potential is defined using a total resource cost (TRC) test to screen measures for cost effectiveness (discussed in more detail in the "Methodology" section of the report). All of the measures discussed in this section pass the TRC. Therefore the "Achievable" potential in this section means that the potential is both economic (cost-effective) and achievable. Previous conservation by FortisBC will also be addressed.

Potential Estimates

As described in the methodology section, end-use load forecast data and energy efficiency measures are combined to produce estimates of energy efficiency. Energy efficiency potential accounts for previous industrial conservation by FortisBC using saturation factors.

Technical Potential

The total technical potential is 35.2 GWh by 2030 or energy savings of 17% of 2030 forecasted load. Table 38 illustrates savings by industrial sector. The wood industry has the largest potential savings, but fruit and pulp industries have a large potential as a percentage of their load.

Table 38
Summary of Energy Efficiency Potential – Technical

		Energy Efficiency	
Sub-Sector	**2030 GWh from End-Use Model**	**Technical Potential GWh**	**Total Potential as % of 2030 Forecast**
Pulp and Paper	17	5	29%
Mining	9	1	12%
Food & Beverage Manufacturing	14	4	27%
Wood Products	90	15	17%
Fruit Packers and Storage	9	3	34%
Miscellaneous Manufacturing	69	7	11%
Total MWh	207	35	17%

Figure 47 illustrates technical potential by measure group. Cross-industry systems have the largest technical potential, with the most savings coming primarily via fans, lighting, and compressed air measures.

Figure 47
Technical Potential by Measure Category

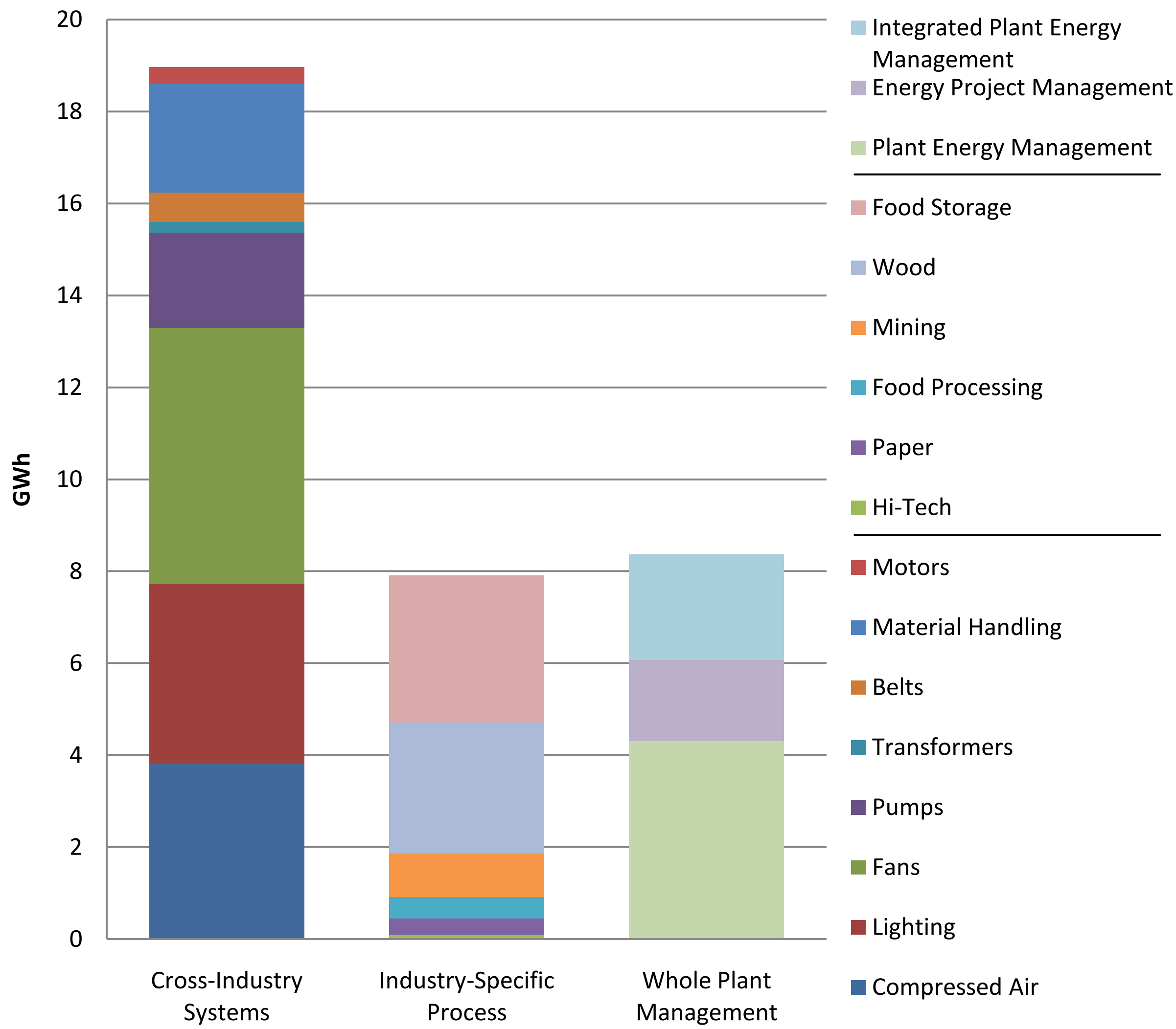


Table 39 illustrates industrial energy efficiency savings potential by end-use.

Table 39
Summary of Energy Efficiency Potential Technical

Measure Group	Measure Type	Potential Savings GWh
Cross-Industry Systems	Compressed Air	3.8
Cross-Industry Systems	Lighting	3.9
Cross-Industry Systems	Fans	5.6
Cross-Industry Systems	Pumps	2.1
Cross-Industry Systems	Transformers	0.2
Cross-Industry Systems	Belts	0.6
Cross-Industry Systems	Material Handling	2.4
Cross-Industry Systems	Motors	0.4
Industry-Specific Process	Hi-Tech	0.1
Industry-Specific Process	Paper	0.4
Industry-Specific Process	Food Processing	0.5
Industry-Specific Process	Mining	0.9
Industry-Specific Process	Wood	2.9
Industry-Specific Process	Food Storage	3.2
Whole Plant	Plant Energy Management	4.3
Whole Plant	Energy Project Management	1.8
Whole Plant	Integrated Plant Energy Management	2.3

Achievable Potential

Using achievability factors, technical potential results are adjusted to realistic levels of conservation over the 20 year study period. Achievability percentages for most measures are 85%.

FortisBC has achieved notable energy saving from industrial measure over the past six years. Conservation by category is shown in Table 40. However, data for past industrial efficiency improvement is built into the top-down savings estimates. For example, in the wood sub-sector, one-third of process equipment is assumed to be upgraded to adjustable speed drive control prior to assessment of potential. Similarly, synchronous belts are assumed to be installed on about 20% of large motors. FortisBC conservation achievements are in line with improvements in the region, so there is no further reduction in the potential due to past conservation.

Table 40
Summary of Past Industrial Conservation
GWh

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**Total**
Motors	0.00	0.00	0.00	0.00	0.01	0.00	0.01
Pumps & Fans	0.67	0.57	0.97	0.00	0.09	0.00	2.32
Industrial Efficiencies	1.13	0.00	0.39	1.92	1.66	3.08	8.19
Compressors	0.23	0.50	0.69	0.52	0.39	0.21	2.54

Therefore, total achievable potential is 27.8 GWh by 2030 or energy savings of 13% of 2030 forecasted load. Table 41 illustrates savings by industrial sector. Again, the wood industry comprises the largest potential savings. Ramp rates are used distribute the savings potential over the 20-year period.

Table 41
Summary of Achievable Energy Efficiency Potential

		Energy Efficiency	
Sub-Sector	2030 GWh from End-Use Model	Total Achievable Potential GWh	Total Potential as % of 2030 Forecast
Pulp and Paper	17	3	21%
Mining	9	1	10%
Food & Beverage Manufacturing	14	3	20%
Wood Products	90	12	14%
Fruit Packers and Storage	9	3	30%
Miscellaneous Manufacturing	69	6	8%
Total MWh	207	27.8	13%

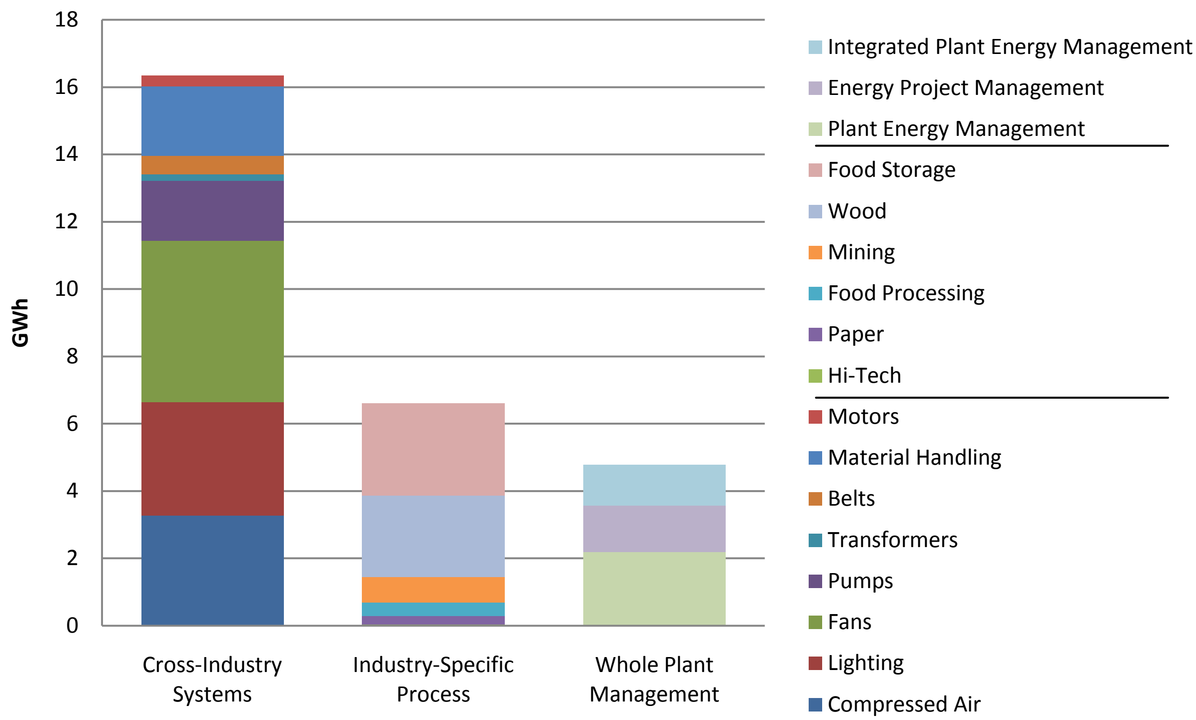
The cumulative achievable potential for 1, 5, 10 and 20 year periods are shown in Table 42. Ramp rates by year are listed in Appendix D.

Table 42
Achievable Potential - Adjusted by Year Using Ramp Rates
GWh

			Year			
		Ramp Rate	**1**	**5**	**10**	**20**
Cross-Industry Systems	Fans	10YearEven	0.25	1.25	2.49	4.80
Cross-Industry Systems	Lighting	New Measure Fast	0.10	1.01	2.69	3.37
Cross-Industry Systems	Compressed Air	10YearEven	0.28	1.52	3.16	3.28
Industry-Specific Process	Food Storage	10YearEven	0.27	1.37	2.74	2.74
Industry-Specific Process	Wood	New Measure Medium	0.04	0.36	1.05	2.43
Whole Plant	Plant Energy Management	New Measure Medium	0.03	0.33	0.95	2.19
Cross-Industry Systems	Material Handling	New Measure Medium	0.03	0.31	0.90	2.07
Cross-Industry Systems	Pumps	20YearEven	0.09	0.44	0.89	1.78
Whole Plant	Energy Project Management	New Measure Medium	0.02	0.21	0.60	1.37
Whole Plant	Integrated Plant Energy Management	New Measure Medium	0.02	0.18	0.53	1.22
Industry-Specific Process	Mining Process	20YearEven	0.04	0.19	0.38	0.75
Cross-Industry Systems	Belts	10YearEven	0.05	0.27	0.54	0.54
Industry-Specific Process	Food Processing	10YearEven	0.04	0.20	0.41	0.41
Cross-Industry Systems	Motors	New Measure Medium	0.00	0.05	0.13	0.31
Industry-Specific Process	Paper	20YearEven	0.01	0.06	0.12	0.25
Cross-Industry Systems	Transformers	20YearEven	0.01	0.05	0.10	0.20
Industry-Specific Process	Hi-Tech	10YearEven	0.00	0.02	0.03	0.03
Total (GWh)			**1.3**	**7.8**	**17.7**	**27.7**

Achievable potential by measure group is shown in Figure 48.

Figure 48
Industrial Achievable Potential by End-Use



Peak Demand Reduction

Tables 43 and 44 summarize winter and summer peak demand reduction potential provided by the energy efficiency measures analyzed in this section. Approximately 10 percent winter peak reduction can be achieved through the energy efficiency measures identified as cost-effective.

Table 43
Comparison Industrial End-Use Forecast with Winter Peak Reduction Estimates

	2030 Winter Peak from End-Use Model MW	Energy Efficiency Achievable Potential Winter MW	Percent of 2030 Load
Pulp and Paper	8.6	0.55	6.5%
Mining	4.2	0.42	10.0%
Food and Beverage	1.6	0.33	20.3%
Wood Products	14.6	1.89	13.0%
Fruit packers and storage	1.6	0.49	29.9%
Miscellaneous Manufacturing	16.4	0.91	5.5%
Total	**47.0**	**4.59**	**9.8%**

Table 44
Comparison Industrial End-Use Forecast with Summer Peak Reduction Estimates

	2030 Summer Peak from End-Use Model MW	Energy Efficiency Achievable Potential Summer MW	Percent of 2030 Load
Pulp and Paper	9.9	0.55	5.6%
Mining	1.5	0.16	11.1%
Food and Beverage	2.5	0.60	24.4%
Wood Products	13.3	1.95	14.7%
Fruit packers and storage	1.0	0.41	39.8%
Miscellaneous Manufacturing	6.0	0.94	15.5%
Total	**34.2**	**4.62**	**13.5%**

Summary

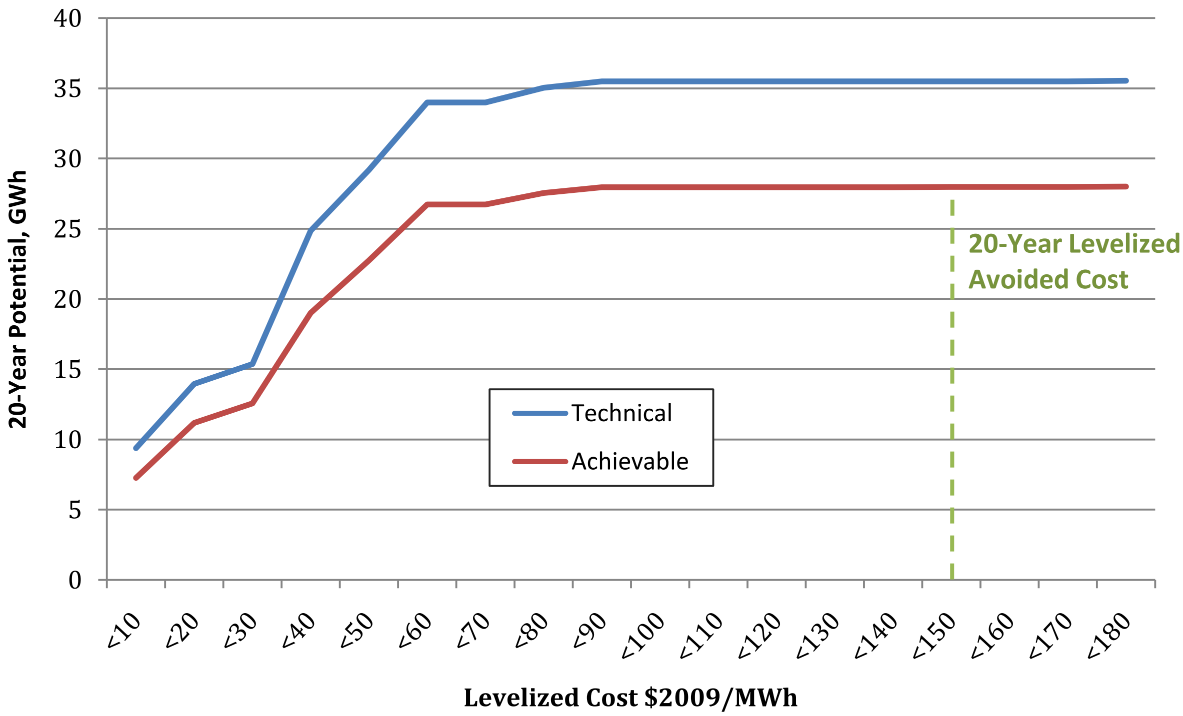
Table 45 compares achievable and technical potential to the end-use load forecast for the year 2030. Achievable potential ranges from 8% to 30% of industrial load based on manufacturing sector. A bulk of the savings comes from measures with low levelized cost of $0.03-$0.04/kWh.

Table 45
Summary of Energy Efficiency Potential

		Technical		Achievable	
Sub-Sector	2030 GWh from End-Use Model	Total Technical Potential GWh	Total Potential as % of 2030 Forecast	Total Achievable Potential GWh	Total Potential as % of 2030 Forecast
Pulp and Paper	16.50	4.8	29%	3.5	21%
Mining	9.12	1.1	12%	0.9	10%
Food & Beverage Manufacturing	13.87	3.8	27%	2.7	20%
Wood Products	90.05	15.1	17%	12.2	14%
Fruit Packers and Storage	8.72	3.0	34%	2.6	30%
Miscellaneous Manufacturing	69.20	7.4	11%	5.9	8%
Total	**207.47**	**35.2**	**17%**	**27.7**	**13%**

Figure 49 illustrates the supply curve of levelized cost and savings for all industrial measures.

Figure 49
Supply Curve – Industrial



Irrigated Agriculture Energy Efficiency Potential

Specific industrial processes and technology are required for savings in the agricultural sector. There are three main categories of potential measures: irrigation hardware, irrigation scheduling and milk production. Currently, FortisBC has a designated rate class for irrigation consumption, all of which are direct customers. Load is not segmented for dairy production, so it is assumed that FortisBC does not have applicable dairy farms for agricultural measures. Also, irrigation scheduling measures are applicable to large field crops, while irrigation load in FortisBC is associated with fruit, apple and grape production.[19]

Therefore, improved irrigation hardware, such as the conversion to low-pressure delivery systems and improved pumps, are measures in the agricultural sector. Table 46 shows measure savings, cost and life for applicable measures from the NWPCC 6th *Power Plan*.

Table 46
Irrigation Hardware Measures

Measure Name	Incremental Capital Cost ($/unit)	Measure Life (yr)	Savings per Applicable Acre (kWh/yr)	Applicable Acres
Convert High Pressure Center Pivot to Low Pressure System	$58	10	504	20%
Convert Medium Pressure Center Pivot to Low Pressure System	$22	10	336	15%
Pump, Nozzle & Gasket Replacement Average Well	$111	10	412	11%
Pump, Nozzle & Gasket Replacement Deep Well	$134	10	765	19%

An estimation of irrigation potential from hardware improvement is possible using a bottom-up approach as in the residential and commercial sector calculations. Irrigation consumption is 52,071 MWh/yr and remains flat over the study period. Assuming 1,400 kWh/yr for each acre, 37,193 acres of agricultural land is irrigated in the FortisBC service territory. Using the irrigated acres and applicability factors in Table 42, technical potential is 12,716 MWh. To be consistent with the NWPCC, an applicability factor of 85% is used to calculate achievable potential of 10,809 MWh. Results for irrigation are show in Table 47.

[19] *2006 Agriculture Community Profiles: Kelowna*. Statistics Canada. www.statcan.gc.ca

Table 47 Irrigation Savings				
	2030 Consumption (MWh)	**2030 Technical Potential (MWh)**	**Achievable %**	**2030 Achievable Potential (MWh)**
Irrigation	52,071	12,716	85%	10,809

Demand Response Savings Potential

Introduction

Demand response measures cycle, or shut down, building equipment during peak load events in order to reduce system peak and the need for new capacity. Options for demand response include direct load control, dynamic real-time pricing, time-of use pricing, payment for reductions, and demand buyback. Table 48 compares each method of demand response and its applicable sectors (residential, commercial, and industrial). The focus of this section of the report is on estimating the potential of the direct load control portion of demand response.

Table 48
Demand Response Methods

		Description	Residential	Small & Medium Commercial	Large Commercial	Industrial
Curtailment Based	Interruptible Load	Utility signs agreement with larger customers to reduce their load at peak periods				X
	Direct Load Control	Utility controlled curtailment of household appliances and HVAC equipment using installed communications gateway	X	X		
	Contractual Demand Response	Payment to selected larger industrial customers to reduce load at select periods			X	X
Price Based	Time of Use (TOU) Pricing	Adjust power price for different times of day and year. Periods are pre-determined	X			
	Dynamic Real Time Pricing	Dynamically adjust power price as demand increases.	X	X	X	X
	Critical Peak Pricing	TOU Rates that correspond to extreme peak hours. Prices reflect the power of generating or purchasing electricity at peak times.	X	X	X	X

Demand response is an area of significant uncertainty because of relatively limited experience in large-scale programs. However, direct load control has more predictability and reliability from the utilities perspective when compared to other forms of demand response. Direct load control is not a new idea, but it is gaining momentum due to better technology and successful pilot programs. Other utilities in the region, namely BC Hydro, have quantified the savings for demand specific conservation measures.

Therefore, direct load control is the focus of demand response estimates. Relevant concepts, case studies and pertinent technology information are included in this report. The FortisBC direct load control potential can be estimated using customer survey data and regional data sources for measures performance.

Technology and Communication Equipment

At its simplest, direct load control is a method of demand response that utilizes a control device to briefly curtail major appliances or space conditioning units – namely hot water heaters and space conditioning units. Curtailments are intended to shave peak demand for utilities, with a limited, if any, effect on consumers.

Direct load control requires both specific technology and management from a utility's operations department. The system relies on controller switches that interrupts customers' electrical load to specific devices during peak load events. These events are called curtailments and usually last 1-3 hours (less if cycling HVAC equipment).

There are several main components to a direct load control system and these are descibed below:

- An electronically-controlled power switch (often 30A) which is used to switch power ON or OFF to the managed load. This can control the device directly, like a water heater or baseboard heating unit, or a central control device like a thermostat.
- A modem for communication with a server capable of initiating and controlling curtailments from a remote location. In the past, these have opperated on radio frequencies, but recent units operate on cell (SMS), wireless and WiMAX networks.
- Non-volatile memory which contains device identity, load scheduling and load-tracking information.

The FortisBC Advanced Metering Infrastructure (AMI) will be the core to any future load control or demand response progam.

Programs and Data Sources

Direct load control technology is relatively new when compared to energy efficiency measures. As such, the data sources for savings, cost saturation and achievability are not as well established. Organizations in the Northwestern United States and British Columbia have attempted to reduce the uncertainly around predicting load control potential. There are several recent pilot programs or potential studies in the Northwest. The most prominent being the

Powershift Program on the Olympic Peninsula in Washington State and the Goodwatts program in Ashland, Oregon. A brief summary of each program is presented in Appendix E.

Most large-scale load control programs have focused on the curtailment of summer cooling load. There are limited programs in winter peaking service territories that are not pilot programs. Therefore, we focused on several potential studies that included data for winter peaking systems.

Data for this potential study are predominantly based on recent potential studies from BC Hydro *(2007 Conservation Potential Review)*, the Northwest Power and Conservation Council *(6th Power Plan)* and PacifiCorp *(Demand Response Proxy Supply Curves)*. These sources were referenced for cost, savings, lifetime, applicability and achievability values.

Methodology

The demand reduction potential from direct load control technology was calculated according to the following steps:

1. Calculate peak winter and summer demand in end-use forecast;
2. Estimate the share of residential and commercial buildings applicable to direct load control (i.e. electric heat, etc) from FortisBC survey data;
3. Select direct load control measures applicable to FortisBC service territory from data sources;
4. Determine the peak demand savings per residential or commercial unit;
5. Compile cost data, exclusive of program costs and AMI meters, as requested by FortisBC;
6. Combine savings and building data to calculate technical potential;
7. Determine initial achievability percentages for each measure;
8. Calculate 5-year achievable potential for direct load control measures and compare with total demand;
9. Forecast achievability percentages for full 20 year study period and calculate savings;

The equation form of this methodology is shown below:

$$\{\text{Annual Demand Reduction}\} = \begin{pmatrix}\text{\# Applicable} \\ \text{Buildings}\end{pmatrix} \text{x} \left(\frac{\text{kW Saving}}{\text{Building}}\right) \text{x(Achievability \%)}$$

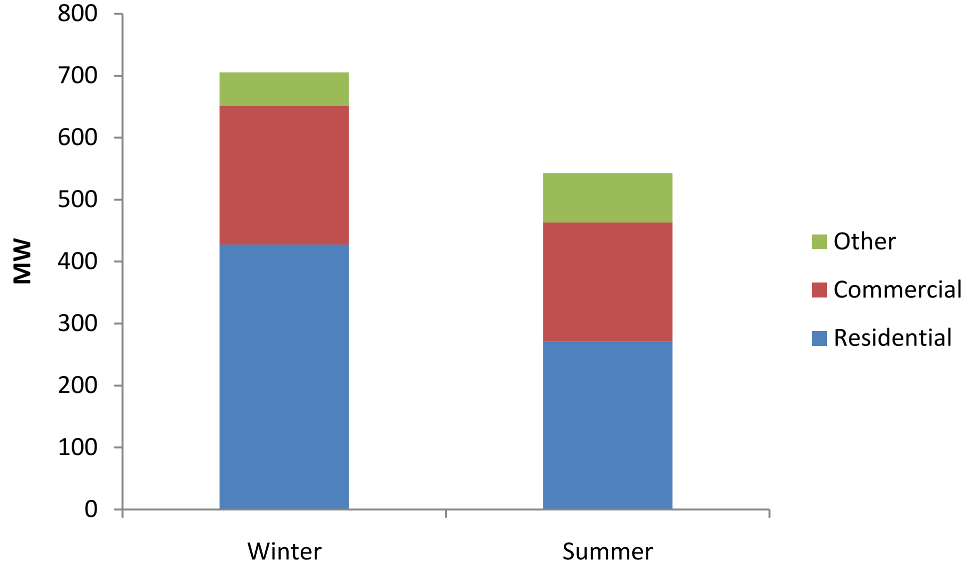
FortisBC Peak Loads

The FortisBC total system winter peak in 2008 was 706 MW and total summer system peak was 560 MW. These peaks are weather-adjusted values. These values will change as the end-use model is modified.

In the Residential Sector, coincident peak load in 2008 was 405 MW in the winter and 219 MW in the summer (see Figure 50). The largest contributor to coincident peak is space heating.

In the Commercial Sector, coincident peak load in 2008 was 225 MW in the winter and 193 MW in the summer (see Figure 50). The largest contributor to commercial peak is lighting.

Figure 50
FortisBC Winter and Summer Coincident Peak, 2008



Direct Load Control - Residential

Measures

All direct load control measures are a curtailment of certain aspects of a home's load at peak periods. The primary candidates for load control are those that have the largest relative contribution to residential peak load and can be curtailed without significant inconvenience to homeowners. Unlike energy efficiency measures, such as weatherization, windows or HVAC upgrades, load control relies on a device to control a major appliance or thermostat, rather than replacing it the appliance itself. Therefore, the communications installed in residential homes drive measure performance and determine future upgrades to the communications protocol and curtailments. The cost of AMI meter installation, operation and maintenance were excluded from this analysis as requested by FortisBC. It is possible to implement direct load control measures without advanced meters. However, in the case of two-way communication units, like those installed on thermostats, AMI is required.

Cost for each measure includes the technology, installation and maintenance over the technology life. To compare measures, the total cost is annualized per or expected savings.

The following DLC measures in Table 49 are included in this study.

Table 49
Residential Direct Load Control Measures

	Description	Winter	Summer
Central Heating	Cycling or setbacks controlled via a central thermostat capable of commutating with grid operators. 2-way communications gives feedback from on-site AMI meters.	X	
Baseboard Heating	Utility controlled switches connected directly to heating units or heating equipment circuits.	X	
Water Heating	Curtailment of water heats using switches installed on water heater or water heater circuit	X	
Air Conditioning Control - Cooling	Curtailment or setbacks of central air-condition units capable of communicating with grid operators.		X

Load control includes three distinct classes of measures: winter space conditioning, hot water heating and summer cooling.

Winter Space Conditioning Measures

Central Heating

Although both thermostat and switch controlled devices reduce heating load during peak periods, they have different performance, cost and applicability. Thermostat controllers shave on average, approximately 30%, of peak heating load at a cost of $40-$50/kW-yr. These are average savings per unit and applicable to homes with central heating. While all heating units might not be on at the same time, savings percentages represent expected peak savings used for annual technical potential. The 30% value accounts for performance, customer overrides, communication failures, and is based on data from pilot program experience. Lifetime is expected to be 10-15 years which is consistent with the life of a conventional thermostat.

Baseboard Heat

Switch-based units are control devices installed directly on baseboard heating equipment or circuits rather than on a central thermostat. They are applicable to homes with zonal electric heat. These devices are generally less sophisticated than thermostat-based controllers. Switch units are less expensive, but are often damaged or not re-configured when heating units are replaced. On average, 15-20% of peak zonal heating load can be controlled at a cost of $28-$35/kW-year.

Thermal Storage

Although is it not a direct load control measure, electric thermal storage units (ETS) have the potential to shave peak demand. This potential is address in the residential and commercial potential sections and is not included in demand response potential.

Water Heating Measures

Water Heating

Water heaters can be curtailed using switches similar to those used for baseboard heating. Heating elements are cycled or turned off during peak curtailment periods by grid operators. This is a very reliable method for peak reduction representing approximately a 0.4 kW per unit savings. While this value may seem low, this is a program level estimate. FortisBC winter and summer daily peak load periods in the late afternoon do not align well with peak water heater usage. During some curtailment events, water heating units might not be running, and therefore will not realize savings. In morning peaking systems, water heater curtailments are more effective and align well with the sharp morning peak in water heater consumption. Also, water heater use is similar year round and does not respond dramatically to outside temperature. Therefore, savings are consistent throughout

Summer Cooling Measures

Air Condition Control - Cooling

Technology for summer cooling curtailments is similar to central heating thermostats for winter heating. The central thermostat controls setbacks and cycling of central AC units based on curtailment commands from utility operators. BC Hydro’s conservation potential study does not include an estimate of summer peak savings from cooling measures. However, the PacifiCorp study does include cost and savings information for cooling direct load control and is shown in Table 48.

Table 50 has a range for costs and savings for each measure. Savings are in kW per residential unit and annual cost averages over the life of the measure. For consistency and depth, values in Table 50 are based primarily on BC Hydro's potential study. However, values are in agreement with savings and cost from the PacifiCorp and NWPCC studies. For example, central thermostat controls have a savings of 1.5 kW/unit in the PacifiCorp study and \$60-\$100/kW-yr cost in the NWPCC study.

Table 50
Cost and Savings Data for Residential Direct Load Control Measures

	Peak Reduction Low *kW/SFD*	Peak Reduction High *kW/SFD*	Cost Low *\$/kW/Yr (1)*	Cost High *\$/kW/Yr (1)*
Winter				
Baseboard Heating	0.74	0.92	\$28.00	\$35.00
Central Heating	1.2	1.5	\$40.00	\$50.00
Water Heating	0.4	0.4	\$49.00	\$55.00
Summer				
Water Heating	0.4	0.4	\$49.00	\$55.00
Air Conditioning Control - Cooling	1.5	1.5	\$64.90	\$64.90

(1) This is an annualized cost of technology and installation per kilowatt of expected annual demand savings from curtailments.

Other DLC Measures

Other DLC measures include non-essential lighting and pool/spa heating; these measures were included only in the BC Hydro study. Therefore, we have included some information here for reference; potential estimates are not included. Costs in Table 51 are incremental and are based on existing communications infrastructure.

Table 51
Secondary Residential DLC Measures

	Peak Reduction Low *kW/unit*	Peak Reduction High *kW/unit*	Cost Low *\$/kW/Yr*	Cost High *\$/kW/Yr*
Lighting				
Non-essential Lighting, 1-way switch-based control	0.234	0.234	34	34
Pools and Spas				
Pool/Spa, 1-way switch-based control	0.5	0.5	61	61

Technical Potential

Technical potential is the amount of energy efficiency potential that is available regardless of cost or other constraints such as willingness to adopt measures. It represents the theoretical maximum amount of peak load reduction if these constraints are not considered.

The main component for determining technical potential is the housing stock characteristics in FortisBC's service territory. In the *2009 Residential Customer End-Use Study*, FortisBC compiled a list of residential characteristics such as heat type, water heating fuel, central thermostats usage, etc. Dwelling saturations and the total number applicable building are shown in Table 52. There are several assumptions used to generate saturation percentages. These are described below.

For heating controls, 38% of homes are currently heated with electric heat and are eligible for load control. Of homes heated by electricity, half (19%) are assumed to have central thermostats and are applicable to thermostat based load control. The remainder of the electrically heated homes (19%) is known to have baseboard heat and applicable to switch-based devices. Water heater controls are applicable to homes with electric hot water heating, which, from the end-use study is 49% of all housing units. Again, while all water heat units are not on at the same time, savings are assumed on an annual per unit basis. For summer cooling, utility load control measures are applicable to units with central AC units and central thermostats. From the survey data, this saturation is 32%.

Given savings values from Tables 50, the technical potential of direct load control measures in the FortisBC service territory was estimated. The technical potential assumes that all homes that can have a particular technology installed will participate and achieve the savings associated with the measure. For example, all homes with electric heat and central programmable thermostats are assumed to participate in load control programs. In effect, there is no cap on the saturation or participation in direct load control measures in the applicable population. These assumptions allow for the estimation of the total potential resulting in the theoretical maximum reduction in peak load from direct load control programs (see Table 52).

Table 52
Residential Direct Load Control Technical Potential

	Dwelling Saturation	Applicable Count	Savings (MW)
Total Number Homes		***137,655***	
Winter			
Baseboard Heating	19%	26,154	19.4
Central Heating	19%	26,154	31.4
Water Heating	49%	67,451	27.0
Summer			
Water Heating	49%	67,451	27.0
Air Conditioning Control - Cooling	32%	44,050	66.1

Achievable Potential

Achievable potential is usually calculated as the portion of technical potential that is cost effective and achievable. For reference, BC Hydro uses $179/kW-yr (in 2009 dollars) as the avoided capacity cost. Therefore, using this value, the direct load control measures included in this study are all cost effective. Avoided demand cost for FortisBC are $189/kW-year (2010 dollars) based on a blended value of BC Hydro's avoided capacity and FortisBC blended capacity. All measure costs are well below the $189/kW-yr threshold even when program costs are included. Direct load control programs are hinged on achievability rates rather than the selection of cost effective measures.

The achievability rates used in this study are based on BC Hydro's study and are shown in Table 53. The low achievability rates can be assumed if Time of Use (TOU) pricing structure is optional while the high achievability case can be assumed when TOU pricing is mandatory.

Table 53
Achievability Rates for Residential Direct Load Control Measures

Measure Name	Low Achievability	High Achievability
Baseboard Heating	10%	20%
Central Heating	10%	20%
Water Heating	10%	20%
Water Heating	10%	20%
Air Conditioning Control - Cooling	5.%	15%

The achievability rates were then applied to the technical potential to obtain the range of achievable potential for direct load control. A table demand savings and incremental cost is shown in Table 54. There are two columns for potential savings, one for high and low achievability, respectively. Again, these represent optional and mandatory TOU pricing. The two values show a range of savings based on how aggressive FortisBC is in implementing new programs. There large and steady increases in demand savings from roughly $30/kW-yr to $60/kW-yr. This corresponds with space and water heating measures.

Table 54
Achievable Peak Savings for Residential DLC Measures

	Cost	Savings (MW)	
	$/kW/Yr	Low Achievability	High Achievability
Winter			
Baseboard Heating	31.5	1.9	3.9
Central Heating	45.0	3.1	6.3
Water Heating	52.0	2.7	5.4
	Total	7.7	15.6
Summer			
Water Heating	52.0	2.7	5.4
Air Conditioning Control - Cooling	64.9	3.3	9.9
	Total	6.0	15.3

Direct Load Control – Commercial

Small to medium sized commercial buildings are largely similar to residential buildings in their function and potential for direct load control technology. Therefore, the commercial sector is modeled in the same way as residential potential, but only the largest commercial buildings are excluded (i.e. large office building with energy management systems). Savings and cost values for commercial sector measures are slightly different from in the residential measure data, and are also based on BC Hydro's potential study.

Because lighting comprises the largest percentage of commercial demand, utility control of non-essential lighting is the primary measure in commercial buildings. The required technology is similar to switch-based heating measures, except installed on lighting circuits. Savings are 10% of total lighting demand. In addition to air conditioning, lighting and refrigeration can also be curtailed to reduce demand in the summer.

Table 55 shows savings and cost for commercial measures.

Table 55
Secondary Residential DLC Measures

	Peak Reduction Low *kW/SFD*	Peak Reduction High *kW/SFD*	Cost Low *$/kW/Yr (1)*	Cost High *$/kW/Yr (1)*
Winter				
Baseboard Heating	0.64	0.87	$32.00	$44.00
Non Essential Lighting	0.85	1.26	$31.00	$46.00
Refrigeration Load Control	2.6	2.9	$38.00	$44.00
Central Heating	1.07	1.43	$45.00	$60.00
Summer				
Non Essential Lighting	0.85	1.26	$21.00	$32.00
Refrigeration Load Control	2.6	2.9	$38.00	$44.00
Air Conditioning Control - Cooling	1.5	1.5	$64.90	$64.90

(1)This is an annualized cost of technology and installation per kilowatt of expected annual demand savings from curtailments.

Technical Potential

From the *2009 Commercial Customer End-Use Study*, 13% of commercial buildings are heated solely by electricity in the FortisBC Service territory. Similar allocations between different heating measures resulted in an even split for each thermostat and switch-based measures heating.

Lighting is a distinctly different measure in the commercial sector. Non-essential lighting has the potential to be controlled in 100% of buildings. Conversely, curtailment of refrigeration load is only applicable to commercial kitchens and retail, which comprise 1% of total commercial buildings.

Saturation rates and applicable buildings (out of 7,002 total small/medium commercial buildings) are shown in Table 56.

Table 56
Commercial Direct Load Control Technical Potential

	Saturation	Applicable Count	Savings (MW)
Total Number Buildings		***7,002***	
Winter			
Baseboard Heating	6.5%	455	0.29
Non Essential Lighting	100.0%	7002	5.95
Refrigeration Load Control	1.0%	70	0.18
Central Heating	6.5%	455	0.49
Summer			
Non Essential Lighting	100.0%	7002	5.95
Refrigeration Load Control	1.0%	70	0.18
Air Conditioning Control - Cooling	12.0%	840	1.26

Economic Potential

Due to the low measure cost relative to avoided demand rates, all measures are assumed to be cost effective similar to the methodology presented for the residential sector. See previous discussion on Economic Potential.

Achievable Potential

A range of achievability factors are used for each measure based on BC Hydro information. See Table 57. In the commercial sector, the difference between high and low achievability is often threefold due to the inherent variability from a smaller stock of buildings.

Table 57
Achievability Rates for Commercial Direct Load Control Measures

Measure Name	Low Achievability	High Achievability
Central Heating, 2-Way Thermostat-Based	5.0%	15.0%
Zonal Heating, Switch-Based	5.0%	15.0%
Non Essential lighting, 1-Way Switch-Based	5.0%	15.0%
Air Conditioning Control - Cooling	5%	15%
Refrigeration Load Control	20%	30%

Achievable savings are shown for winter and summer peak periods, respectively, in Table 58. There is a range of low and high achievability factors. Commercial lighting and cooling are the two largest relative contributors to commercial demand reduction potential.

Table 58
Achievable Peak Energy Savings, Commercial Direct Load Control

	Cost	Savings (MW)	
	$/kW/Yr	Low Achievability	High Achievability
Winter			
Non Essential Lighting	38.0	0.01	0.04
Baseboard Heating	38.5	0.30	0.89
Refrigeration Load Control	41.0	0.04	0.05
Central Heating	52.5	0.02	0.08
	Total	0.37	1.06
Summer			
Non Essential Lighting	26.5	0.30	0.89
Refrigeration Load Control	41.0	0.04	0.05
Air Conditioning Control - Cooling	64.9	0.06	0.19
	Total	0.4	1.1

Direct Load Control – Industrial

While small and mid-sized commercial buildings can benefit from more widget based load control options like water heater and furnace controls, larger building and industrial buildings require a more tailored approach. Irrigation scheduling, standby generation and commercial/industrial programs are also viable options, but require specific technology and commissioning to meet the specific needs of the building function. These programs tend to have higher upfront and administrative costs. However, if designed well, larger building curtailments can provide significant reductions in peak demand, and, therefore, significantly reduce the need for capacity infrastructure. While specific buildings and industries in the FortisBC service territory were not modeled for direct load control, commercial and industrial settings could be a cost effective solution for capacity constraints in the future. These programs require careful selection of buildings and a comprehensive knowledge of larger building energy management.

There are a limited number of programs in the region especially in winter peaking systems. The most notable is Northwest Open Automated Demand Response Program run by Seattle City Light. Seattle City Light found that 0.57 W/ft2, or roughly 14% the building's peak demand was possible to curtail during events from of lighting and HVAC measures. The Seattle Open ADR program is the first of its kind in the region and gives an idea of what is possible in the large commercial sector. However, a tailored and process based engineering analysis is required before pursuing a similar program.

Conclusions

While direct load control is a new area of demand side management relative to energy efficiency, direct load control can provide resources to meet peak demand. Direct space conditioning and water heating control, in addition to commercial lighting are viable options now and for new demand response programs. These measures alone result in roughly 8.1 – 16.7 MW of winter peak and 6.4 – 16.4 MW of summer peak load reduction potential for under $189/kW-yr. They provide system reliability at a low first cost and are relatively simple to install, in line with voluntary programs. FortisBC might also consider implementing other direct load control measures such as residential lighting and plug loads as incremental measures.

In total, an estimated 3.6%-5.3% reduction in winter peak demand (of which 1.4-2.9% is from DLC measures) is possible by 2015. Total summer peak reduction is 3.6%-5.5%. There is variability in the range of savings based on high and low achievability rates. These estimates exclude expensive thermal storage measures and are consistent with studies from other utilities, which are shown in Table 59.

Table 59
Comparison of Demand Response Forecasts Across Utilities

Utility	Target Year	Forecasted Demand Response as Percent of Peak Load
BC Hydro[20]	2011 (5 Year)	2.30%
BC Hydro	2016 (10 Year)	4.60%
PacifiCorp	2009	5.10%
Idaho Power	2013	8.10%
Portland General Electric	2012	4.10%
New York ISO	2009	5.90%
PJM	2008	3.20%
California ISO	2011	6.50%

[20] Values are average savings for direct load control (capacity specific) measures from the *2007 Conservation Potential Review*.

Savings are forecasted out for the full 20 year study scope in Table 60. This analysis assumes that, as programs become more developed, participation will increases from better marketing and consumer acceptance. Conservative achievability rates were used and derived from the lower end of those in the BC Hydro study.

Table 60
20-Year Forecasted Direct Load Control Savings

	Achievability Percent				Annual Savings (MW)			
	5 Year	10 Year	15 Year	20 Year	5 Year	10 Year	15 Year	20 Year
Residential								
Winter								
Baseboard Heating	10%	23%	30%	33%	1.94	4.45	5.81	6.44
Central Heating	10%	23%	30%	33%	3.14	7.22	9.42	10.45
Water Heating	10%	23%	30%	33%	2.70	6.21	8.09	8.98
Summer								
Water Heating	10%	23%	30%	33%	2.70	6.21	8.09	8.98
Air Conditioning Control - Cooling	5%	10%	23%	30%	3.30	6.61	15.20	19.82
Commercial								
Winter								
Baseboard Heating	5%	11%	14%	15%	0.01	0.03	0.04	0.04
Non Essential Lighting	5%	11%	14%	15%	0.30	0.63	0.83	0.89
Refrigeration Load Control	20%	46%	60%	67%	0.04	0.08	0.11	0.12
Central Heating	5%	11%	14%	15%	0.02	0.05	0.07	0.07
Summer								
Non Essential Lighting	5%	11%	14%	15%	0.30	0.63	0.83	0.89
Refrigeration Load Control	20%	46%	60%	67%	0.04	0.08	0.11	0.12
Air Conditioning Control - Cooling	5%	10%	23%	30%	0.06	0.13	0.29	0.38
				Total Winter	10.1	22.5	30.1	34.7
				Total Summer	6.4	13.7	24.5	30.2

Energy Savings

Additionally, while direct load control measures are designed to shave peak demand, there is a minimal amount of associated energy savings. The total number and length of curtailment events will alter the amount of savings. To estimate this, 35 winter and 17 summer curtailment events were assumed. Each event is 2 hours long. This is consistent with pilot study results from the Goodwatts Program in The City of Ashland. Table 61 shows energy savings for both high and low achievability. Assuming conservative achievability, peak demand measures have 942 MW of associated energy savings in the FortisBC service territory. Note that all measures with the exception of water heating have energy benefits. For hot water heaters, the load is shifted to off-peak hours, but the total energy consumption is the same using direct load control.

Table 61
Energy Savings from Peak Demand Measures

	Peak Reduction kW/unit	Units Low Achievability	Units High Achievability	Savings (MWh) Low Achievability	Savings (MWh) High Achievability
Residential					
Winter					
Baseboard Heating	0.74	2615	5231	139.4	278.7
Central Heating	1.2	2615	5231	226.0	451.9
Summer					
Air Conditioning Control – Cooling	1.5	2202	6607	112.3	337.0
Commercial					
Winter					
Baseboard Heating	0.64	23	68	1.0	3.1
Non Essential Lighting	0.85	350	1050	21.4	64.3
Refrigeration Load Control	2.6	14	21	2.6	3.9
Central Heating	1.07	23	73	1.8	5.6
Summer					
Non Essential Lighting	0.85	350	1050	10.1	30.4
Refrigeration Load Control	2.6	14	21	1.2	1.9
Air Conditioning Control – Cooling	1.5	42	126	2.1	6.4
			Total Summer	***517.9***	***1,183.2***

Behaviour Conservation Savings

Introduction

Behavioural measures or programs are those where energy or peak demand savings are based on customers changing their patterns of energy consumption. Behavioural measures are reviewed in this study; however, it is recommended that FortisBC conduct more thorough studies before implementing these programs.

Behavioural Measures

Behavioural programs might include a combination of education, awareness campaigns, or incentives regarding things like turning the thermostat down at night or unplugging small appliances when not in use. Table 62 (from the BC Hydro 2006 study) summarizes behavioural measures applicable in the residential sector. Among these, BC Hydro found that behaviours related to computers, domestic hot water use, lighting, and space heating showed the greatest potential for energy savings.

Table 62
Residential Behavioural Measures

Space Heating and Cooling	**Refrigeration and Freezers**
Turning down the temperature at night or day	Maintain proper temperature
Heating only occupied parts of the building	Defrost freezer more frequently
Maintain draft proofing	**Appliances**
Install storm windows	Air dry dishes in dishwasher
Covering windows when using the AC	Minimize hot and warm water washing
Increasing temperature when using the AC	Use temperature/moisture sensor in dryer
Lighting	**Computers and Peripherals**
Select low-watt bulbs, reduce lumens	Activate power management features
Using only necessary safety lighting	Shutting of PC and/or monitor when not in use
Turning off lights when leaving the room	**TV and Entertainment**
Water Heating	Turning off TV when not in use
Turn off or down water heater when away	Unplug TV regularly and when away
Lower water temperature	Unplug entertainment system regularly
Small Appliances	
Unplug charger power supplies	

Table 63 (from the BC Hydro 2006 study) summarizes behavioural measures applicable in the commercial sector. Among these, BC Hydro found that behaviours relating to lighting showed the greatest potential for energy savings.

Table 63
Commercial Behavioural Measures

Space Heating and Cooling	**Refrigeration and Freezers**
Adjusting heat up in summer	Maintaining proper temperature
Adjusting heat down in winter	**Plug Loads**
Using shades/blinds in summer	Activating power management features
Using shades/blinds in winter	Shutting off PC and monitor when not in use
Using natural ventilation	Shutting off monitor when not in use
Keeping doors closed	Switching off computer power bar when not in use
Lighting	Shutting off idle equipment
Making use of daylighting	**Whole Building**
Turning off task lights when not in use	Taking stairs rather than the elevator
Using task lights instead of ambient lighting	Changing hours of activity
Reducing or eliminating unnecessary lighting	

BC Hydro found that approximately 11 percent of energy could be saved through behavioural measures among the residential sector and 3.8 percent of energy in the commercial sector. The percentage of savings assumes base load prior to any DSM implementation or additional programs.

Clotheslines are another behaviour measure that might save clothes drying energy consumption for FortisBC customers during warm months. This measure was not specifically included in the potential estimates; however, the Ontario Power Authority quantified clothesline savings at 225 kWh per year at a cost of approximately $85 and a life of 10 years. Using these cost and savings data, clotheslines are cost-effective using the TRC test.

FortisBC Results

Results of a similar analysis for FortisBC, using data obtained from the BC Hydro 2006 study, show a potential savings of 12 percent of base load in the residential sector and 5.3 percent of base load in the commercial sector from behavioural measures (Tables 64 and 65).

Table 64
Behavioural Programs - Residential Energy Savings
Unbundled Technical Potential

	Base Year Consumption *(GWh/yr)*	**Behaviour Measure**	**Unused Energy Services** *(% of Base Year)*	**Unbundled Potential** *(GWh/yr)*
Space Heating	370	Temperature setback - over night	3%	10
	370	Temperature setback - daytime	2%	7
	370	Heat only occupied parts of house	1%	3
	370	Maintain weatherproofing	2%	8
	370	Install storm windows	1%	4
		Sub-Total	9%	33
Air Conditioning	123	Close windows and blinds	4%	5
	123	Increase temperature 3 deg. C	10%	12
		Sub-Total	14%	17
Lighting	234	Low wattage incandescent bulbs	2%	5
	234	Only necessary outdoor lighting	2%	5
	234	Turn off lights when no one in room	10%	23
		Sub-Total	14%	33
DHW	168	Turn off DHW when on vacation	1%	1
	168	Reduce temperature of DHW	1%	2
	168	Minimize hot and warm wash	27%	45
		Sub-Total	29%	48
Refrigeration	112	Maintain proper refrigerator temp.	3%	4
	62	Maintain proper freezer temp.	3%	2
	62	Defrost freezer more frequently	1%	1
		Sub-Total	10%	6
Appliances	6	Air dry dishes in dishwasher	18%	1
	88	Use sensor for clothes dryer	1%	1
	0	Brick chargers	3%	0
		Sub-Total	2%	2
Computers	118	Activate power management	29%	34
	118	Shut off PC and monitor	6%	7
	118	Shut off monitor	3%	3
		Sub-Total	37%	44
TV & Entertainment	62	Turn off TV when no-one watching	15%	9
	62	Unplug TV regularly	19%	12
	62	Unplug TV when on vacation	1%	1
	9	Unplug stereo regularly	31%	3
	9	Unplug stereo when on vacation	2%	0
		Sub-Total	35%	25
Residential Total	**1,720**		**12%**	**207**

Table 65
Behavioural Programs - Commercial Energy Savings
Unbundled Technical Potential

	Base Year Consumption *(GWh/yr)*	**Behaviour Measure**	**Unused Energy Services** *(% of Base Year)*	**Unbundled Potential** *(GWh/yr)*
Lighting	374	Make use of daylighting	2.3%	8.6
	374	Turn off task lights	0.4%	1.5
	374	Use task instead of ambient light	3.8%	14.2
	374	Reduce unnecessary lights	0.8%	3.0
		Sub-Total:	7.3%	27.3
HVAC	69	Adjust heat up in summer	0.6%	0.4
	145	Adjust heat down in winter	0.7%	1.0
	69	Use shades/blinds - summer	1.1%	0.8
	145	Use shades/blinds - winter	1.6%	2.3
	69	Use natural ventilation - summer	4.4%	3.0
	145	Keep doors closed - winter	1.1%	1.6
	69	Keep doors closed - summer	0.4%	0.3
		Sub-Total	4.4%	9.4
Plug Loads	34	Activate Power Management	44.7%	15.3
	34	Turn off PC and monitor	4.3%	1.5
	34	Turn off monitor only	1.4%	0.5
		Sub-Total	50.4%	17.2
Whole Building	89	Refrigerator	0.6%	0.5
	3	Elevator	0.9%	0.0
		Sub-Total	0.6%	0.6
Commercial Total	**1,033**		**5.3%**	**54.5**
Commercial and Residential Unbundled Total Technical Potential				**262**

Achievable Potential

The technical potential for behavior measures is significant. However, when the achievability factors are applied the potential is reduced to fewer than 50 percent of the technical potential. The BC Hydro 2007 Conservation Potential Review included detailed surveys and analysis of behavior achievability factors. Table 66 shows the achievability rates and subsequent achievable potential by sector.

Table 66
Behavioural Programs Achievable Potential (Unbundled)

	Technical Potential, GWh	Achievable Percent	Achievable Potential, GWh
Residential	207	40%	82
Commercial	54	63%	34
Total	262		116

Programs

While utility pilot program results are limited, several recent programs examples will help illustrate the potential energy savings of these approaches:

- Hydro One and NSTAR installed PowerCost Monitor devices. The average savings resulting from these units in addition to findings from in-home display studies in both Nevada and Florida, suggest that average savings of 3% to 7% with a midpoint of around 5% are likely to be achieved for participants of these kinds of direct feedback programs. It is important to note, these programs did not make use of a control group. These savings were achieved with a motivated population.

- Electricity use reports developed by Positive Energy (rebranded OPower Inc.) offer neighbour comparisons to help motivate SMUD's customers (Sacramento Municipal Utility District) to make changes to energy use, lowering demand by 2% in a broad non-targeted population. The concept of this program is that individuals are motivated by their perceptions of what other people do and find acceptable.

  Connexus Energy is wrapping up a 12 month pilot program for 40,000 customers, reporting a two to three percent reduction in energy consumption. The utility is pleased with the results and intends to continue the program for the next several years. About two percent have opted out of the program.

  Xcel Energy Inc. is currently implementing a three year pilot study targeting 35,000 gas and electric customers. The reports are mailed to customers and compare a customer's combined electric and gas use from the previous month to 100 neighbours in similar-size homes. The report provides a second comparison against the most efficient neighbours. Each household is provided a ranking among the 100 neighbours with those in the top 20 receiving positive feedback.

- BC Hydro has found the use of personal commitments, incentives, and online information tools to be an effective means to drive behavior changes. The utility has enrolled more than 60,000 customers in the first few months of this effort.

Costs

Cost data for behavioural programs is limited and unreliable. However a couple cost points were identified from early results of pilot programs. These costs range from $0.03 per first year-kWh for Positive Energy (OPower) programs (from SMUD) to $0.30 per first year-kWh for PowerCost monitor technologies. When levelized[21], these costs represent a range of approximately $20/MWh to $80/MWh, well under the cost-effectiveness limit. Another cost consideration is the life of these programs. It may become increasingly costly to continually make programs such as Positive Energy new and exciting as time passes and customers tire of participating. Because costs are uncertain, a range of cost estimates are included for FortisBC behavioural program potential. These 20-year total costs are provided in Table 67 below. If the potential were distributed evenly over the planning period, this would represent an annual cost range of $147,000 to $2 million.

Table 67
Behavioural Potential Total Cost Estimates

	Potential, GWh	Low Cost Estimate	High Cost Estimate
Residential	82	$2,460,000	$24,600,000
Commercial	34	$1,020,000	$16,345,485
Total	116	$3,480,000	$40,945,485

Summary

The pilot programs described above will provide important cost data for future behavioural program analyses. Overall, the above analysis concludes that FortisBC could save approximately 116 GWh in the residential and commercial sectors through behavioural programs.

[21] Assuming a discount rate of 5% and 2 and 4 year measure lives, respectively

Conservation and Risk

Conservation resources have generally been known as low-risk resources. The risks that apply to energy efficiency resources are those associated with utility investment in capital that is not owned or maintained by the utility. “Risk” in terms of energy efficiency refers to the likelihood that the predicted savings will be achieved over the life of the measure. Risk components of conservation resources include:

1. Failure of measure before end of useful life
2. Removal or early replacement
3. Actual energy savings are less than estimated

Risks 1 and 2 above are often considered when evaluating measure savings. In the Northwest US, the Northwest Power and Conservation Council discounts measure savings to account for early removal, failure, or modified use patterns. In addition, risk premiums may be added to measure costs when evaluating cost-effectiveness from a total resource cost perspective. Programs that are mature and are based on trusted technologies present the least amount of risk while programs based on emerging technologies present significantly greater risk.

Risk 3 above is an issue of contention in many areas. Actual savings values vary across house types, climate, and interactions with other measures. Savings estimates for CFLs are a good example of how different regions or planning agencies assign savings values for energy efficiency measures. Based on a dated (2004) M&E report, FortisBC’s assigns an nominal savings value of 87 kWh for a CFL in their service territory. On the other hand, BC Hydro uses a savings value of 63 kWh per year. Lastly, the Bonneville Power Administration (BPA) currently gives a credit of 33 kWh per CFL to their wholesale customers. The 33 kWh per CFL value includes factors for take-back, space conditioning interaction, and removal. All three of these entities are located in similar climate zones with similar housing characteristics and yet the savings value for CFLs varies from 33 to 87 kWh per year. In order to address this risk, the more conservative savings values are used in this study.

Energy efficiency resources are generally viewed as risk mitigation strategies rather than viewed for their inherent risk. Energy efficiency resources are used to mitigate risks such as increasing generation or power purchase costs, limited transmission and distribution systems, fuel price volatility, and increasing costs due to possible climate change legislation. Energy efficiency is a clean, localized resource strategy that reduces a utility’s dependence on fossil fuels, transmission resources, and costly new resources or market power price variations.

Combined CDM Potential Summary

Table 68 summarizes the energy efficiency savings potential for all sectors. The savings estimates below are for program achievable potential (savings from codes and standards are excluded). Also, savings from fuel switching measures, behavioural measures, and customer-owned renewable projects are reported separately in subsequent tables. Through energy efficiency measures, FortisBC can expect to meet 14.7 percent of the forecasted 2030 load. These estimates indicate that, given the load forecast assumptions, FortisBC could meet 59 percent of load growth with program achievable potential energy efficiency resources across all sectors.

Table 68
Comparison End-Use Forecast with Energy Efficiency Potential Estimates

	2008 Base Year Consumption (GWh)	2030 Forecast Consumption (GWh)	Energy Efficiency Program Achievable Potential (GWh)	% of 2030 Load
Residential	1,720	2,247	369	16.4%
Commercial	1,033	1,456	173	11.9%
Industrial	207	207	28	13.4%
Lighting	14	14	4	28.8%
Irrigation	52	52	11	20.8%
Total	3,026	3,976	585	14.7%

Table 69 illustrates energy efficiency potential summarized above in five-year increments. Note that street lighting potential is included in the commercial sector potential

Table 69
Program Achievable Potential, MWh

	2011	2015	2020	2025	2030
Residential	19	94	192	281	369
Commercial(1)	10	53	107	142	177
Industrial	1	8	18	23	28
Irrigation	1	3	5	8	11
Total	**30**	**158**	**322**	**453**	**585**

(1) Includes street lighting potential

Figure 51 illustrates the potential given in the tables above. The majority of the potential is from the residential sector, which is not surprising since residential customers consume 57 percent of total load.

Figure 51
Summary of Energy Efficiency Potential 20-Year Program Achievable Potential

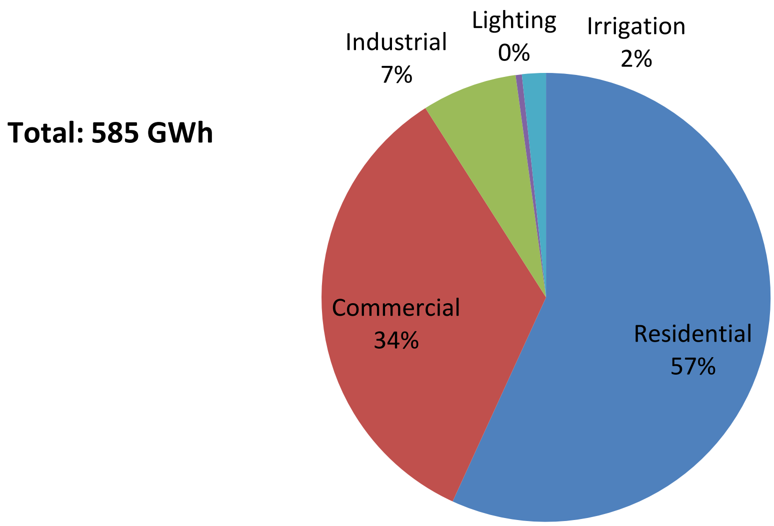
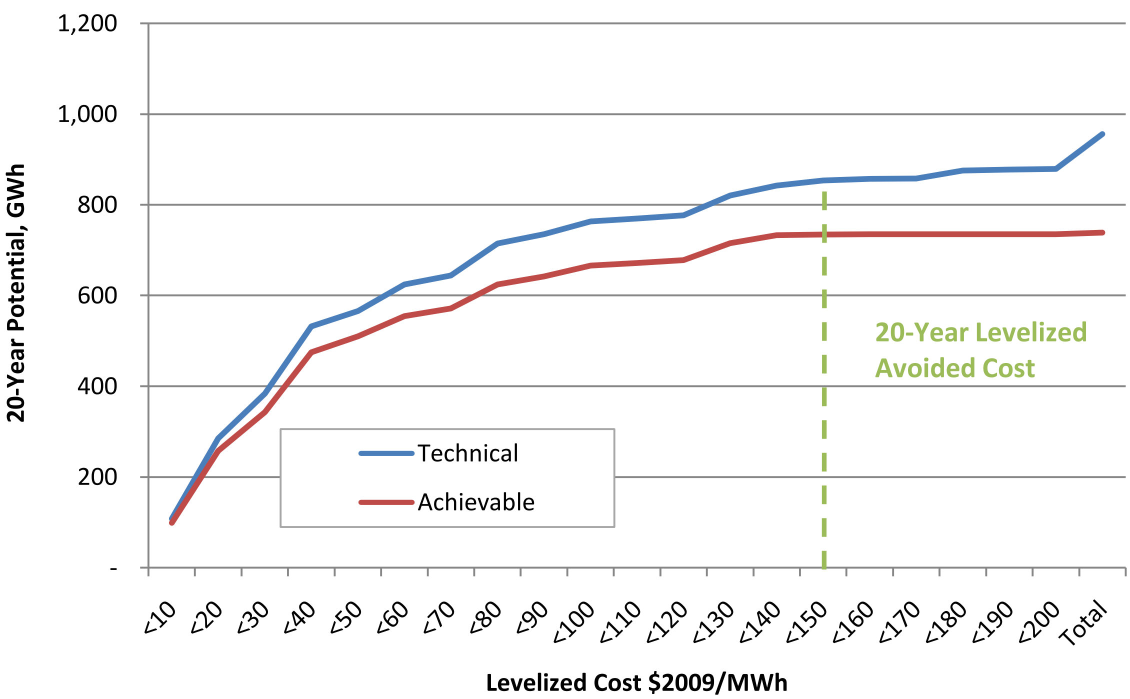


Figure 52 illustrates the supply curve for energy efficiency potential across all sectors.

Figure 52
Energy Efficiency Supply Curve – All Sectors



Demand savings potential is summarized in Table 70 below. Peak demand savings from energy efficiency measures and demand response measures are separated. Overall, approximately 16.2 percent of 2030 winter peak demand can be saved through a combination of energy efficiency and demand response programs.

Table 70
Total Demand Savings Potential, MW

	Energy Efficiency	Demand Response	Total
Winter	124	35	159
Summer	81	30	111

FortisBC Naturally Occurring Conservation

Naturally occurring conservation refers to the amount of conservation that would be achieved in absence of utility programs. This includes:

1. Efficiency gains from the turnover of older equipment to current standard equipment (with higher efficiency);
2. The adoption of high-efficiency equipment due to natural market forces; and
3. Market effects that include national or provincial government programs, past utility programs or marketing efforts, or equipment vendor efforts.

With regard to the FortisBC conservation potential assessment, the amount of naturally occurring conservation is accounted for in two ways. The first is in the load forecast. Since the end-use load forecast was calibrated to the system forecast, in includes a basic level of naturally occurring conservation, based on past experience. Second, some of the energy efficiency measure savings values are adjusted for market saturation and turnover rates for equipment that is naturally replaced over the planning period.

While it is difficult to quantify naturally occurring conservation, a few organizations have attempted it. The published data indicate that a range of between 6 and 10 percent of achievable potential is naturally occurring. For FortisBC, this amounts to approximately 1.2 percent of 2030 load.

Given the assumption that naturally occurring conservation is 1.2 percent of 2030 load, FortisBC might expect to meet 56.5 percent of load growth with DSM resources through 2030.[22]

[22] Naturally occurring conservation = 1.2 percent of 2030 load = 48 GWh. Load Growth = 950 GWh. Program achievable conservation potential = 585 GWh. Percent of load met with utility program conservation = (585-48)/950 = 56.5%

Behavioural Measure Scenarios

The table below summarizes different levels of program planning to achieve behavioural potential. The scenarios are developed based on average behavioural measure costs and the percent of annual DSM budget allocated to those programs. Budget percents are 2.5, 5, and 10 percent for the low, medium, and high scenarios respectively.

Table 71
Behavioural Measure Scenarios

	Savings			Costs	
Behavioural	**MWh**	**Winter MW**	**Summer MW**	**Annual Cost**	**First Year $/kWh**
Low	497	0.00	0.00	$82,016	$0.17
Medium	2,175	0.00	0.00	$358,799	$0.17
High	10,678	0.00	0.00	$1,761,897	$0.17

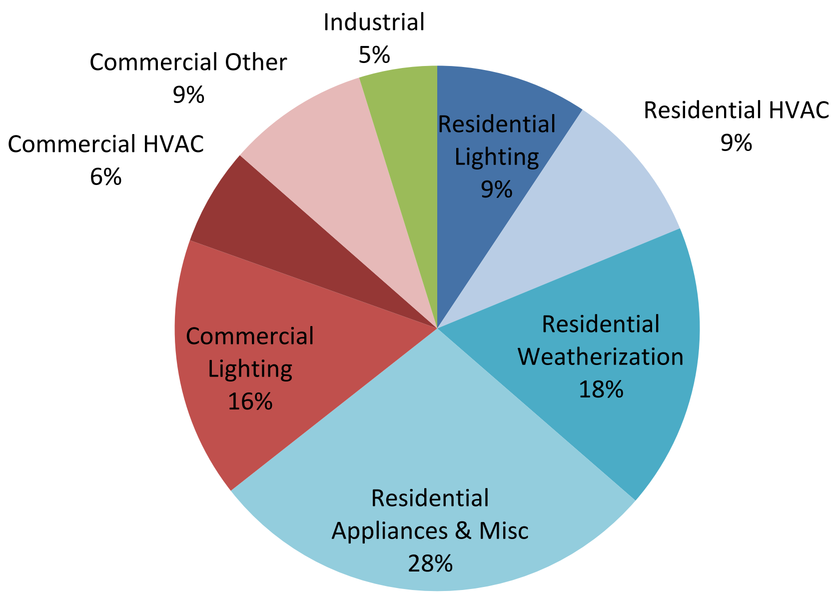
Program Implications

This conservation and demand potential assessment provides information and data for resource planning. In addition, the results can assist with DSM planning efforts. This section highlights some of the DSM program opportunities available to FortisBC

Energy Efficiency

The overall approach to energy efficiency in the FortisBC service territory can be assisted by looking at the significant categories of energy efficiency. Figure 59 summarizes the energy efficiency potential by major categories across all sectors. Over half of the energy efficiency potential is in the residential sector and only a small portion (5 percent) in the industrial sector, with the remaining 31 percent is in the commercial sector.

Figure 53
Energy Efficiency Achievable Potential Summary



Residential

Residential Weatherization

Windows, insulation and air sealing measures make up the largest category in the residential sector. These are traditional utility programs and should continue. The end-use survey indicated there are plenty of un-weatherized homes in the service territory.

Residential Lighting

There is still time to acquire significant savings through lighting programs before code changes dictate efficient lighting beginning in 2012. After 2012, savings potential will be achieved under codes and standards rather than utility programs. Standard (spiral) CFLs phased out at the end of 2009. Only specialty CFLs (3-way, dimmable, reflector) types are now eligible for incentive. After 2012, new lighting measures will be available that will focus on CFL specialty bulbs not included in the new standard and LED applications.

Residential HVAC (Heat Pumps)

Heat pumps should also continue to be part of a future program. All electrically heated homes without heat pumps are prime targets for this measure. Even homes with older heat pumps could benefit from a heat pump upgrade. Included in the potential estimates are the ductless heat pumps which are recently being introduced into the North American market. These heat pumps appear to be an excellent choice for homes with existing baseboard heat, and may be good applications for manufactured homes, condos, and row houses.

Residential Water Heating and Appliances

Electric water heating upgrades for electric water heaters continues to be strong measure. Low flow showerheads are another measure that is program-ready. Also included in this study are heat pump water heaters. While this technology has tried and failed in the past, there is renewed interest and numerous pilot studies and research projects are underway with this technology. Three major brands, including GE, have launched HPWH product lines in the past year. FortisBC should strongly consider initiating a pilot program with this technology.

The appliance category includes conservation measures such as Energy Star refrigerators, refrigerator and freezer recycling (decommissioning), efficient clothes washers, and dishwashers. Most of these measures have a relatively low savings per unit, but also offer low-cost incentive opportunities. Aligning with the Energy Star brand is also beneficial to overall consumer education and program marketing.

Commercial

Commercial Lighting

Commercial lighting is a significant portion of the conservation potential representing approximately 19% of the total potential. This category represents a huge number of individual measures and options depending on the building type and lighting technology. FortisBC may wish to streamline commercial lighting projects by developing a program for specific applications such as small office or retail. A significant portion of commercial sector conservation potential is in lighting upgrades and previous efforts have not exhausted these resources. Some utilities find that residential CFL lighting spills over to commercial applications. Allowing for the spillover increases measure saturation though creates difficulty in tracking program effectiveness.

Commercial HVAC

The HVAC category includes variable speed chillers, premium rooftop HVAC systems, HVAC controls, ECM on VAV boxes, packaged roof top optimization and repair, and integrated building design (new construction).

Commercial Other

Grocery store refrigeration measures, computer and office equipment, and stand-alone commercial refrigerators and freezers are part of the other commercial potential.

Industrial

The industrial sector requires personal connections with the large industrial customers resulting in custom energy efficiency projects.

Demand Response

Control Space Heating

Peak demand can be controlled in part through controlling space heating equipment. A variety of measures were analyzed in this report. A comprehensive program could include several options for heating system control:

- *Central Heating Controls*- Central heating can be controlled through one or two-way devices. Through the implementation of smart meters, heating system control becomes relatively easy to accomplish.
- *Zonal Heating Controls*- Switch-based units are control devices installed directly on zonal heating equipment or circuits. These devices do not require meter infrastructure and could be used in areas where the smart meters are not installed.
- *Thermal Storage* - Central thermal storage units require significant investment for purchase and installation of equipment. Room-based thermal storage units are similar in savings and life to central systems, but require several smaller units. A typical house would need four units. Cost is slightly higher and units are generally applicable situations where baseboard heating would be avoided.

Water Heating

Electric water heaters can be curtailed using 1-way switches. Heating elements are cycled or turned off during peak curtailment periods by grid operators. This is a reliable method for peak reduction representing approximately a 0.4 kW per unit savings. Water heater use is similar year round and does not respond dramatically to outside temperature.

Air Condition Control - Cooling

Technology for summer cooling curtailments is similar to central heating thermostats for winter heating. The central thermostat controls setbacks and cycling of central AC units based on curtailment commands from utility operators. A program that implements this measure could be helpful in offsetting FortisBC's growing summer peak.

Other DLC Measures

Other DLC measures include non-essential lighting and pool/spa heating and could be implemented in addition to other programs. For the commercial sector, controlling non-essential lighting could result in significant peak reductions.

Summary

Through their energy efficiency program efforts, FortisBC plans to meet at least 50 percent of forecasted load growth through 2020 with demand-side resources. In order to achieve this goal, FortisBC must reduce forecasted load growth (553 GWh/year) by 277 GWh/year. FortisBC is well on their way to meeting this goal. From 2006 through 2008, average annual energy efficiency achievement was an additional 26 GWh per year. Projecting these savings over the next 10 years would save a total of 263 GWh/year. The potential study shows that 318 GWh of program achievable potential is available to FortisBC by 2020. With the addition of program measures such as ductless heat pumps, Energy Star® appliances, and streamlined program design for commercial lighting, FortisBC is on track to meet 50 percent of load growth with DSM through 2020. This program achievable potential is based on current codes and standards in place and known to be implemented during the study period. The Provincial and Federal governments are on track to accelerate the adoption of energy efficiency codes and standards. As these codes and standards are adopted, a larger portion of the achievable savings would realized through this avenue.

In addition to utility programs, Fortis BC will continue to promote Province-wide programs such as LiveSmartBC, investigate demand response programs, time-of-use rates, behavioural programs, and emerging technologies.

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Appendix A – Codes and Standards

A significant number of new code changes have been enacted between 2008 and 2010 for both residential and commercial buildings. The code changes that take effect after 2010 impact the portion of the potential that will be achieved through programs. For residential, significant energy efficiency will be achieved through the General Service Lamps code change in 2012 which will effectively require most light bulbs to have the efficiency of a CFL or better. In addition, it is expected that new efficiency standards will significantly impact consumer electronics, including televisions and standby power equipment. Other near-term residential code impacts include furnace fan motors and room and portable air conditioners.

The known residential code changes expected to occur during the 2011 – 2030 timeframe will result in an estimated 121 GWh of energy efficiency. The Province of British Columbia or the Federal government may adopt more aggressive energy efficiency codes and standards, in which case more of the achievable savings potential would be attributed to code changes. See Table A1 for current code details.

Table A1
Residential Code Changes (National and BC)

End-Use Technology	New Code Effective Date
Recent Changes	
Ceiling Fans	2008
Refrigerators and Freezers	2008
Windows	2009
Building Code	2010
Clothes Washers	2010
Dishwashers	2010
Electric Storage Water Heaters	2010
Residential Dishwashers	2010
Torchieres	2010
Near-Term Changes	
Lighting (General Service Lamps)	January 1, 2012 (high lumen) December 31, 2012 (low lumen)
General Service Electric Motors	January 1, 2011
Room and Portable Air Conditioners	January 1, 2011
Small Motors (Furnace Fans)	January 1, 2011
Consumer Electronics, Including Standby Power	January 1, 2011 (for standby) TBD for TVs, etc.

For the Commercial sector, recent changes have been made to codes impacting commercial clothes washers, ice-cube makers, and large motors. In the near term, changes will impact HID lamps and ballasts, large air conditioners, and package terminal air conditioners.

The commercial code changed expected to occur during the 2011 – 2030 timeframe will result in an estimated 26 GWh of energy efficiency. See Table A2 below for code change details.

Table A2
Commercial Code Changes (National and BC)

End-Use Technology	New Code Effective Date
Recent Changes	
Commercial Clothes Washers	2008
Ice-Cube Makers	2008
Large Motors	2010
Near-Term Changes	
HID Lamps and Ballasts	2012
Large Air Conditioners	2012
Package Terminal Air Conditioners	2012

Appendix B – Cost-Effectiveness in British Columbia

Introduction

The British Columbia Ministry of Energy, Mines and Petroleum Resources ("Ministry") amended the Public Utilities Commission Act (Bill 15-2008) to require public utilities to estimate cost-effective demand side resources (DSM) as part of their long term resource plan and to provide a plan to acquire those resources as a first priority over supply-side options. This memo summarizes how the Ministry expects utilities to estimate cost-effectiveness.

Long-Term Resource Plan

Section 44.1, Long-term resource and conservation planning, of the Public Utilities Act[23] requires that a public utility's Long-Term Resource Plan (LTAP) must include all the following:

(a) an estimate of the demand for energy the public utility would expect to serve if the public utility does not take new demand-side measures during the period addressed by the plan;

(b) a plan of how the public utility intends to reduce the demand referred to in paragraph (a) by taking cost-effective demand-side measures;

(c) an estimate of the demand for energy that the public utility expects to serve after it has taken cost-effective demand-side measures;

(d) a description of the facilities that the public utility intends to construct or extend in order to serve the estimated demand referred to in paragraph (c);

(e) information regarding the energy purchases from other persons that the public utility intends to make in order to serve the estimated demand referred to in paragraph (c);

(f) an explanation of why the demand for energy to be served by the facilities referred to in paragraph (d) and the purchases referred to in paragraph (e) are not planned to be replaced by demand-side measures; and

(g) any other information required by the commission.

[23] Utilities Commission Act [RSBC 1996] Chapter 473. Current to September 9, 2009 available online at: http://www.bclaws.ca/Recon/document/freeside/--%20U%20--/Utilities%20Commission%20Act%20%20RSBC%201996%20%20c.%20473/00_96473_01.xml#section44.1

Demand-Side Resources

Cost-effective measures to be examined include rate, measure, action or program measures. The DSM evaluations must be approved by the British Columbia Utilities Commission (BCUC). In order for the BCUC to consider a portfolio of DSM programs complete, that portfolio must include:

- *Low-Income Programs* – Low-income households are defined by Statistics Canada's Low-Income Cut-Offs (LICO) for a particular year
- *Rental Programs* – Programs may target either tenant and or landlord. The focus must be on the accommodation rather than the residents (emphasis on technology).
- *Education Programs* – Includes funding of the development of education program regarding energy efficiency and conservation.
- *Post-Secondary Programs* – Includes funding of programs such as the integration of energy efficiency into a business or MBA program curriculum and trades training.

Cost-Effectiveness

The cost effectiveness of each measure may be calculated either at the individual level, in a bundle with other measures, or at a portfolio level.

Low-Income

Low income DSM programs have additional benefits that are not accounted for in energy savings such as fewer shutoff/reconnect costs, fewer rearranges, and less bad debt to be written off. Therefore, 30 percent in additional benefit is to be added to low income program measure cost-effectiveness tests.

Specified DSM and Technology Innovation

- Specified DSM includes the following measures:
  - Education
  - Funding energy efficiency training for manufacturers, sellers, installation tradesmen, brokers, managers of energy efficiency products and buildings.
  - Community engagement programs that assist, cooperate or directly increase stakeholders' awareness of energy efficiency. Stakeholders include first nation, government, or non-profit groups.
- Technology innovation programs including market transformation.

These measures will be evaluated in a group with other measures or as a portfolio to help support the expenditures. The reasoning behind the grouping of measures for the purpose of cost-effectiveness tests is that these measures are supportive and long term rather than immediate or standalone.

Total Resource Cost

Avoided Cost

Bulk electricity purchasers from BC Hydro must use BC Hydro's long-term marginal cost rather than the purchase price of power. This avoided cost requirement for bulk purchasers increases the amount of DSM that is cost-effective.

Summary

It appears the British Columbia does not require specific total resource costs and benefits be included in the benefit-cost analysis. In their 2007 study, BC Hydro uses avoided transmission and avoided power costs to evaluate measure cost-effectiveness. BC Hydro escalated their avoided power costs (energy) by 50%. Measure costs are either full or incremental capital costs.

Appendix C – Cost-Effectiveness Tests

Two general screening methods can be used to rank demand and supply options. These are benefit-to-cost ratios and levelized cost. A benefit-to-cost ratio divides resource benefits by resource costs to calculate a ratio. If the ratio is greater than one, the resource is cost-effective; if the ratio is less than one, the resource is not. Levelized costs sum the fixed and variable costs of a resource over its life, taking into account the time value of money, and divide them by the associated output or savings. A cost per unit of output or savings is developed and is usually expressed in a constant dollar year. This levelized cost can then be compared with a fixed generating resource or power contract to determine cost effectiveness.

Several different economic tests are available for evaluating resource options. All of the tests incorporate benefit-to-cost analyses. However, the perspective from which the costs and benefits are evaluated differs among the tests. The five tests are the total resource cost (TRC) test, ratepayer impact measure (RIM) test, participant test, utility cost test, and societal test. The tests are used primarily to evaluate DSM resources.

In the Northwest, the Council uses the TRC as the primary cost test to determine cost effectiveness of DSM options. Using the TRC benefit cost ratio, all DSM measures can be compared with available supply resources. Other tests can then be applied to determine the cost effectiveness from the various perspectives (e.g., utility, ratepayer).

Cost and Benefit Components

Changes in Supply Costs. One of the main benefits of a DSM option is its associated reduction in supply costs. This can occur as a result of a decrease in energy use or as a result of a shift of energy from a more expensive period to a less expensive period. The avoided supply cost is calculated by multiplying the reduction in total net generation by the marginal cost. If energy has been shifted instead of reduced, the resulting increase has to be included on the cost side. The changes in supply cost for periods where energy use increases are costs (increased supply cost), and the changes in supply costs for periods where energy use decreases are benefits (avoided supply cost).

Changes in Revenue and Bills. Another large effect of DSM programs is revenue reduction. Lost revenues are a cost to the utility and tend to increase rates on a per-unit basis. On the other hand, DSM program participants receive equivalent benefits, because their consumption is reduced.

Utility Costs. This category includes all costs of planning, implementing and evaluating a DSM program, except for incentives paid directly to the participant. Also included are those for marketing, administrative, equipment and program monitoring and evaluation.

Participant Costs and Avoided Participant Costs. Participant costs include all out-of-pocket expenses that a participant incurs as a result of participating in the program. These costs are calculated before the participant receives any rebate or incentive payment. If the participant avoids some cost by participating, it is considered a benefit to the participant.

Incentives and Participation Charges. Incentives are any dollar amount that the utility pays directly to the participant. These include rebates, bill reductions, rate discounts and below-market loans. The incentive that a utility pays a dealer or builder is a utility cost unless the incentive is passed through to the participants. A participation charge is the payment by the participant to the utility related to a DSM program.

Tax Credits and Payments by Third Parties. If the participant receives any tax credit for participating, it is accounted for in this benefit category. Any payment made to the participant by a non-utility source (e.g., a manufacturer's rebate) also falls under this account.

Externalities. This category includes any costs or benefits that are external to standard cost-accounting methods. Externalities include effects, both positive and negative, to society.

Overview of the Tests

This section briefly describes the five most commonly used cost-effectiveness tests. Each test represents a different perspective in determining the cost-effectiveness of a program.

Total Resource Cost Test. The TRC test is a measure of the total net expenditures of a DSM program from the perspective of the utility and its ratepayers. The benefits are avoided supply costs, net avoided participant costs and tax credits. The costs include increased supply, net participant costs and utility costs. Since the utility and its ratepayers are considered together by this method, transfer payments between the two are ignored. This test is a measure of the change in the average cost of energy services. The following formula explains the relationships within the TRC method.

$$B_{TRC} = \sum_{t=1}^{N} \frac{UAC_t + TC_t + PAC_t *}{(1+d)^{t-1}}$$

$$C_{TRC} = \sum_{t=1}^{N} \frac{UC_t + PC*_t + UIC_t}{(1+d)^{t-1}}$$

* Participant costs and participant avoided costs in this test are net of free riders.

Utility Cost Test. The utility cost test is a measure of the changes in total costs to the utility from a DSM program. It evaluates the DSM program from the perspective of a utility's total cost. The benefit component is avoided supply costs. The cost components are increased supply costs, incentives, and utility program costs. The test measures the change in the average energy bills across all customers.

The utility cost test is identical to the RIM test, except that the utility's revenue losses are not included as a cost input in the utility cost test, and revenue gains from increased sales are not included as a benefit. The following formula describes the utility cost test calculations.

$$B_{UC} = \sum_{t=1}^{N} \frac{UAC_t}{(1+d)^{t-1}}$$

$$C_{UC} = \sum_{t=1}^{N} \frac{UC_t + INC_t + UIC_t}{(1+d)^{t-1}}$$

Participant Test. The participant test measures the quantifiable benefits and costs to the customer as a result of program participation. Benefits include reductions in customers' utility bills, avoided customer costs, incentives and tax credits. Participant costs include any customer out-of-pocket expenses resulting from participation. The test is a measure for the average customer and ignores free riders. The participant test provides a good indication of the attractiveness of the program to the average non-free rider expected to participate. The participant test calculation is based on the calculation that follows.

$$B_p = \sum_{t=1}^{N} \frac{BR_t + TC_t + INC_t + PAC_t}{(1+d)^{t-1}}$$

$$C_p = \sum_{t=1}^{N} \frac{PC_t + BI_t}{(1+d)^{t-1}}$$

Societal Test. A common variation on the total resource cost test is the societal test. It measures the benefits and costs to all of society (i.e., including other utilities, government agencies, and citizens outside the jurisdiction). The societal test differs from the total resource cost test in three ways. First, a societal discount rate is used to place value on all future benefits and costs, reflecting society's low-risk view of future investments. Second, environmental externalities are included in the benefit-to-cost equations. Third, this test excludes tax credits because they are transfer payments within society. The mathematical equations for the societal test follow.

$$B_S = \sum_{t=1}^{N} \frac{UAC_t + PAC*_t + EB_t}{(1+s)^{t-1}}$$

$$C_S = \sum_{t=1}^{N} \frac{UC_t + PC*_t + UIC_t + EC_t}{(1+s)^{t-1}}$$

* Participant costs and participant avoided costs in this test are net of free riders.

Ratepayer Impact Measure Test. The ratepayer impact measure (RIM) test quantifies the impacts on customers' rates resulting from changing utility revenues and operating costs. It assumes that DSM reduces utility revenues and increases costs and that customer rates must be increased to balance the utility's books.

Benefits considered by the RIM test are avoided supply costs and revenue gains. Costs for the RIM test are increased supply costs, utility program administration, incentives and reduced revenues from energy savings. The calculation of the RIM test is as follows.

$$B_{RIM} = \sum_{t=1}^{N} \frac{UAC_t + RG_t}{(1+r)^{t-1}}$$

$$C_{RIM} = \sum_{t=1}^{N} \frac{UIC_t + RL_t + UC_t + INC_t}{(1+r)^{t-1}}$$

Glossary of Symbols

B_P Benefit to participants (participants test)
B_{RIM} Benefits to rate levels or customer bills (ratepayer impact measure test)
BI_t Bill increases in year t
BR_t Bill reduction in year t
B_S Benefits of the program (societal test)
B_{TRC} Benefits of the program (total resource cost test)
B_{UC} Benefits of the program (utility cost test)
C_P Costs to participants (participants test)
C_{RIM} Costs to rate levels or customer bills (ratepayer impact measure test)
C_S Cost of the program (societal test)
C_{TRC} Costs of the program (total resource cost test)
C_{UC} Costs of the program (utility cost test)
d Discount rate
EB_t External benefits to society due to the program in year t
EC_t External costs to society due to the program in year t
INC_t Incentives paid to the participant by the sponsoring utility in year t
PAC_t Participant avoided costs in year t
PC_t Participant costs in year t
r Return on investment
RG_t Revenue gains from increased sales in year t
RL_t Revenue loss from reduced sales in year t
s Societal discount rate
TC_t Tax credits in year t
UAC_t Utility avoided supply costs in year t
UC_t Utility program costs in year t
UIC_t Utility increased supply costs in year t

For additional information regarding these and other cost effectiveness test, refer to the California Standard Practice Manual.[24]

[24] California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects. July 2002. http://drrc.lbl.gov/pubs/CA-SPManual-7-02.pdf

Appendix D – Ramp Rates

Table D-1
Ramp Rates

	Year																			
Ramp Type	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**
Electronics	0.3%	0.5%	1.0%	2.0%	3.0%	5.0%	5.8%	3.0%	1.0%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
HVAC- Code Change	4.0%	5.0%	6.0%	6.0%	5.5%	5.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	3.0%	2.0%	2.0%	2.0%
EnerGuide80	5.0%	5.0%	5.0%	5.0%	5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
New Measure Medium	1%	2%	3%	4%	5%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
New Lighting - Code Change	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
New Measure Fast	2%	4%	6%	8%	10%	10%	10%	10%	10%	10%	10%	10%	0%	0%	0%	0%	0%	0%	0%	0%
New Lighting - Program	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	2.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
20YearEven	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
EnerGuide90	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
12YearEven	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
CFL Code Change	10%	10.0%	8.0%	6.0%	3.0%	2.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
10YearEven	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10YearEven, CC 2014	10.0%	10.0%	10.0%	10.0%	10.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2011 Code Change	10.0%	10.0%	10.0%	8.0%	6.0%	4.0%	2.0%	2.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
5YearEven	20.0%	20.0%	20.0%	20.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Appendix E – Direct Load Control Case Studies

The pilot programs surveyed for the FortisBC study differ but seem to agree on several key points. First, load control must be carefully planned to coincide with peak demand, otherwise, any demand reduction will not reduce a utility's coincident peak demand. This may seem obvious, but different service territories and climates have different peak periods and can benefit from different load control schedules.

Second, technology is evolving rapidly. These changes present challenges when applying numbers from one utility's potential or pilot study to another area difficult. There are areas of overlap, but understanding exactly the technology used is essential.

Third, customer willingness to participate and remain in load control programs is as important as the technology itself. Retaining participants requires providing feedback to consumers and understanding if they are comfortable with the curtailments. If work is not done to secure participants, customers will drop out of the programs causing estimates of load reduction potential to be inaccurate. An overview of two prominent programs follows.

Direct load control programs can cycle many household appliances and space conditioning units. Most pilot programs have used control devices on several components of residential load. The logic being: if you spend the money to install the infrastructure, it should control all large components of load. Table E1 lists potential energy savings for different components.

Table E1
Potential Load Reduction by End-Use

End Use Load	Average Load Reduction per Event (KW)
Water Heater	0.6 (Winter)
Heat Pump Strip Heat	1.02 (Winter)
Forced Air Strip Heat	0.85 (Winter)
Electric Forced Air Cooling	0.78 (Summer)

Source: Goodwatts and Power Shift

Goodwatts

There are several pilot programs in the Northwest, but the GoodWatts Program is an especially pertinent case study that highlights several key findings and program design. The GoodWatts Program was a demand response pilot program initiated in 2005 and 2006 in Ashland, Oregon. The program was supported by the Bonneville Power Administration. Ninety-two residential customers of Ashland Electric had 2-way communicating meters, programmable thermostats, load control meters for pool pumps and water heaters, and communication technology placed in their home to send signals of curtailment in controlled appliances on event days during the summer and winter periods. Curtailment events were called during the summer periods of 2005 and 2006 (June – September) and the winter 2005 and 2006 (January – March).

Unlike weather-related energy use, the water heater system daily load profile is consistent throughout the year with usage peak between 6:15 a.m. and 8:15 a.m., and a second, but less pronounced peak, between 5:00 p.m. and 7:00 p.m. (Figure 5).

Total residential use, conversely, tends to have a morning peak in the winter (Figure 5) and late afternoon/early evening peak in the summer (Figure 6).

Figure E1
Daily Winter Load

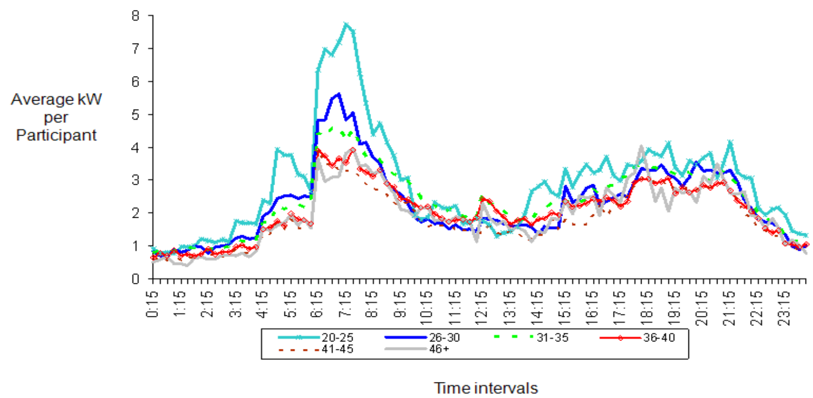
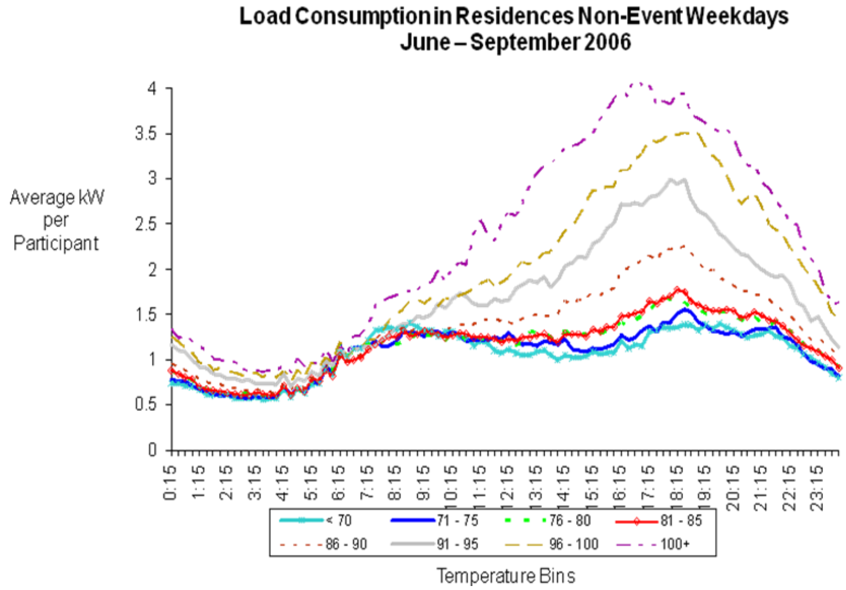


Figure E2
Daily Summer Load

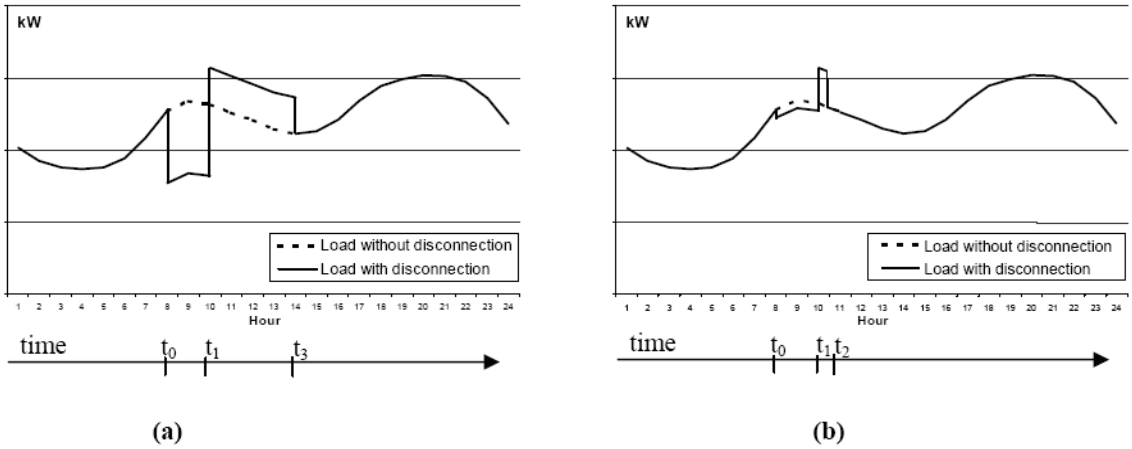


For hot water heater curtailments, load drop is highest when coincident with system peak – as more appliances are in use during that period. Therefore, for winter events where system peak is 6:15 a.m. to 8:30 a.m., curtailing water heaters resulted in observed in load drop of up to 15% on days colder than 30°F (6% on other days). Additionally, GoodWatts results suggest that events duration should be around 2 hours.

The potential savings are also affected by the households targeted for control devices. Figure 7 shows hypothetical household energy consumption from a Norway study. Group (a) is high demand users while Group (b) is low demand users. It is assumed that hot water tanks are the same size across all users. The white area in the bar graphs is the time period where the water heater recovers after use given no interruption. It is assumed that water heaters begin recovery the same instant the hot water is being drawn. The black area, or payback area, is the recovery period given an interruption has occurred.

Figure E3 illustrates that after reconnection, low demand consumers experience a larger peak than otherwise would have occurred. High-demand consumers produce flatter, longer peaks after reconnection occurs.

Figure E3
Water Heater Demand Example



Source: Ericson, Torgeir. "Direct Load Control of Residential Water Heaters." Discussion Papers No. 479, October 2006. Statistics Norway, Research Department.

These hypothetical load curves are based on consumers that do not anticipate disconnection. This also suggests that the timing of household water consumption is important in determining load shapes. Also, the duration of the disconnection will directly influence the payback demand.

Other Pilot Programs

GridWise

http://gridwise.pnl.gov/docs/pnnl_gridwiseoverview.pdf

The GridWise demonstration program addressed consumer behavior, price-responsive household technology, and dynamic electricity pricing in 112 homes on the Olympic Peninsula. The project combines real-time pricing, smart appliances that respond to pricing signals, and an internet-based event driven software. The average participating household saved 10 percent on their electricity bill over the 1 year period. The results of the Olympic Peninsula Project showed that if all customers were engaged at a similar level as test subjects, about $70 billion of new generation, transmission, and distribution could be avoided over 20 years.

East Kentucky Power Cooperative

http://www.psc.state.ky.us/pscscf/2007%20cases/2007-00553/psc_order_032008.pdf

The East Kentucky Power Cooperative (EKPC) implemented a direct load control demonstration program over a period of 12 months from October 2006 through September 2007. The program involved a total of 386 participants in two service territories. Over the 12 month period, water heater demand reduction averaged to 0.46 kW and 0.59 kW per appliance in the summer and winter months respectively. These appliances were controlled for the 4 hour period of on-peak use.

Norway

http://ideas.repec.org/p/ssb/dispap/479.html

In Norway, 475 households participated over the November 2003 through April 2004 period. The study interrupted water heater service in both morning and evening peaks hours, alternatively. The hour of interruption was varied. The results of the study found that between 0.6 and 0.58 kW per household in the morning hours can be saved while between 0.18 and 0.60 kW can be saved in the afternoon.

Portland General Electric

http://www.nwcouncil.org/energy/dr/library/dr_assessment.pdf

During a 37 day period in January and February 2003, Portland General Electric (PGE) collected data for their water heat direct load control project. The utility remotely turned off electric water heaters for 2 hours each weekday morning in 81 participant households. The average peak demand savings for these months was between 0.65 and 0.69 kW per water heater.

Louisville Gas & Electric

http://www.eon-us.com/rsc/lge/default.asp

GE has partnered with (LG&E) to initiate a new line of smart appliances that use wireless technology and energy conservation meters to help consumers save electricity. These appliances are paired up with smart electric meters that communicate with the appliance. For example, a washing machine may skip a wash cycle or a refrigerator may skip a defrost cycle during peak demand periods. GE plans to spend nearly $1 billion on marketing and development of smart appliances in the next 3 to 5 years. These appliances are expected to cost consumers 5 to 10 percent more than standard GE appliances. As more utilities implement advanced metering and tiered pricing, the market for smart appliances can expand.

Xcel Energy® - Boulder Smart Grid City™

http://smartgridcity.xcelenergy.com/index.asp

The plan is to install over $100 million worth of smart grid technology to improve reliability and cut costs for both consumers and the utility. The project includes direct load control among an expansive smart grid program that includes:

- Online tools for home energy use tracking, planning, and budgeting
- Real-time energy pricing or green power energy price signals allowing users to reduce energy costs or use more green energy
- Advanced smart meters that communicate with home appliances that provide opportunity for energy and cost savings