

Electricity
Conservation
Potential
Review,
1988 – 2010:

The Commercial Sector

Phase I: Unconstrained Potential

ELECTRICITY CONSERVATION POTENTIAL
IN BC HYDRO'S SERVICE AREA

COLLABORATIVE COMMITTEE FOR
THE 1991-1994 CONSERVATION POTENTIAL REVIEW

VANCOUVER, B.C. - FEBRUARY 1993

Notes to the Reader

- ➡ **The results contained in this report are based on 100% change-over to the most electrically efficient technologies. Practically achievable levels are being estimated in Phase II, expected to be completed in 1994.**

One hundred per cent (100%) changeover to the most electrically efficient technologies are assumed in the target years, 2000 and 2010. Thus, these estimates are "unrealistic" in the sense that they do not take into account practical barriers to the availability and the adoption of electrically efficient technologies.

- ➡ **The estimates in this report assume a world without Power Smart, B.C.Hydro's conservation initiative.**

Thus, the electricity savings that have already been achieved through the use of Power Smart programs, and the savings expected in the future years of this initiative, have to be subtracted from the estimates contained in this report to determine what remains to be pursued.

- ➡ **The 1991-94 Conservation Potential Review was undertaken under the direction of a Collaborative Committee made up of representatives of the major stakeholders in B.C.Hydro's service area, plus B.C.Hydro and West Kootenay Power.**

One of a handful of collaborative processes tried in Canada, this is the first collaborative in the utility industry in the country.

- ➡ **This report is one of four documents which present the results of Phase I of the 1991-94 Conservation Potential Review.**

Phase I of this Review has estimated the technological, social and economic electricity conservation potential to the year 2010 for B.C.Hydro's service area. This document contains the technical report on the commercial sector by Marbek Resource Consultants of Ottawa and associated firms. There are two other technical reports: one for the residential sector, also by Marbek, and one for the industrial sector by M.K. Jaccard and Associates of Vancouver. The fourth document is a summary report written for a general audience that concisely presents the findings for each of the three sectors.

An Introduction from the Collaborative Committee

This report is one of four documents reporting the results of Phase I of the 1991- 94 Conservation Potential Review. This Review has been undertaken as part of B.C. Hydro's ongoing efforts to improve understanding of the possible size and scope of electricity conservation and the role it can play in the utility's resource mix to serve future electricity needs. This volume reports the examination of the commercial sector in B. C. Hydro's service area by Marbek Resource Consultants and associated firms. Companion technical volumes deal with the residential and industrial sectors. A summary report covering all three sectors is also available.

West Kootenay Power used the same consultants to obtain similar information for its service area. West Kootenay's study was conducted without a collaborative process and is published separately. Taken together, these estimates for B.C. Hydro's service area and West Kootenay Power's work indicate the possible size of electricity conservation as a resource in the province.

The Collaborative Committee, which oversees the conduct of the Conservation Potential Review, would like to draw your attention to the following matters as you consider this report.

An Unconstrained Perspective

The Collaborative Committee chose to start with an unconstrained approach to defining conservation potential. It instructed its consultants to try to free their minds of all the usual behavioral, institutional, and market barriers that stand in the way of using electricity efficiently and investing in electrically efficient technologies. Instead, it asked the consultants to temporarily put aside practical considerations and to concentrate on what might be possible if all the most efficient technologies and most efficient behaviors and operating and maintenance practices were to be universally adopted in the province.

The resulting estimates of **technological and social potential*** should be understood as representing a probable outside or theoretical limit to the size of conservation as a resource, based on current knowledge and informed judgments about the future. Thus, from the perspective of those used to dealing with energy audits of individual plants and buildings and the limitations imposed by current investment criteria and capital availability, these technological and social estimates may appear to be quite optimistic or "impractical."

* Definitions of technological, social, and economic potentials are contained in the executive summary of this report.

This unconstrained perspective was chosen in order to avoid overlooking possibilities that are ruled out by current decision-making practices that could change in future circumstances, or that the utility could influence to make investment in electrically conserving technologies easier.

From this unconstrained perspective, the Review then moves to examine what proportion of the conservation potential is expected to be the same or less cost than investing in acquiring new sources of electricity. This is referred to as the **economic potential**.

In Phase II of the Review, the Committee and its consultants will be investigating what proportion of the unconstrained potential is likely to be realistically achievable under a variety of assumptions about utility investment and action, legislative and standards support for conservation, and public and private commitment to pursuing higher levels of energy efficiency. This **achievable potential** is closer to what the average reader would expect to see as a "practical" or "realistic" estimate. Achievable potential will be reported upon the completion of Phase II, expected in 1994.

The Nature of Modeling Exercises

Modeling exercises inherently involve aggregation and abstraction. They also involve the use of judgment where data is absent or incomplete. In the case of the commercial sector, both the level of abstraction required and the quality of the base data available have caused some difficulty.

The commercial sector is extremely diverse in nature with many different types and sizes of buildings. The resources available for this effort enabled the consultants to construct only a small number of thermal archetypes, or base buildings, to represent the diversity of buildings in B.C. Hydro's service area, inevitability oversimplifying reality.

The base stock and floor stock data available to the consultants in the commercial sector left a great deal to be desired, both in completeness and in probable accuracy. Many judgments and assumptions have had to be made by the consultants in estimating electricity conservation potential in the commercial sector. Varying some of the key assumptions, such as base year penetrations of electrically efficient technologies or prevailing building ventilation rates, could produce different results.

The authors of this report from Marbek identify the areas where they have less confidence in the data that has been available to them. The Collaborative Committee anticipates that it will be useful to rerun some of the commercial sector estimates if the quality and coverage of the base data improves, as anticipated, in the next few years.

Social Potential and Operational Practices

One of the innovations in this Review is the attempt to estimate separately the potential savings that could be realized in electricity use if all buildings and equipment were to be operated in the most energy efficient manner and if maintenance were routinely designed and carried out to minimize electricity use. Marbek's work here is a useful first step that can be built upon as more information becomes available about the current operational practices in commercial buildings in B. C.

It is important to note that the reporting of aggregate social potential in the long term, in the year 2010, tends to understate the potential impact of human behavior and to mask the savings that could be achieved in the short to medium term. While the aggregate social potential, 3%, may seem small, the electricity it represents is quite considerable. The consultants estimate roughly 400 GWh annually can be made available by electrically efficient operating and maintenance practices by the year 2010. This is more than half of the electricity consumed in 1992 in the City of Victoria by residential and commercial customers.

In addition, this aggregate masks the magnitude of savings that can be achieved in individual end uses. For example, the consultants estimate that 10% to 25% savings may be achievable in lighting through improvements in lighting scheduling and 10% to 36% through the proper use of automated controls. They suggest regular cleaning of light fixtures could increase lighting savings by a further 10%. Developing the habit of turning off monitors, computers, and other office equipment when it is not in use could reduce office equipment electricity consumption by up to 50%. Clearly, human behavior can make a significant difference in the commercial sector!

Relation to Power Smart Achievements

The consultants were asked to assume a world without Power Smart. This means the estimates in this report must have the already achieved and expected savings from B.C. Hydro's Power Smart programs subtracted from them to determine what potential for savings remains.

The estimate of savings already achieved, or expected to be achieved, over the life of the Power Smart programs available to commercial customers in the fall of 1992 is 1,400 GWh annually in the year 2000 and 1,380 GWh annually in 2010. These expected electricity savings have to be subtracted from Marbek's estimate of economic potential to see what remains to be achieved.

Some Thoughts on Realism

The estimates contained in this report may be considered "unrealistic" in the sense that they do not take into account practical barriers to their implementation, as discussed above in the description of the unconstrained approach adopted by the Committee. Consequently, some readers may think the estimates are extremely optimistic and unlikely to be achievable.

However, it is also possible that these estimates will be proven over time to be conservative. The predictions of other similar studies in the past 30 years have often demonstrated the hazards inherent in forecasting the pace of technological change. Even estimates their authors considered to be on the fringe have been proven by events to substantially underestimate the scope of change. In the face of the current pace of innovation and improvement in energy efficiency, the estimates in this report may turn out to be conservative as well.

A Precedent-Setting Approach

The Conservation Potential Review has been undertaken as a collaborative exercise in order to arrive at estimates that all the major interest areas in the province can agree upon and use as a common basis for decision making. It has also been undertaken with such broad representation in the decision making in order to draw on the knowledge, experience, insight, and creativity of the many individuals and organizations in the province who have promoted conservation and implemented energy efficiency measures.

The Collaborative Committee which oversees the Review has thirteen members directly representing 34 organizations and two utilities. Each member of the Committee was selected by an interest area and seeks to represent the perspective of the organizations in that interest area. Members represent residential, commercial and industrial utility customers; environmental organizations; First Nations' Peoples; local governments; B.C. Hydro; and West Kootenay Power, Ltd. A staff member from the Ministry of Energy, Mines, and Petroleum Resources also sits as a special participant on the Committee, who joins in discussion, but not in the Committee's decision-making. The Committee chose an independent party to chair its meetings and facilitate its decision-making.

It is the hope of the Collaborative Committee that its work will serve as a key part of the foundation for decision-making on the use of conservation to meet future electricity needs. It is also the hope of the Committee that its successful experience with consensus decision-making among diverse, and sometimes oppositional, perspectives will encourage others to try more cooperative approaches to decision making.

Acknowledgements

In addition to the Committee members and their alternates, there are other volunteers involved in the Review. Many individuals have generously allowed the consultants to draw on their knowledge and experience. Others have served as members of working groups that have made recommendations as to how to deal with externalities and uncoded environmental and social impacts.

The total number of contributors to the Review's work to date, including volunteers and utility and consultant staff, exceeds 100. Thus, the Review results have been shaped by the collective expertise of a significant cross section of experience.

The Collaborative Committee wishes to acknowledge the contributions of these many individuals and to thank them for their efforts.

An Invitation to the Reader

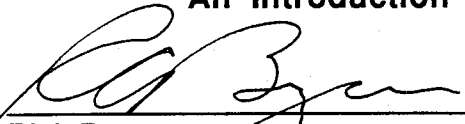
For this Review, the consultants used the best data available to them. However, as mentioned, there are obvious limitations and weaknesses in the information currently available in the commercial sector, especially on base equipment stocks and floor stocks.

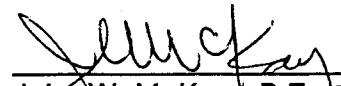
For the more problematical areas, the Committee has made recommendations for further work that it thinks will be constructive in addressing current data limitations. The basic assumptions made in this commercial sector study are documented; so that estimates can be rerun as better information is acquired. The Committee is also recommending areas for further research and exploration. For example, little is known about the characteristics of electricity use by small scale commercial establishments.

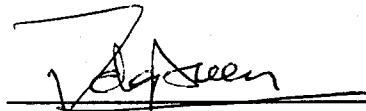
The Committee invites the reader to contribute his or her knowledge to improving the base data and assumptions which are summarized in this document and its appendices. Interested readers are invited to check the assumptions and comment on their accuracy in light of their own knowledge and experience. Comments may be sent to the address on the inside front cover of this document.

Readers are also invited to make suggestions for further work that could advance the understanding of the potential for electricity conservation among commercial customers in B.C. Hydro's service area.

The Collaborative Committee for the 1991- 94 Conservation Potential Review looks forward to hearing from you.


Dick Bryan
Council of Forest Industries of B.C.
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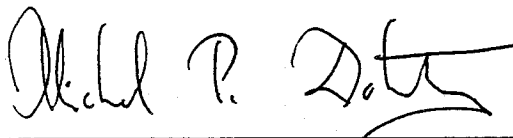

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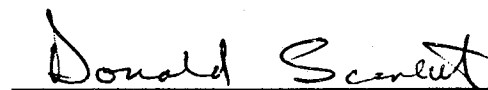

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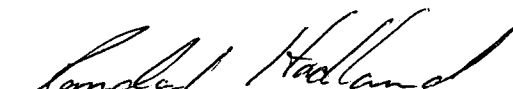

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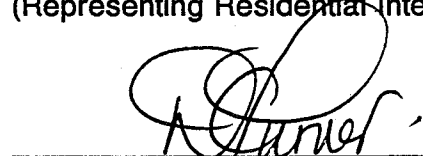

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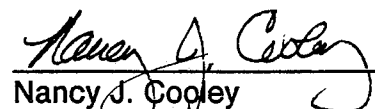

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1991 - 1994 CONSERVATION POTENTIAL REVIEW

**Estimates of Electricity Savings
in British Columbia to 2010 Assuming
Unconstrained Use of Technically and
Economically Viable Energy Efficiency
Technologies and Measures**

Final Report Commercial Sector

Prepared for:

BC Hydro

By:

Marbek Resource Consultants Ltd.

In Association with:

**Prism Engineering Ltd.
Pacific Energy Associates, Inc.**

February, 1993

EXECUTIVE SUMMARY COMMERCIAL SECTOR

OBJECTIVES

The objective of this study was to determine the technological, social and economic potential for increasing electricity efficiency in the BC Commercial Sector over the period 1988 to 2010, assuming unconstrained¹ use of electrically efficient technologies and operational measures.

The study was overseen by the Collaborative Committee for the Review, whose members represented major areas of interest in the province plus West Kootenay Power and BC Hydro. The study was carried out by Marbek Resource Consultants Ltd., with assistance from Prism Engineering Ltd., and Pacific Energy Associates.

The study was limited to the BC Hydro service area. No fuel substitution was allowed for in the study.

DEFINITIONS

Frozen Efficiency: An estimate of future electricity consumption assuming the energy efficiencies of all existing and new buildings and equipment remain constant at their 1988 levels throughout the study period, and operational practices remain unchanged at their current levels.

Technological Potential: The potential savings in electricity consumption assuming existing technologies are completely replaced with the most efficient, technically viable options that are commercially available or expected to be market ready over the study period, with operational practices remaining unchanged at their current levels.

Social Potential: The potential savings in electricity consumption assuming maintenance, scheduling and other operational practices are improved to their best possible levels.

¹ Unconstrained use of energy efficient technologies means 100% penetration of these technologies or measures over the study period, depending only on their technical and economic viability and no other market factors.

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Economic Potential: The potential savings in electricity consumption assuming existing technologies are replaced over the study period with those which have a total resource cost² less than or equal to the price of supplying new electricity to the Lower Mainland of BC in the absence of Power Smart programs.

COMMERCIAL SECTOR FLOOR AREAS

The first step in the analysis was to estimate 1988 building floor areas for each of 12 commercial sector building segments. A variety of sources were used to determine floor areas, including previous estimates derived for BC Hydro. High and low growth forecasts of floor areas in 2000 and 2010 were made using growth rates specified by the Collaborative. Table 1 shows 1988 and target year forecasts of floorspace used in the study.

ENERGY CHARACTERISTICS OF EXISTING AND NEW BUILDING STOCK IN 1988

The next step was to review the characteristics of building envelopes and energy using equipment in buildings built before 1988 (existing buildings) and those being built in 1988 (new buildings). The operational practices (maintenance and scheduling) which are currently used in these building segments were also determined through interviews with building owners and managers and from a literature survey. Estimates of the additional electricity use associated with each of these practices were made.

Commercial sector buildings in BC were mostly found to have relatively low levels of insulation, single glazed windows, use conventional fluorescent and incandescent lighting systems, and use a standard heating, ventilation, and air conditioning (HVAC) configuration. The electrical fuel share for heating was low in most buildings, with electric heating systems being mostly heat pumps in large buildings and electric resistance units in smaller buildings.

Operational practice was found to affect mostly lighting scheduling and HVAC maintenance, resulting in operational penalties in these end-uses of between 10% and 25%.

Based on the technical and operational information collected, a series of end-use intensities (EUIs) were developed for each end-use (lighting, space heating, etc.) and building segment.

The EUI is defined as electricity used per unit floor area per year for each end-use served by electricity. Detailed typical building profiles were also produced for each building segment.

² The Total Resource Cost in this study is defined as the discounted annual cost of a technology per kWh of electricity saved less an environmental credit. An environmental credit represents the value of a technology (expressed as a percentage of the cost of new electricity) in reducing the environmental impact of new electricity. Three discount rates (4%, 8% and 12%) and five levels of environmental credit (0%, 15%, 30%, 60% and 100% of the cost of new electricity) were used in the study.

Table 1
BC Hydro Conservation Potential Review
Commercial / Institutional Sector Floor Space 1988 to 2010 (square metres)

Building Segment	1988	High Growth		Low Growth	
		2000	2010	2000	2010
Large Office	975,000	1,358,069	1,655,479	1,295,997	1,518,942
Small Office	7,305,000	10,175,074	12,403,359	9,710,011	11,380,380
Non – Food Retail	6,750,000	9,402,020	11,349,141	7,606,069	8,074,954
Food Retail	1,000,000	1,392,892	1,681,354	1,126,825	1,196,290
Restaurant	900,000	1,239,047	1,481,036	1,114,848	1,256,091
Wholesale/warehouse	6,640,000	10,388,105	13,040,452	7,571,500	8,363,647
Hotels/Motels	2,450,000	3,372,962	4,031,709	3,034,865	3,419,358
Hospitals	1,250,000	1,623,008	1,939,986	1,512,288	1,687,120
Nursing Homes	975,000	1,265,947	1,513,189	1,179,585	1,315,954
Schools	5,840,000	7,582,695	9,063,613	7,065,410	7,882,226
University/Colleges	1,870,000	2,428,021	2,902,219	2,262,383	2,523,932
High Rise Apartments (1)	4,645,000	6,031,099	7,208,987	5,619,662	6,269,339
Other Buildings	3,500,000	4,544,423	5,431,960	4,234,406	4,723,937
Total	44,100,000	60,803,362	73,702,485	53,333,850	59,612,170

1. Includes both suites and common areas for apartment buildings with 5 or more floors.

END-USE ANALYSIS

In preparation for estimating conservation potential, the next step was to develop an energy end-use accounting model which estimates electricity consumption from building floor area, electric fuel share and energy end-use intensities. For example:

$$\text{Annual Electricity Use for Space Heating (kWh/yr)} = \text{Floor Area (m}^2\text{)} \times \text{Electric Fuel Share (fraction)} \times \text{Space Heating End-Use Intensity (kWh/m}^2\text{.yr)}$$

The model sums electricity use over all end-uses and building segments for a selected year. It is a simple spreadsheet-based model which requires any interactive effects between end-uses (e.g., lighting reductions which also decrease cooling loads) to be taken into account outside of the model through the input EUIs.

Table 2 shows 1988 electricity use broken down by building segment. Table 2 shows that the building segments with the largest electricity consumption are Small Offices (24% of building electricity) and Non-food Retail (19% of building electricity). The high electricity consumption in Small Offices is an important finding, since it is large office buildings that frequently receive the most attention in energy management.

Electricity consumption predicted by the end-use model for 1988 agreed well with BC Hydro sales data on a sector basis. There were, however, quite wide variations for certain sectors such as Restaurant and Tavern (-16%), Schools (-16%), and Hospitals (+12.5%) which reflects the inadequate floor space data available for the analysis. The discrepancies for Schools and Hospitals are particularly puzzling, since both sales and floor space information for these subsectors should be reliable.

EFFICIENT TECHNOLOGIES AND OPERATIONAL PRACTICES

The performance, cost and applicability of all technically viable electrically efficient technologies and measures were reviewed and documented. The greatest potential for improvement was found in lighting where efficient lamps, ballasts and reflectors could result in 65% savings over conventional lighting systems. The efficient use of daylighting throughout the building using lightshelves, light pipes, automated controls such as occupancy sensors, and other technologies can also provide significant reduction in lighting requirements increasing overall savings to more than 70%. Finally, lighting levels themselves can be optimized to match each task bringing overall savings to over 80%. Early in the next decade, a new generation of fluorescent lamps could push these potential savings close to 90%.

Significant improvements in efficiency can also be achieved in space heating and cooling through a combination of improved wall insulation, high efficiency windows and high efficiency heat

Table 2
1988 Electricity Use in the BC Commercial Sector

By Building Segment	Consumption (GWh/yr)	Share of Building Electricity
Large Office (> 3,700 m ²)	241.5	3%
Small Office (< 3,700 m ²)	1,961.4	24%
Non-Food Retail	1,568.3	19%
Food Retail	715.3	9%
Restaurant/Tavern	540.6	6%
Hotels/Motels	534.5	6%
Warehouse/Wholesale	622.7	7%
Hospitals	260.1	3%
Nursing Homes	108.5	1%
Universities/Colleges	265.5	3%
Schools	484.6	6%
High Rise Apartments (common areas only) ¹	192.5	2%
Miscellaneous	439.4	5%
Sub-Total	7,935.1	95%
Non-Buildings	1,423.8	
Total Commercial Sector	9,358.9	
High Rise Apartments (suites) ¹	400.0	5%
Total (Buildings incl. High Rise Apt Suites) ²	8,335.1	100%

¹ High Rise Apartments include those with 5 stories or more.

² For modelling purposes, High Rise Apartment Suites were included in the Commercial Sector. BC Hydro classifies suite electricity as Residential.

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pumps and chillers. HVAC electricity, used to power pumps and fans, can also be reduced by using innovative control strategies and other measures.

Savings of between 10% and 25% in operational practice can be achieved through improvements in lighting scheduling and proper use of automated controls (10% to 36% savings), HVAC systems maintenance and scheduling (5% to 20% savings), and occupant behaviour. Light fixture cleaning can increase lighting savings by a further 10%.

RESULTS

Table 3 summarizes the results of the analysis which are discussed separately below.

Frozen Efficiency:

Frozen Efficiency assumes that there is no change in current practice or energy using technologies for lighting, heating, cooling, etc.

By 2010, electricity consumption is estimated to rise 74% with high growth, or 42% with low growth. The proportions of each building segment are expected to be similar to 1988 with Small Office (24%) and Non-Food Retail (19%) having the highest consumption. On an end-use basis, while lighting still represents the highest consumption (43%), plug-in equipment moves into second place (14%) ahead of HVAC electricity (12%).

Technological Potential:

The information on the performance, cost and applicability of all technically viable energy efficient technologies and measures was used to estimate the impact of the most efficient of these technologies on each EUI. Technological Potential represents an unconstrained look at future electricity use, assuming all known commercially available and emerging technologies are fully utilized by 2010. The estimate was produced by replacing the Frozen Efficiency (1988) EUIs in 2000 and 2010 with the reduced EUIs for each maximum efficiency package of technologies, assuming that all currently available technologies would be in place by 2000 and all emerging technologies would be in place by 2010.

The most significant EUI reductions can be achieved in lighting. Assuming reduced light levels are achieved with task tuning, use of daylighting throughout the building, automated controls, low diameter fluorescent lamps with reflectors, and dimmable electronic ballasts, up to 85% savings could be achieved in office buildings, with 65% to 80% savings in other building segments. Replacing conventional lamps with "two-photon" induction lamps, which are now under development, would increase the savings to between 85% and 90%, depending on the building type.

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Table 3
Conservation Potential in BC Commercial Buildings

Year and Growth Rate	Frozen Efficiency	Technological Potential	Social Plus Technological Potential	Economic Potential
	Percent Increase over 1988	Percent Reduction over Frozen Efficiency	Percent Reduction over Frozen Efficiency	Percent Reduction over Frozen Efficiency
2000 HIGH	44%	55%	60%	54%
2010 HIGH	74%	65%	68%	57%
2000 LOW	27%	56%	60%	54%
2010 LOW	42%	65%	69%	58%

The largest savings would be achieved in lighting and space heating, with over 80% reduction from Frozen Efficiency by 2010 in offices and over 70% in retail and some other segments. If two-photon lamps are assumed for all uses, savings could increase to about 90% in most segments.

The highest savings on a building segment basis were in Schools, Small Offices and Non-Food Retail (78%, 70% and 74% respectively). The latter two are also the segments with the greatest electricity consumption. The overall reduction in commercial electricity use over Frozen Efficiency was 65%. Small end-uses such as refrigeration, plug-loads, and miscellaneous equipment represent much higher proportions of total sector use when the above high efficiency equipment is used in lighting, space heaters etc. This is partly because, in the absence of good data, much more conservative estimates of energy efficiency were made.

Social Potential:

As described above, savings of between 10% and 25% in operational practice can be achieved through improvements in lighting scheduling and proper use of automated controls(10% to 36% savings), HVAC systems maintenance and scheduling (5% to 20% savings), and occupant behaviour. Light fixture cleaning can increase lighting savings by a further 10%.

Social plus Technological Potential is defined as the savings that would be achieved if, in addition to using the most efficient technologies, all buildings are operated in the most efficient manner. The results were produced using the end-use model by eliminating the penalties associated with current operational practices and recalculating the EUIs used for Technological Potential to reflect the improved practice.

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Combining Social with Technological Potential would have the overall effect of adding 3% savings to those achievable under Technological Potential, i.e. 68% over Frozen Efficiency. While not as large as the savings associated with technical improvements only, these operational savings are significant in lighting and HVAC energy end-uses because they can usually be obtained by refocusing training and building operator practices on energy efficiency and do not involve high cost.

Economic Potential:

The total resource cost (TRC) was estimated for each energy efficient technology at three discount rates of 4%, 8% and 12%. The economic viability³ of each technology was determined at five different environmental credits and at an 8% discount rate. The results were produced using the end-use model by replacing the Frozen Efficiency EUIs with those for the most efficient technologies which were economically viable at an 8% discount rate and a 0% environmental credit. Table 4 shows the economic viability of each efficiency technology in terms of the environmental credit required to make the technology cost effective at an 8% discount rate.

Analysis of the cost efficient technologies showed that a high proportion of technically viable technologies are also economic. At an 8% discount rate and with no environmental credit, a 57% reduction over Frozen Efficiency is possible. The size of the environmental credit applied has the highest impact on the viability of fluorescent lighting and building envelope insulation. At a 30% environmental credit, the most efficient lighting upgrades become economic and the savings approach Social plus Technological Potential - 68% savings over Frozen Efficiency. At a 60% environmental credit, all efficient technologies except building wall retrofit to R14 and variable air volume (VAV) ventilation become economic. The effect of the discount rate is also significant. At a 4% discount rate, most technologies are economic with no environmental credit. At a 12% discount and no environmental credit, several of the more expensive technologies cease to be cost-effective. It is estimated that with no environmental credit, 66%, 52% and 40% reductions over Frozen Efficiency are possible at discount rates of 4%, 8% and 12% respectively.

³ A technology is considered economically viable when its total resource cost (TRC) less its environmental credit is less than the cost of new electricity supply.

Table 4
Cost Effectiveness of Commercial Sector
Technologies between 2000 and 2010 at an 8% Discount Rate

Technology	Hours of Operation	Environmental Credit at which Technology is Economic
Fluorescent Lighting		
F32 + Reflector	3000	0%
T8 lamp + Energy Efficient Ballast + Reflector	3000	0%
T8 + Dimmable electronic ballast (EBD) + Reflector	3000	100%
T8 lamp + EBD + Reflector + Daylighting	3000	60%
T8 lamp + EBD + Reflector + Efficient Design	3000	60%
F32 + Reflector	5000	0%
T8 lamp + Energy Efficient Ballast + Reflector	5000	0%
T8 lamp + EBD + Reflector	5000	15%
T8 lamp + EBD + Reflector + Daylighting	5000	0%
T8 lamp + EBD + Reflector + Efficient Design	5000	0%
Incandescent Lighting		
Compact Fluorescent	3000	0%
Tungsten Halogen	3000	0%
Compact Fluorescent	5000	0%
Tungsten Halogen	5000	0%
High Intensity Discharge Lighting		
Metal Halide	3000	0%
Low Pressure Sodium	3000	0%
Metal Halide	5000	0%
Low Pressure Sodium	5000	0%
Lighting Controls		
Automatic Lighting Controls (ALC)	3000	0%
ALC + Occupancy Sensors	3000	0%
Automatic Lighting Controls (ALC)	5000	0%
ALC + Occupancy Sensors	5000	0%
Building Insulation		
Retrofit of Low/Uninsulated Bldg to R11		0%
Retrofit of Low/Uninsulated Bldg to R14		100%
Retrofit of Average Insulated Building to R14		>100%
New Building Insulation to R31		0%
Window Film on Single Pane		0%
Window Replacement ¹		
Super Double Window		30%
Insulated Super Double Window		30%
High Insulation Technology Window		30%

¹ Replacement at end of economic life.

Table 4 (continued)
Cost Effectiveness of Commercial Sector
Technologies between 2000 and 2010 at an 8% Discount Rate

Technology	Hours of Operation	Environmental Credit at which Technology is Economic
Heat Pump Upgrade		
High Efficiency (HE) Air Source	1600	0%
HE Water Source	1600	0%
HE Recovery Chiller	1600	0%
Electric Resistance Conversion		
HE Air Source – Existing Building	1600	60%
HE Water Source – Existing Building	1600	100%
HE Recovery Chiller – Existing Building	1600	60%
HE Air Source – New Building	1600	0%
HE Water Source – New Building	1600	0%
HE Recovery Chiller – New Building	1600	0%
Efficient Cooling Equipment		
HE Reciprocating	1000	0%
HE Centrifugal	1000	0%
Economizers – Existing Building	1000	0%
Economizers – New Building	1000	0%
Ventilation Options		
Variable Air Volume (VAV) – Existing Building	4500	15%
Compartmental VAV – Existing Building	4500	>100%
VAV – New Building	4500	0%
Compartmental VAV – Existing Building	4500	100%
Low Temp. Distribution and Thermal Energy System – New Building	4500	0%
HVAC Electricity		
Energy Efficient Motors	4500	0%
Variable Frequency Drives	4500	0%
Direct Digital Control/Building Automated System	4500	60%
Air and Water Balancing	4500	0%
Service Hot Water		
Faucet Aerators/Low Flow Showerheads		0%
High Efficiency Washing Equipment		0%
Refrigeration		
Multiplexed Compressors		0%
Door/Cover Upgrades		0%

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FORECASTS OF ELECTRICITY USE

Figures 1 and 2 show four high growth and four low growth forecasts of electricity consumption for commercial buildings in BC, relative to current BC Hydro 1988 sales data, based on the estimates of Frozen Efficiency, Technological Potential, Social plus Technological Potential and Economic Potential determined using the computer model.

The forecasts clearly show the large conservation potential that exists in BC commercial building stock, and show how a high proportion of these technological measures are also economic.

ACCURACY AND AVAILABILITY OF DATA SOURCES

Sources for the following data were considered to be of relatively good quality:

- Lighting configuration assumptions and energy intensities in typical existing and new buildings,
- Envelope characteristics in typical existing and new buildings, and
- Performance and cost information on conventional and most commercially available efficient technologies.

These data were based on either local BC experience of the study team and BC building owners, or on reliable international sources. There were also no significant variations between data sources.

Data from other sources were less reliable as follows.

- Building floor space data was inadequate, even for building segments such as schools and hospitals where there is a single jurisdiction, and reliable estimates could be expected.
- Commercial sector sales data are not disaggregated consistently by Standard Industrial Classification (SIC) code. This occurs most often in multiple-use buildings where it is not clear to what building category or SIC the sales should be allocated.
- Information on operational practices was limited. While some local interviews in BC provided insight, there is not much information available in BC or in the literature on operational practice. This prevented quantification and costing of improvements in maintenance and scheduling.
- Good estimates of space and water heater fuel shares were not available for existing or new buildings in BC, and local BC opinion was divided.

FIGURE 1 BC Commercial Sector Electricity Forecasts High Growth

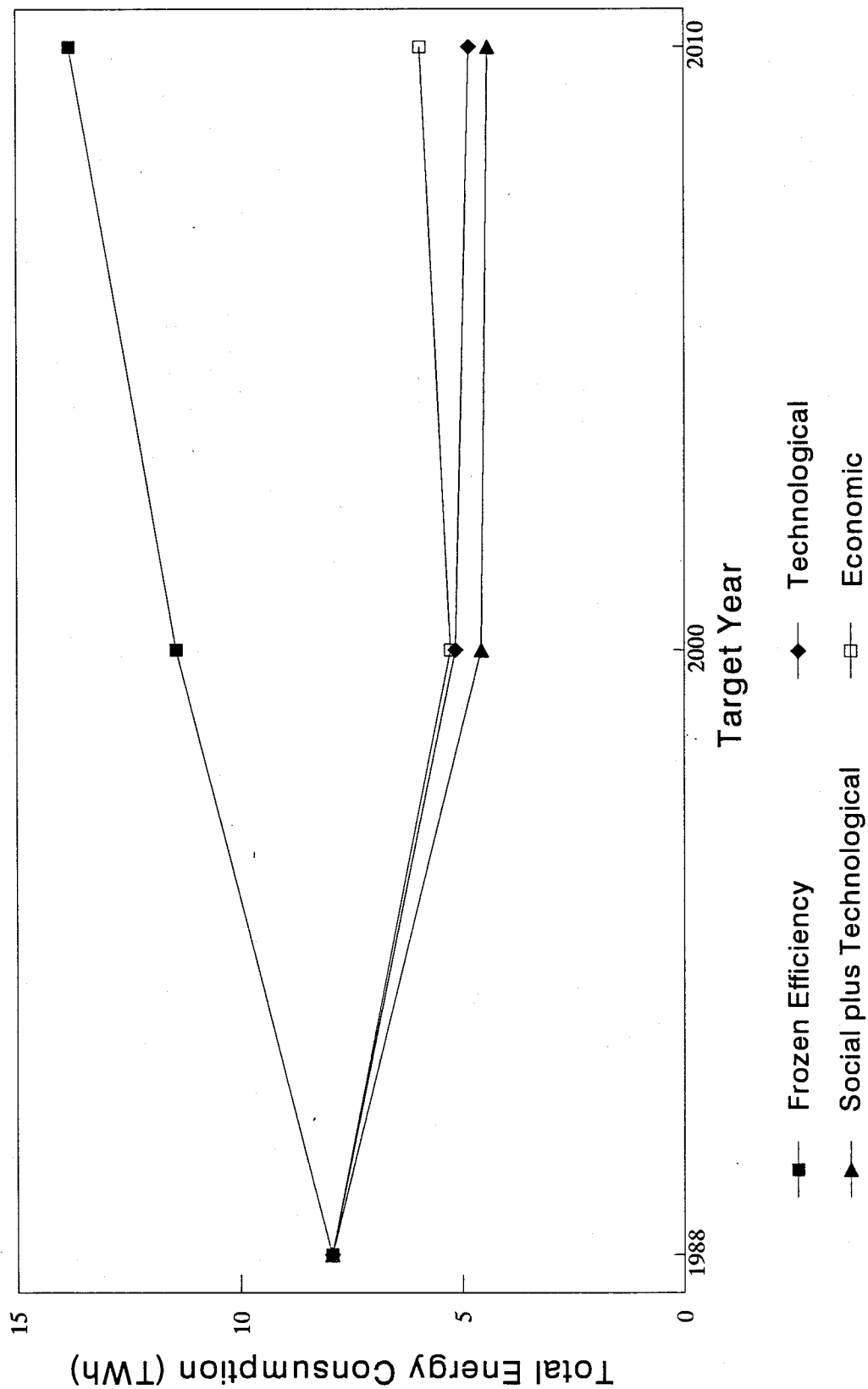
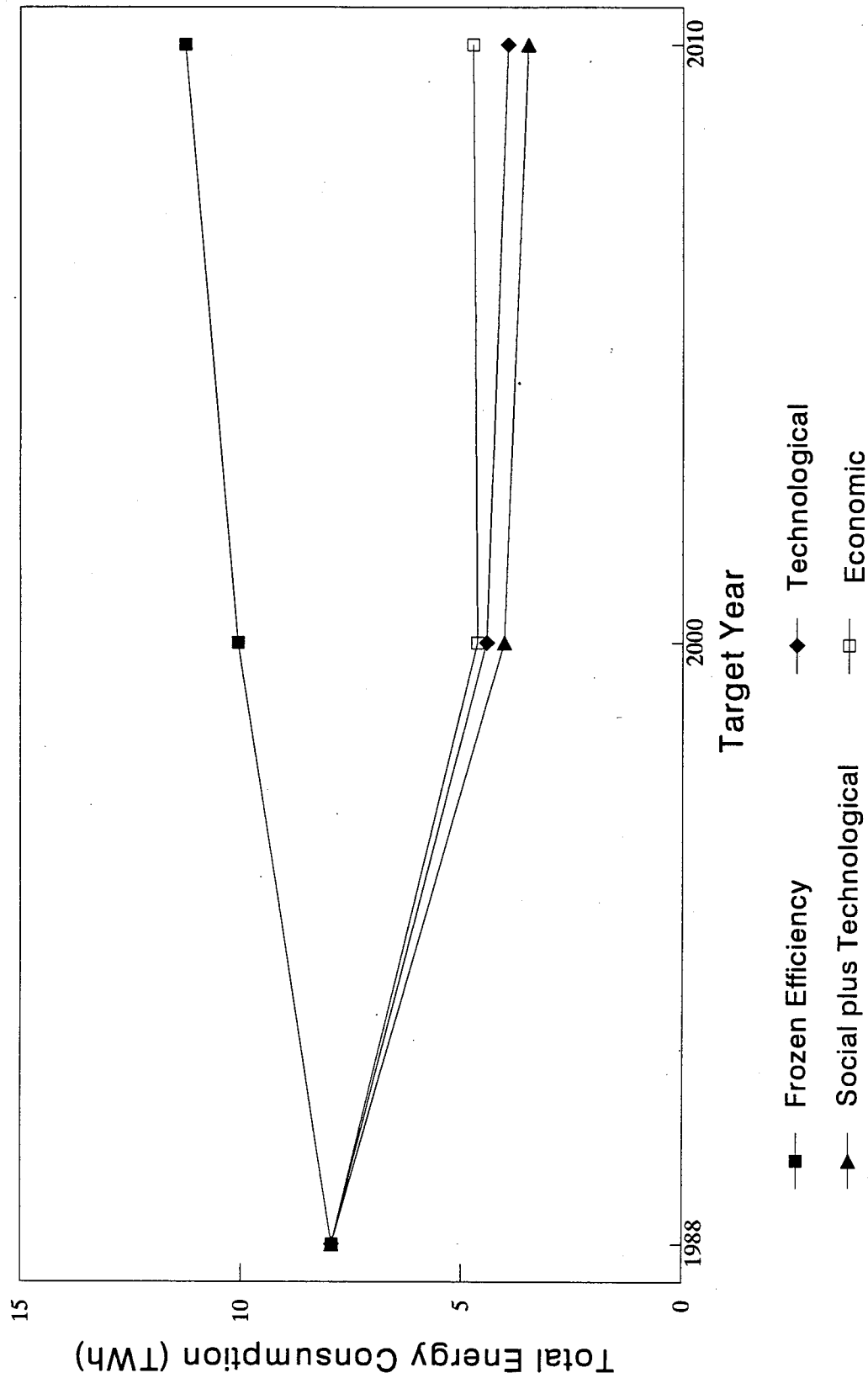


**FIGURE 2 BC Commercial Sector Electricity Forecasts
Low Growth**



BC Hydro 1991 - 1993 Conservation Potential Review - Commercial Sector Executive Summary

- Differences in ventilation rates between existing and new buildings also varied considerably between local BC data sources.
- The performance and cost of emerging technologies and those not yet widely available in North America were often difficult to obtain. Several useful case studies were found, however, and more definitive data is expected to become available as these technologies become more widely used in North American buildings.

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PART I

**INTRODUCTION
AND
BASIC ASSUMPTIONS**

1. INTRODUCTION

1.1 Study Objectives

The objective of this sectoral study, carried out for BC Hydro as part of their 1991 Conservation Potential Review, was to determine the outside limits of electricity efficiency for the period 1988 to 2010 in BC Hydro's service area.

The study produced forecasts of electricity use in the British Columbia commercial sector, assuming unconstrained⁴ use of energy efficient technologies and measures that are technically and economically viable.

1.2 Methodology

The study was carried out in the following steps:

- i) the current technical and operational (maintenance and scheduling) practice in institutional and commercial buildings was identified and current electricity use broken down by end-use
- ii) estimates of growth rates in the commercial sector were established
- iii) technological measures to reduce electricity consumption were researched and costed
- iv) maintenance, scheduling and other operational measures to improve and optimize the operation of existing and technological upgrades were researched and costed
- v) using a computer model, estimates were made of the increases in electricity consumption that would be expected during the study period without any technological or operational improvements (Frozen Efficiency)

⁴ Unconstrained use is defined as 100 % usage (penetration) of efficient technologies and measures, depending only on technical and economic viability, and unaffected by other market factors.

- vi) using the same model, estimates of the savings in electricity that could be achieved by the end of the study period were made:
 - a) with technological improvements only (Technological Potential);
 - b) with technological and operational improvements (Social plus Technological Potential); and
 - c) with only those improvements that are economic against the marginal price of electricity (Economic Potential)
- vii) high and low growth forecasts of electricity consumption over the study period were prepared assuming Frozen Efficiency, Technological Potential, Social plus Technological Potential and Economic Potential.

The study covered only electricity conservation potential in BC commercial buildings, including high rise apartment (both suites and common areas). Electricity conservation potential in non-buildings such as pumping stations, electric transit, etc. was not addressed. When deriving forecasts of electricity use in commercial buildings as per vii) above, however, high rise suite electricity was excluded. In the BC Hydro rate classification system, suite electricity is part of the Residential class.

1.3 Structure of Study Report

This report is derived in four parts as follows:

PART I INTRODUCTION AND BASIC ASSUMPTIONS

Section 1 outlines the study objectives, methodology and definitions used, and provides an overall framework for defining technical and operational Practice.

Section 2 covers the selection of commercial building segments (types) for the study and determines a baseline 1988 electricity sales distribution.

Section 3 addresses the question of floor areas in commercial buildings and develops estimates of floor area for each building segment for use in the study. Appendix 1 and 2 contain floor area source data.

PART II CURRENT PRACTICE IN BC COMMERCIAL SECTOR BUILDINGS

Section 4 reviews current technical practice in BC commercial buildings built before 1988 and those being built (new) in 1988. Technical practice includes technologies used for lighting, heating and cooling, wall, roof and window insulation levels, ventilation rates, etc.

Section 5 addresses maintenance, scheduling and other operational practices in BC building stock, based on a literature review and interviews with energy managers. A more detailed literature survey is provided in Appendix 3, the questionnaire used in Appendix 4.

Section 6 describes how end-use intensities (EUIs) were derived for each electricity end-use in existing and new buildings. Typical building profiles for existing and new buildings are given in Appendix 6. These are statistical representations developed only for use in the computer planning model.

PART III ENERGY EFFICIENT TECHNOLOGIES AND MEASURES

Section 7 provides a comprehensive review of the maintenance, scheduling and other operational measures that could improve energy efficiency in commercial buildings in BC, and an end-use by end-use review of most commercially available (within the study period) energy efficient technologies. Appendix 5 provides more details on operational (social) improvements.

PART IV CONSERVATION POTENTIAL

Section 8 describes the end-use planning model used in the study and provides the results of the frozen efficiency model run. It also addresses the question of calibration of the model against 1988 sales data.

Section 9 describes how the model was used to determine Technological Potential, including the "bundling" of technologies used for each end-use, and how new EUIs were estimated. Appendix 7 contains detailed derivations of lighting EUIs.

Section 10 reviews the savings that can be achieved through operational (social) measures, and describes how the model was used to estimate Social plus Technological Potential.

Section 11 provides estimates of the Total Resource Cost for each technology, describes the bundling of economic technologies, and describes how the model was used to estimate Economic Potential.

Section 12 summarizes the results of the study in the form of high and low growth forecasts for BC commercial buildings.

Section 13 addresses source data quality and other caveats, and provides some comments on future work under the Conservation Potential Review.

1.4 Study Assumptions

1.4.1 Base Year and Target Years

Base Year: 1988
Target Years: 2000, 2010

1.4.2 Geographical Area

- The study included all of BC Hydro's service area, plus New West Power. The service area of West Kootenay Power is excluded.

1.4.3 Growth Rates

- All growth rates were based on the following projected increases in population and Gross Domestic Product (GDP):

	Annual Growth Rate			
	1988 - 2000		2001 - 2010	
	Low	High	Low	High
Population:	1.6%	2.2%	1.1%	1.8%
GDP:	1.9%	3.8%	1.6%	3.2%

1.4.4 Baseline Conditions

- Current practice in the base year of 1988 was defined as the equipment currently used to provide an energy service and the way in which this equipment is currently used - both of which determine the amount of electricity used to provide the service.
- Technical practice was defined as the installed electricity-using equipment, including all features of the capital investment - design, physical equipment and installation. It was assumed that this equipment was properly designed and installed according to current industry norms.
- Operational (social) practice was defined as the way in which electricity-using equipment is operated and managed, including maintenance practices and user behaviour.
- Current technical and operational practice, and the resulting electricity consumption was differentiated between
 - i) those buildings that existed in the base year of 1988 (average)
 - ii) buildings built in 1988 (marginal)
- Electricity use in the base year was broken down by end-use and square metre of floor area.

1.4.5 Technological Upgrades

- A technological upgrade was assumed to be an energy efficient technology that is currently commercially available or is expected to be commercially ready during the study period.
- The electricity savings for the technological upgrade was defined as the reduction in electricity consumption over currently used technology.
- The cost of the technological upgrade was defined as its capital and operating cost under normal market conditions (i.e. commercialized in the BC Hydro service area and following any expected real reductions in unit price over the study period), minus the capital and operating cost of current technology. Add-on technologies are costed fully.

1.4.6 Operational Improvements

- An operational improvement was assumed to be an action which i) brings maintenance procedures up to their optimum levels, and ii) changes usage patterns so that electricity use is minimized without change in level of service.
- The electricity savings of an operational improvement was defined as the reduction in electricity consumption over current practice.

- The cost of an operational improvement was assumed to be the additional cost associated with the improved maintenance procedure or change in user behaviour (if quantifiable).

1.4.7 Economic Measures

- A technical upgrade or operational improvement was considered economic when its cost (adjusted for environmental credits⁵) is less than or equal to the marginal price of electricity.
- The cost of the technical and operational measure used for the economic test will be the total resource cost, which is equal to the annualized incremental cost of the initial investment plus the annual incremental operation and maintenance (O&M) cost divided by the annual electricity savings.
- Expected program delivery costs are not included in the total resource cost.
- A discount rate of 8% was used in estimation of total resource cost.
- Environmental credits were those specified by the client, expressed as a percentage of marginal electricity price.

1.5 Definitions

1.5.1 Frozen Efficiency

- Frozen Efficiency is defined as an estimate of electricity consumption when:
 - i) all buildings and equipment existing in the base year remain at constant (average) energy efficiency and constant fuel share over the study period, and
 - ii) all buildings or equipment added in subsequent years have the same (marginal) efficiency and fuel share as those built or added in the base year.
- Equipment saturation is assumed constant throughout the study period except for utilization of office equipment which is assumed to increase by 50% over the first five years of the study.⁶

⁵ An environmental credit is a credit assigned to an energy saving technology representing its value as a measure which reduces the environmental impact of electricity generation.

⁶ Competitek *The State of the Art: Appliances*, page 279.

1.5.2 Technological Potential

- Technological Potential is defined as the savings in electricity that result when the most efficient technologies are introduced into the commercial sector over the study period.
- Technological upgrades are introduced into the sector either at normal stock turnover rates or before the first target year, depending on the basis of costing (normal or accelerated replacement).
- It is assumed that current operational practice remains unchanged but that special maintenance procedures required for new technologies are followed.

1.5.3 Social (Operational) Potential

- Social Potential is defined as the savings in electricity that result from actions to improve maintenance and user behaviour, taken before the first target year.
- When all technological improvements are also implemented as per Technological Potential, the savings are described as Social plus Technological Potential.

1.5.4 Economic Potential

- Economic Potential is defined as the savings in electricity that result when only those technologies and operational measures which were economic according to the total resource cost test are introduced into the commercial sector.
- Implementation rates are as per Technological plus Social Potential.
- If more than one measure is economic for a given end-use, the one which saves the most electricity is used.
- The marginal price of electricity used to define Economic Potential is the cost of new electricity delivered to the lower mainland in the absence of Power Smart programs.

1.6 Data Sources

In addition to the information brought to the project by the consulting team, the following data sources were used in preparing this report:

1.6.1 BC Hydro

The following information from BC Hydro was used in the analysis:

- Electricity sales to the commercial and institutional sectors in the base year
- Floor space estimates currently used in BC Hydro load analysis
- Selected Power Smart reports

1.6.2 Other BC

The following other BC data sources were used:

- BC Building Corporation
- BOMA - BC (Building Owners and Managers Association)
- Greater Vancouver Regional District
- BC Assessment Authority
- BC Ministry of Health
- BC Worker's Compensation Board

1.7 Framework for Defining Technical and Operational Practice

One of the first steps in documenting current technical and operational practices in British Columbia was to develop a framework containing the individual components and practices that affect energy consumption in each end-use. This is shown in Table 1.1. The framework provides a useful overall picture of energy use in the commercial sector for the subsequent derivation of current practice and analysis of technological, operational and economic options.

BC Hydro Conservation Potential Review		Table 1.1 – Commercial Sector Technical and Operational (Social) Practice	
Energy End–Use	End–Use Component	Features that affect Technical Practice	Features that affect Operational Practice
Lighting	Fluorescent Lighting	Lamp, type and wattage Ballast Luminaire Circuit/Controls Lighting Design	Hours of use Light levels Maintenance Cleaning Switching regime
	Incandescent Lighting	Lamp type (PAR, incan, compact fluor. etc) Lamp wattage Circuit/Controls	Hours of use Light levels Switching regime
	HID Lighting (interior)	Lamp type and wattage Luminaire Controls	Hours of use Light levels Maintenance Switching regime
	HID Lighting (exterior)	Lamp type and wattage Luminaire Controls	Hours of use Light levels Maintenance
Space Heating	Envelope heat loss	Wall insulation/Thermal bridging Window type, RSI Window/wall ratio Infiltration	Opening regime of doors and windows
	Make–up air heating	Type of ventilation system	Fresh air requirements Controls calibration Damper maintenance
	Heating System	Type and fuel of perimeter system Type and fuel of main system Heating controls	HVAC O & M package
Cooling	Envelope heat gain	Window type, shading coef Window/wall ratio Infiltration	Opening regime of doors and windows
	Make–up air cooling + internal gain	Type of ventilation system	Fresh air/dehumidity requirements Controls calibration
	Cooling System	Type of cooling system Cooling controls	HVAC O & M package

BC Hydro Conservation Potential Review		Table 1.1 – Commercial Sector Technical and Operational (Social) Practice	
Energy End–Use	End–Use Component	Features that affect Technical Practice	Features that affect Operational Practice
HVAC Electricity	Fans	Type of air circ/vent system Air controls	HVAC O & M package + air balance Fresh air requirements
	Pumps	Type of water system Water controls	HVAC O & M package + water balance
Service Hot Water	Hot Water Loads	Hot Water Applications and Equipment	Water using habits Maintenance of hot water using equipment
	Water Heating Sys.	Type and fuel of system	Maintenance
Refrigeration		Type of system	
Cooking		Type and fuel of equipment	
Plug in equipment		Type, wattage & saturation of equipment	Usage patterns
Misellaneous		Type, size, wattage	Hours of use

Note 3: Social Practice includes all aspects of equipment or system operation

Note 4: HVAC O & M package:

Maintenance	filter cleaning calibration of controls belt tightening
Operation	system and control monitoring manual vs automatic control regime staff turnover and training operational documents system/load matching

PAR: Parabolic aluminized reflector

HID: High intensity discharge

HVAC: Heating, ventilation and air conditioning

O&M: Operation and maintenance

2. SELECTION OF BUILDING SEGMENTS

2.1 Building Segments used by BC Hydro for Analysis of SIC Billing Data

BC Hydro uses the following building segments to analyze sales to commercial sector users. Each is matched to a series of SIC classifications.

- Transportation
- Warehouse and Wholesale
- Communication
- Retail
- Grocery (Food Retail)
- Office/Administration
- Apartments (common areas only)
- Services
- Schools
- Colleges and Universities
- Lodging (Hotels/Motels)
- Restaurants
- Hospitals
- Miscellaneous

These building segments include both buildings and non-buildings (facilities) and in the case of apartments, only the common areas (i.e., excluding suites). Most apartments included in the commercial sector are high rise (> 4 stories) since few low rise apartments have common areas. The modelling of energy use is most easily carried out using discrete building segments that are built using masonry or curtain wall techniques and use commercial lighting and heating/ventilation equipment. Data on non-buildings is also difficult to obtain and energy improvements are often unique to each facility. **The study was therefore limited to commercial buildings only, and for the modelling portion of the study, high rise apartments were modelled including suites.**

2.2 Selection of Building Segments for Modelling

The building segments were selected to match BC Hydro sales and forecasting segmentation as far as possible. However, some changes were made to group buildings according to their energy use patterns and to reduce the large proportion of general or miscellaneous categories (currently 29%). The following is a summary of the changes made in building segmentation.

Several SIC groupings which are "facilities" rather than buildings were collapsed into a single "Other Non-Building" category. Hospitals and Offices were subdivided to reflect differences in heating, ventilation and air-conditioning (HVAC) equipment type and operational criteria. SIC groupings in Services were reallocated into more appropriate segments. Finally, it was decided that electricity use in "common areas" in row housing, townhouses, mobile homes, and low rise apartments with less than 5 stories would be insignificant relative to high rise common areas, and that electricity use in high rise (5 stories or more) apartment suite areas, currently included in the residential sector by BC Hydro, would be modelled with the commercial sector. This made it easier to model energy use in complete buildings. The apartment segment in the commercial sector would therefore consist only of high rise apartments but include all energy use by high rises. The above reallocations result in more than 80% of electricity consumption being in well defined building segments.

More detail on segment selection is given below:

- Nursing homes and other health services are treated separately from Hospitals because of the different energy consumption patterns and types of mechanical systems found in the two types of buildings.
- Transportation, Communications and Miscellaneous segments are combined into an "Other Non-Building" segment, and not considered in the commercial building analysis. These segments include transmission towers, pumping stations, electrified transit, and aircraft hangers which cannot be analysed as buildings.
- SIC groupings in Services, Institutional and Others are reallocated as follows:
 - Education Services to Small Office
 - Health Services to Small Offices
 - Personal and Household to Retail
 - Membership Associations to Small Office
 - Other Services to Retail
 - Federal Government Services to Other Buildings
 - Remainder to Other Buildings
- Common areas (hallways, etc.) of Rowhouse/Townhouse SIC code 7523-7529, Mobile Home Parks SIC code 7591 and low rise apartments (4 stories or less) are assumed to be insignificant and included with high rise apartments. High rise apartments (5 stories or more) are expanded to include suites as well as common areas in high rise buildings.

- Office/Administration is subdivided into Large Office ($> 3,700 \text{ m}^2$) and Small Office ($< 3,700 \text{ m}^2$) segments. A number of energy conservation technologies are only applicable to large commercial office buildings. Large offices tend to use central systems for heating, ventilation and air conditioning (HVAC) while small offices tend to use rooftop equipment with different performance characteristics.

For modelling purposes, the commercial/institutional sector was therefore segregated into the following building segments for the study:

Buildings:

- Large Office ($> 3,700 \text{ m}^2$)
- Small Office ($< 3,700 \text{ m}^2$)
- Non-Food Retail
- Food Retail
- Restaurant/Tavern
- Hotels/Motels
- Warehouse/Wholesale
- Hospitals
- Nursing Homes
- Universities/Colleges
- Schools
- High Rise Apartments (both common areas and suites in buildings with 5 stories or greater)
- Other Buildings

2.3 1988 Electricity Sales by Building Segment

Table 2.1 shows 1988 commercial sector electricity sales data by BC Hydro building segments. The data is allocated to study segments in Table 2.2. High rise apartment suite electricity use was estimated by analyzing current BC Hydro sales to the Residential Sector (see Residential Sector Report). It is estimated that about 400 GWh/yr of electricity was sold to high rise apartment suites in 1988.

**Table 2.1 Commercial Sector Electricity Sales Data for 1988
(BC Hydro)**

B.C. Hydro Building Segments	Sales (MWh)
Transportation	673,466
Warehouse and Wholesale	622,749
Communication	243,522
Miscellaneous	506,867
Retail	1,268,059
Grocery	715,278
Office/Administration	2,028,651
Apartment Buildings (common areas only)	192,517
Services: Institutional and others	960,708
Schools	484,642
College and University	218,754
Lodging	534,475
Restaurants	540,630
Hospitals	368,596
Total	9,358,914

**Table 2.2 Commercial Sector Electricity Sales Data for 1988
(Including High Rise Apartment Suite Electricity)**

Conservation Review Segments	Adjusted Sales (MWh)
Office	2,202,945
Non-Food Retail	1,568,302
Food Retail	715,278
Restaurant and Tavern	540,630
Hotel and Motel	534,475
Warehouse and Wholesale	622,749
Hospitals	260,055
Nursing Homes	108,541
Universities and Colleges	265,492
Schools	484,642
High Rise Apartments (common areas only)	192,517
Other Buildings	439,433
Sub-Total Buildings	7,935,059
Other Non-Buildings	1,423,855
Sub-Total	9,358,914
High Rise Apartments (suites) ¹	400,000
Total (Buildings and Non-Buildings)	9,758,914
Total (Buildings Only)	8,335,059

¹ See Residential Sector Report

PART II

**CURRENT PRACTICE
IN BRITISH COLUMBIA
COMMERCIAL SECTOR BUILDINGS**

3. FLOOR AREAS

3.1 Data Sources

Several sources of information are available on commercial and institutional floor areas in BC:

- The Campbell-Goodell Report 1988
- BC Assessment Authority
- BC Buildings Corporation
- Greater Vancouver Regional District
- BOMA, BC
- Ministry of Health

Each of these sources is described below. None of the sources covers all building segments, but together they form a reasonably comprehensive basis of the derivation of floor areas for this study.

3.1.1 *Campbell-Goodell Report 1988*

This report provided information on the office, retail and rental floorspace in four BC municipalities: Nanaimo, Kelowna, Prince George and Victoria (Capital Regional District).

As well, the study estimated floor area across the Province in several commercial and institutional segments using "surrogates" for floorspace as follows:

- Restaurants: a total of 17.5 million square feet in both licensed and unlicensed establishment, based on number of seats.
- Grocery: a total of almost 16.0 million square feet in the small and large food retail sectors, based on proportion of large supermarkets.
- Hospitals: a total of 14.5 million square feet in acute, intermediate and extended care areas, based on number of beds.
- Prisons: a total of 2.0 million square feet in both federal prisons and provincial correctional institutions.
- Motels: a total of 11.9 million square feet including unit-specific and common space.

- Hotels: a total of 14.5 million square feet including unit-specific and common/amenity space.
- Apartment buildings: a total of 221.4 million square feet including both high and low rise construction (low rise defined as 5 storeys or less), based on number of units.
- Mobile homes: a total of 27.0 million square feet, based on number of units.

Further details are provided in Appendix 1, along with additional contacts for further information.

3.1.2 BC Assessment Authority

The BC Assessment Authority maintains an ongoing record of all building permits issued in the province broken down into twelve major sectors:

- 1) Residential
- 2) Farm
- 3) Commercial
- 4) Industrial Classification
- 5) Food and Beverage Processing Industry
- 6) Forest and Allied Industry
- 7) Forest Use
- 8) Petroleum Industry
- 9) Mining and Allied Industry
- 10) Boatbuilding
- 11) Transportation, Communication and Utility Improvements
- 12) Civic, Institutional and Recreational

The computerized database system was launched three to four to years ago along with a plan to fully install and update all records. The data is currently about 40% complete.

- The building data is defined according to "actual use codes", similar but not identical to the Standard Industrial Classification System (SIC System) used internationally. The use codes or building categories are discrete enough to allow higher level grouping into the project's defined building segments.
- The data is also defined by municipality which provides a facility to group floorspace by weather discrete regions or B.C Hydro regions.

- On a lower priority, the data also has "permit date of issue" information which may or may not provide reliable insight into building vintages, renovations or demolitions.

3.1.3 BC Buildings Corporation

BC Buildings Corporation maintains an ongoing record of floorspace and energy use data for approximately 222 buildings. This computerized database has been used as an energy tracking and monitoring system since 1982. The data up to and including 1988 has been summarized below in Table 3.1.

Table 3.1
BCBC Floorspace Information

BCBC Region	Quantity	Floor Area (m²)	Energy Use (MJ/yr)
Region One	68	261,627	240,599
Region Two	76	464,744	524,367
Region Three	78	192,919	199,043
Total	222	919,290	964,009

The building segments represented in the database primarily include a mix of Large Office, Small Office and Hospital / Health Care Units (21). To a much lesser degree, the database includes Nursing Homes (2), Schools (3), Institutional Facilities (3), Transportation (1) and Residences (5).

3.1.4 Greater Vancouver Regional District

The GVRD maintains a database of most commercial buildings in the Lower Mainland. A high level of completeness is achieved for a number of building categories. Table 3.2 summarizes the floor space for large and small offices, food and non-food retail, restaurant/tavern and warehouse/wholesale based on the consolidation of several smaller categories for 17 municipalities in the Lower Mainland. GVRD uses a "use category" for building classification similar to BC Assessment.

Table 3.2
GVRD 1988 Floor Area (Square Feet)

Building Segment	Floor Area
Large Office	9,450,123
Small Office	61,989,569
Non-Food Retail	42,238,812
Food Retail	1,270,551
Restaurant	1,667,742
Wholesale/warehouse	53,557,272

To estimate the floor areas for the BC Hydro service area as a whole, the GVRD areas for each of the six building segments were scaled up using the ratio in electricity sales to the BC Hydro Service Area and the sales to the Lower Mainland for each segment. The results are shown in Table 3.3.

3.1.5 BOMA, BC

The Building Owners and Managers Association (BOMA) maintains a database for its Office, Warehouse and Industrial Park membership in the Greater Vancouver area. The most comprehensive component of these is the office segment, which accounts for almost all office buildings of 20,000 square feet and over in the Greater Vancouver area.

BOMA BC Greater Vancouver Office floor space data for 1989 is summarized below in Table 3.4.

Table 3.3 Estimation of Commercial Floorspace in BC from GVRD Floor Areas						
	GVRD Area ft ²	GVRD Sales MWh	BC Sales MWh	BC Area ft ²	BC Area m ²	BC Hydro Sales Categories Used to Scale – up Areas
Large Office	9,450,123	286,322	318,649	10,517,083	977,424	Office Buildings
Small Office	61,989,569	696,291	882,851	78,598,679	7,304,710	Other Buildings/Real Estate
Non – Food Retail	42,238,812	1,038,679	1,785,900	72,625,223	6,749,556	Retail Trade
Food Retail	1,270,551	1,038,679	1,785,900	2,184,580	203,028	Retail Trade
Restaurant	1,667,742	320,794	540,630	2,810,624	261,210	Food and Beverage
Wholesale/warehouse	53,557,272	548,778	732,306	71,468,447	6,642,049	Wholesale Trade/Storage

GVRD: Greater Vancouver Regional District
BC: B.C. Lower Mainland

Table 3.4
BOMA GVRD Office Floor Area Data

Greater Vancouver Area 1989	Floor Area (Leased only) (ft²)
Vancouver Downtown	18,626,793
Vancouver Broadway Corridor	4,553,026
Burnaby	3,779,421
Richmond	2,636,002
North Shore	1,772,838
New Westminster	870,624
Total	32,188,706

3.1.6 Ministry of Health

The BC Ministry of Health maintains an energy accounting database of hospitals in the province. The floor area, energy use and energy costs may be obtained from this system. The database indicates a total of 16.8 million ft² of Hospital Segment floor space in the B.C Hydro service area. This represents approximately 94% of the total hospital floor space in BC. This floor area estimate compares with the 14.5 million ft² estimated by Campbell Goodell for the BC Hydro service area only, which is based on the number of beds times an assumed area per bed. Both estimates appear high when the floor area multiplied by typical fuel shares and energy use per unit floor area is compared with actual sales from BC Hydro. (See also Section 8).

3.2 BC Hydro Current Assumptions

Table 3.5 provides the present breakdown of building segments, floor area (in square metres), and sources used by BC Hydro. A detailed listing of current assumptions is provided in Appendix 2.

Table 3.5
BC Hydro 1988 Floor Area Assumptions

BC Hydro Segments	Floor Area (m²)	Source
Office/Administration	7,500,000	Campbell-Goodell
Retail	6,740,000	Campbell-Goodell
Grocery	1,450,000	Campbell-Goodell
Restaurants	2,090,000	Campbell-Goodell
Lodging	2,450,000	Campbell-Goodell
Warehouse/Wholesale	2,800,000	Campbell-Goodell
Hospitals	1,345,000	Campbell-Goodell
Nursing Homes	975,000	Ministry of Health
Universities/Colleges	1,870,000	Ministry of Advanced Education
Schools	5,840,000	Ministry of Education
Apartments	20,580,000	Campbell-Goodell
All Other Segments	21,720,000	Model defaults/Audits

3.3 Floor Areas used for Modelling

Final floor areas used in the Conservation Potential Review for the modelling of the BC commercial sector were based on a number of sources depending on the building segment as follows:

Large Offices	GVRD
Small Offices	GVRD
Non-Food Retail	GVRD
Food Retail	See note 1
Restaurant Tavern	See note 2
Hotels/Motels	BC Hydro (Campbell-Goodell)
Warehouse/Wholesale	GVRD
Hospitals	See note 3
Nursing Homes	BC Hydro (Ministry of Health)
Schools	BC Hydro (Ministry of Education)
Universities and Colleges	BC Hydro (Ministry of Advanced Education)
High Rise Apartments	See note 4
Other Buildings	BC Hydro

- Note 1: There is a large discrepancy in estimated floor area for Food-Retail between the Campbell-Goodell estimate based on reported supermarket floor areas (1,450,000 m²) and that based on GVRD assessment data (203,000 m²). The GVRD areas are for stand-alone premises only, therefore any food stores in malls, offices and other segments would not be accounted for. On the other hand an estimate on reported floor areas from owners (Campbell-Goodell) would contain some small stores which are not billed separately. A floor area of 1,000,000 m² was used as a compromise between the two sources.
- Note 2: There is also a large discrepancy in estimated floor area for restaurants between the Campbell-Goodell estimate which is based on the number of seats (2,090,000 m²), and GVRD assessment data (260,000 m²). As with food-retail, the differences are due to the fact that GVRD includes only stand-alone premises and the Campbell-Goodell estimate includes all restaurants, including those which do not bill separately (a large number of restaurant are located in office and retail buildings). A floor area of 900,000 m² was used as a compromise between the two sources - i.e. half of all restaurant floor area is in premises that bill separately.
- Note 3: Sales to hospitals reported by BC Hydro are considerably lower than the expected electricity consumption based on either floor areas for the full province from the Ministry of Health (1.56 million m²) or for the BC Hydro service area by Campbell-Goodell (1.35 million m²). A lower figure of 1.25 million m² was used in the study to create a closer match. (See also Section 8).
- Note 4: Floor areas for High Rise Apartments were estimated by multiplying the area for all apartments derived by Campbell-Goodell by 22.8%, the fraction of apartment units in buildings 5 stories or greater from the BC Hydro Residential End-Use Database.

Table 3.6 shows the final 1988 floor areas used for modelling in the Conservation Potential Review, together with the 1988 BC Hydro floor area assumptions for comparison.

3.4 Current Occupancy Rates

Occupancy rates in all segments were considered "normal" in 1988, i.e. between 85% and 90% in the Office and Retail segments. Since 1988 there has been a large increase in the vacancy rate in the Office segment due to a number of factors, including the recession and a spate of new construction. While this will affect the increase of new floor space after 1991, it will not affect

Table 3.6
BC Hydro Conservation Potential Review
1988 Commercial Floorspace (square metres)

Building Segment	Used in Study	BC Hydro Estimate
Large Office	975,000	*
Small Office	7,305,000	7,500,000
Non – Food Retail	6,750,000	6,740,000
Food Retail	1,000,000	1,450,000
Restaurant	900,000	2,090,000
Wholesale/warehouse	6,640,000	2,800,000
Hotels/Motels	2,450,000	2,450,000
Hospitals	1,250,000	1,345,000
Nursing Homes	975,000	975,000
Schools	5,840,000	5,840,000
University/Colleges	1,870,000	1,870,000
High Rise Apartments**	4,645,000	4,645,000
Other Buildings	3,500,000	3,500,000
Total	44,100,000	41,205,000

* Included in small office.

** 22.8 % of total apartment floor area (Buildings with 5 or more floors)
from Campbell Goodell and BC Hydro Residential End–Use
Survey Database.

the growth of new stock starting from the base year of 1988. There will always be periods when the growth of new floor space is above or below the growth in GDP because of changes in vacancy rates, etc., but in general it can be assumed to follow the GDP over the 25-year period to 2015, although not on a direct relationship (See Section 3.5 below).

3.5 Floorspace Growth Over The Study Period

Growth rates in the commercial segments over the next 25 years will depend mostly on increases in the GDP, while growth rates in institutional segments will depend on population growth. The following growth rates have been set as forecast economic and demographic growth rates by the BC Ministry of Finance and Corporate Relations:

	Annual Growth Rate (%)			
	1988 - 2000		2001 - 2010	
	Low	High	Low	High
Population:	1.6%	2.2%	1.1%	1.8%
GDP:	1.9%	3.8%	1.6%	3.2%

Growth rates for a number of commercial building categories based on these economic and demographic forecasts were used by the Collaborative to determine activity levels for the Conservation Potential Review. These growth rates were as follows:

Building Category	Annual Growth Rate (%)			
	1990 - 2000		2001 - 2010	
	Low	High	Low	High
Office	2.4%	2.8%	1.6%	2.0%
Service	1.8%	2.7%	1.2%	1.8%
Retail	1.0%	2.8%	0.6%	1.9%
Warehouse	1.1%	3.8%	1.0%	2.3%
Other	2.1%	3.2%	1.4%	2.2%

Since the study estimates of 1988 commercial floorspace were different from the BC Hydro areas used as the basis for the Collaborative's projected activity levels for 2000 and 2010, the growth rates used by the Collaborative were applied to the study estimates of 1988 commercial floor space to derive new activity levels for use in the study. It was assumed that growth in all institutional building segments (hospitals, nursing homes, schools, universities and colleges, and apartments) will be directly proportional to population growth.

Table 3.7 shows the growth rates used for each building segment. Table 3.8 shows the high and low estimates of floorspace for each segment and target year based on these assumptions. Table 3.9 shows expected annual demolition rates for each segment.

Table 3.7
BC Commercial/Insttutional Sector Growth Rate Assumptions

Building Segment	High Growth		Low Growth	
	1988-2000	2001-2010	1988-2000	2001-2010
Large Office	2.8%	2.0%	2.4%	1.6%
Small Office	2.8%	2.0%	2.4%	1.6%
Non-Food Retail	2.8%	1.9%	1.0%	0.6%
Food Retail	2.8%	1.9%	1.0%	0.6%
Restaurant	2.7%	1.8%	1.8%	1.2%
Wholesale/warehouse	3.8%	2.3%	1.1%	1.0%
Hotels/Motels	2.7%	1.8%	1.8%	1.2%
Hospitals	2.2%	1.8%	1.6%	1.1%
Nursing Homes	2.2%	1.8%	1.6%	1.1%
Schools	2.2%	1.8%	1.6%	1.1%
University/Colleges	2.2%	1.8%	1.6%	1.1%
High Rise Apartments ¹	2.2%	1.8%	1.6%	1.1%
Other Buildings	2.2%	1.8%	1.6%	1.1%

Note: ¹ Apartments with 5 or more stories

Table 3.8
BC Hydro Conservation Potential Review
Commercial / Institutional Sector Floor Space 1988 to 2010 (square metres)

Building Segment	1988	High Growth 2000	High Growth 2010	Low Growth 2000	Low Growth 2010
Large Office	975,000	1,358,069	1,655,479	1,295,997	1,518,942
Small Office	7,305,000	10,175,074	12,403,359	9,710,011	11,380,380
Non – Food Retail	6,750,000	9,402,020	11,349,141	7,606,069	8,074,954
Food Retail	1,000,000	1,392,892	1,681,354	1,126,825	1,196,290
Restaurant	900,000	1,239,047	1,481,036	1,114,848	1,256,091
Wholesale/warehouse	6,640,000	10,388,105	13,040,452	7,571,500	8,363,647
Hotels/Motels	2,450,000	3,372,962	4,031,709	3,034,865	3,419,358
Hospitals	1,250,000	1,623,008	1,939,986	1,512,288	1,687,120
Nursing Homes	975,000	1,265,947	1,513,189	1,179,585	1,315,954
Schools	5,840,000	7,582,695	9,063,613	7,065,410	7,882,226
University/Colleges	1,870,000	2,428,021	2,902,219	2,262,383	2,523,932
High Rise Apartments ¹	4,645,000	6,031,099	7,208,987	5,619,662	6,269,339
Other Buildings	3,500,000	4,544,423	5,431,960	4,234,406	4,723,937
Total	44,100,000	60,803,362	73,702,485	53,333,850	59,612,170

Note: ¹ Apartments with 5 or more stories

Table 3.9

**B.C. Commercial Sector
Existing Floor Area Annual Demolition Rates 1988 to 2010**

Large Office (> 3,700 m ²)	0.34%
Small Office (< 3,700 m ²)	0.34%
Non-Food Retail	0.54%
Food Retail	0.54%
Restaurant/Tavern	0.66%
Hotels/Motels	0.66%
Warehouse/Wholesale	0.57%
Hospitals	0.41%
Nursing Homes	0.41%
Universities/Colleges	0.62%
Schools	0.53%
High Rise Apartments	0.25%
Miscellaneous	0.65%

4. TECHNICAL PRACTICE

4.1 Existing Buildings - 1988

This section provides a description of the equipment and systems found in a typical building for each building segment. Information on the type of fuel used in each energy end-use for all the building segments is also provided. The descriptions are organized by the major energy using systems or end-uses listed below:

- General Lighting
- Service Area Lighting
- Other (High Bay) Lighting
- Space Heating
- Space Cooling
- Heating, Ventilation and Air Conditioning (HVAC) Electricity
- Service Hot Water
- Cooking Equipment
- Refrigeration Equipment
- Office (Plug-in) Equipment
- Miscellaneous Equipment

Each end-use is further described by its applicability in each building segment. In some cases it was necessary to break end-uses down into sub-end-uses or end-use components to better discuss certain building system attributes. For example, Space Heating was broken down into Envelope Heating and Ventilation Heating components. These are further discussed in Section 6.0 End-Use Intensities. Typical Building Profiles for each building segment are given in Appendix 6.

4.1.1 General Lighting

General Lighting refers to the lighting system in a particular building segment that is used by the occupants on a regular basis for day to day activities. It includes office areas, reception areas, hotel or apartment suites, etc.

The predominant form of general lighting in most commercial building segments is four foot fluorescent lighting, typically with 40 watt lamps and conventional ballasts. The luminaries typically have white enamel reflectors and acrylic lenses or plastic louvers. The remaining share of general lighting is typically incandescent, in-track or downlighting systems.

- Exception 1: Non-Food Retail and Food Retail use an appreciable share of eight foot fluorescent and metal halide high intensity discharge (HID) lamps. The fluorescent luminaries have slimline or high output "deluxe" colour lamps with conventional ballasts in white enamel reflectors and prismatic lenses. The metal halide luminaries have 175 watt to 400 watt clear lamps with aluminum reflectors in architectural HID rounds or downlighting units.
- Exception 2: Restaurants/Taverns, Nursing Homes and High Rise Apartments use a major share of incandescent lighting. The luminaries are typically downlights, table lamps or wall mounted units with valences or wrap around lenses.
- Exception 3: Warehouses use major shares of eight foot slimline or high output fluorescent lamps and HID lighting in mercury vapour and high pressure sodium lamps. Fluorescents are typically in a luminaire with a white enamel reflector with or without metal louvers. The HID lighting is typically in a luminaire with a spun aluminum reflector. A low glare, wide distribution lens or refractor is used in low bay applications.
- Exception 4: Universities/Colleges and Schools use some mercury vapour and metal halide lamps in their gymnasiums, auditoriums and multi-purpose rooms. Both these lamp types are typically mounted in luminaries with spun aluminum reflectors with wire guards or lenses. Architectural HID downlighting is used in auditoriums.

Lighting controls are typically provided from circuit breaker panels in the majority of building segments. Local wall switching is typically provided for enclosed rooms only.

Lighting levels, equipment efficiencies, hours of use, percent floor fractions and other utilization factors used in computing General Lighting energy use are given in Appendix 6.

4.1.2 Service Area Lighting

Service Area Lighting refers to the lighting systems used in corridors, lobbies, vestibules, washrooms and, in general, any non-critical area adjacent to the areas illuminated by the General Area Lighting.

The majority of commercial buildings use incandescent or four foot fluorescent lighting. Incandescent lamps range from 40 to 100 watts and PAR (Parabolic Aluminized Reflector) lamps range from 90 to 150 watts. These lamps are mounted in either downlighting or track mounted luminaries. Fluorescent lighting typically has 40 watt-lamps with conventional ballasts in luminaries with white enamel reflectors and acrylic lenses or metal louvres.

An exception is warehouses, which use mostly eight foot fluorescents with conventional ballasts, typically in a luminaire with a white enamel reflector and metal louvre.

Lighting controls are typically provided from circuit breaker panels in the majority of building segments. However, the lighting in these areas are typically left "on" longer due to their strategic location in the building, i.e. as safety or security lighting at a main entrance or principle means egress.

Lighting levels, equipment efficiencies, hours of use, percent floor fractions and other utilization factors used in computing Service Area Lighting energy use are given in Appendix 6.

4.1.3 Other (High Bay) Lighting

Other (High Bay) Lighting refers to the lighting systems used in high bay areas of the building, namely, large atria and lobbies, gymnasiums, etc.

The majority of commercial building segments use high intensity discharge (HID) metal halide lighting from 250 to 400 watt lamps. The luminaries are typically reflectorized units housed in architectural enclosures, with or without a lens.

- Exception 1: Hotels/Motels use a major share of incandescent and eight foot fluorescent systems. The incandescent systems are typically 40 to 60 watt decorative type lamps in chandeliers, etc. or 500 to 1500 watt quartz lamps in downlighting systems. The eight foot fluorescent systems are typically 75 watt slimline or 105 watt high output lamps with conventional ballasts mounted in coves or behind valences.
- Exception 2: Food Retail, Restaurants/Taverns, Nursing Homes, and High Rise Apartments do not typically have Other (High Bay) Lighting systems.

Lighting controls are typically provided from circuit breaker panels in the majority of building segments. However, where the lighting in these areas are in main building areas they may be required to be left "on" as in the case of Service Area Lighting.

Lighting levels, equipment efficiencies, hours of use, percent floor fractions and other utilization factors used in computing Other (High Bay) Lighting energy use are given in Appendix 6.

4.1.4 Space Heating

The Space Heating load may be broken down into the Envelope and Ventilation components. The building envelope (wall, roof, windows) determines the Envelope component, the make-up air determines the Ventilation component. These component loads may be further differentiated in terms of the central and perimeter systems which serve them. The space heating systems serving both components are discussed below for each building segment.

Envelope Component Description

Large Office - Older buildings tend to have masonry walls with wood studs or lathing and interior gyproc or plaster. The majority of the large offices built within the last 25 years have curtain wall construction. Approximately 60 percent of this segment has single glazing. Wall insulation is either non-existent or batt type. Older buildings tend to have single pane, "openable" window units, whereas newer buildings usually have single pane fixed windows⁷. Window frames are either wood or aluminum. Thermal bridging is a problem with steel beam construction and metal framed windows, reducing effective U-values by as much as 25%. Glazing usually represents 35% of the total wall area.

Roof construction tends to be flat deck with tongue and groove planking for older buildings, and steel or concrete deck for newer buildings. Built-up roofing is most typical, with 25 mm felt as insulation in the older structures, and 25 mm rigid insulation in newer buildings.

Typical U Values: Wall : 0.95 W/m².°C
 Roof : 0.91
 Windows: 5.68

Leakiness or infiltration is judged to be average to high, with an overall figure of 1.52 L/s.m² of wall area.

⁷ While single pane windows predominate in large offices and most other buildings segments, some double pane installations do exist.

Small Offices - The building envelope description for large offices also applies here, however, insulation levels may be slightly lower. Window areas average 25% to 35% of the total wall area in this segment.

Typical U Values: Wall : 0.81 W/m².°C
Roof : 0.071
Windows: 5.68

Non-Food Retail, Retail and Restaurants/Taverns - Older buildings tend to have masonry or wood walls with wood studs or lathing and interior gyproc or plaster. Wall insulation is either non-existent or batt type. Windows are usually single pane units with wooden or aluminum frames. Glazing usually represents 20% of the total wall area. Newer buildings are primarily concrete block construction, with metal studs and batt insulation.

Roof construction tends to be flat deck with tongue and groove planking for older buildings, and steel deck for newer buildings. Built up roofing is most typical, with 25 mm felt as insulation in the older structures, and 25 mm rigid insulation for newer buildings.

Typical U Values: Wall : 0.81 - 0.85 W/m².°C
Roof : 0.057-0.71
Windows: 5.68

Hotels/Motels - Older buildings tend to have masonry or wood walls with wood studs or lathing and interior gyproc. Wall insulation is usually batt type. Windows are openable, single pane units with frames of wood or aluminum. Glazing usually represents 35% of the total wall area. Newer buildings are primarily poured or concrete block construction, with metal studs and batt insulation.

Roof construction is flat steel or concrete decking. Built up roofing is the most common, with 25 mm felt as insulation in the older structures, and 25 mm to 50 mm rigid insulation in newer buildings.

Typical U Values: Wall : 0.57 W/m².°C
Roof : 0.36
Windows: 5.68

Leakiness or infiltration is judged to be average to high, with an overall figure of 1.52 L/s.m² of wall area.

Warehouses - Buildings tend to have masonry or wood walls with wood studs or lathing and minimal interior finishing. Wall insulation is either non-existent or batt type. Windows are openable, single pane units in the oldest buildings, or single pane fixed windows. Window frames are either wood or aluminum, and glazing usually represents 5% of the total wall area.

Roof construction tends to be flat deck with tongue and groove planking for older buildings, and steel deck for newer buildings. Built up roofing is most common, with no insulation in the older structures, and 25 mm rigid insulation in newer buildings.

Typical U Values: Wall : 1.14 W/m².°C
Roof : 0.45
Windows: 5.68

Leakiness or infiltration is judged to be average to high, with an overall figure of 1.52 L/s.m² of wall area.

Hospitals and Nursing Homes - Older buildings tend to have masonry walls with wood studs or lathing and interior gyproc or plaster. Wall insulation is either non-existent or batt type. Windows are single pane openable units with frames of wood or aluminum. Glazing usually represents 25% to 35% of the total wall area. Newer buildings are primarily poured and concrete block construction, with metal studs and batt insulation.

Roof construction tends to be flat deck with tongue and groove planking or steel for older buildings, and steel deck or poured concrete for newer buildings. Built up roofing is most typical, with 25 mm felt as insulation in the older structures, and 25 mm rigid insulation for newer buildings.

Typical U Values: Wall : 0.42 W/m².°C
Roof : 0.57
Windows: 5.68

Leakiness or infiltration is judged to be average to high, with an overall figure of 1.52 L/s.m².

University/Colleges and Schools - Older buildings tend to have masonry or wood walls with wood studs or lathing and interior gyproc or plaster. Wall insulation is either non-existent or batt type. Windows are single pane openable units with frames of wood or aluminum. Glazing usually represents 30% to 40% of the total wall area. Newer buildings are primarily concrete block construction, with metal studs and batt insulation.

Roof construction tends to be flat deck with tongue and groove planking for older buildings, and steel deck for newer buildings. Built up roofing is most common, with 25 mm felt as insulation in the older structures, and 25 mm rigid insulation for newer buildings.

Typical U Values: Wall : 0.47 W/m².°C
 Roof : 0.47
 Windows: 5.68

Leakiness or infiltration is judged to be average to high, with an overall figure of 1.53 L/s.m² of wall area.

High Rise Apartments - Older buildings tend to have masonry or wood walls with wood studs or lathing and interior gyproc or plaster. Wall insulation is either non-existent or batt type. Windows are openable, single pane units with frames of wood or aluminum. Glazing usually represents 25% of the total wall area. Newer buildings are primarily poured concrete construction, with metal studs and batt insulation. Higher priced properties use more glazing, averaging between 30% to 40% of total wall area.

Roof construction is usually flat deck with tongue and groove planking for older buildings, and steel or concrete deck for newer buildings. Built up roofing is most typical, with 25 mm felt as insulation in the older structures, and 25 mm to 50 mm rigid insulation in newer buildings.

Typical U Values: Wall : 0.47 W/m².°C
 Roof : 0.47
 Windows: 5.68

Leakiness or infiltration is judged to be average to high, with an overall figure of 1.52 L/s.m² of wall area.

Ventilation Component Description

Large Offices - Fresh air is generally introduced through the central air circulation system with air intakes well above ground level. Most systems mix outside air with return air, condition it and return it to the interior zone. Ventilation rates (the amount of fresh outside air introduced) in existing buildings tend to be very high in BC due to the common practice of keeping fresh air dampers open at all times. Rates of 14 to 47 L/s per occupant are common. The mixed air is generally heated by hot water coils before returning it to the working zones. Time clocks are normally used to operate fans and dampers. Systems are commonly constant air volume (CAV) plus reheat or variable air volume (VAV), currently split about 50:50. VAV is more common in newer buildings.

Small Offices, Non-Food Retail, Retail and Restaurant/Taverns - Roof top units with gas heating are the most common source for ventilation air. Systems usually operate in the "auto" or "on" mode without night setback.

Hospitals - Ventilation air is provided by a multiple of air handling systems throughout the building. Most areas are served by 100% outside air. Hot water or steam coils are the most common heat source. Systems tend to run continuously.

University/Colleges and Schools - Ventilation air is usually provided by unit ventilators in classrooms, or by central air handling systems. Electric heat is rarely used for ventilation heating. Systems are usually manually controlled to operate from the time the building is opened until it is closed.

High Rise Apartments - Ventilation air is provided to the corridors using a central system (usually 100% outside air). The fan in this ventilation system usually runs continuously. Hot water coils are the most common heating source.

Typical ventilation rates for each building segment are shown in Table 4.1.

Core Space Heating Systems

Large Offices - Heating sources are hot water, steam and electric. Hot water is generally heated by a gas fired, fire tube boiler(s). Several buildings in the downtown core of Vancouver use central steam with steam/hot water heat exchangers. An estimated 2% of large office buildings use electric resistance heat as their main heating source. Heat pumps, in the form of double bundle chillers, are used in less than 10 percent of the buildings. Less than 5% of large offices use incremental water source heat pumps.

Small Offices - Heating sources are hot air, hot water, and electric. Hot water is generally heated by a gas fired, fire tube or atmospheric boiler(s). Hot air is heated by furnaces in mechanical rooms or in roof top units. Approximately 25% of small office buildings use electric resistance heat as their main heating source. Approximately 20% of small offices use incremental water source heat pumps with a backup heating system (gas or electric).

Table 4.1
Typical Ventilation Rates⁸ in Existing
BC Commercial Buildings

	Ventilation Rate (CFM*/person)	Density (ft ² /person)
Large Office	40	300
Small Office	25	300
Non-Food Retail	15	400
Food Retail	20	250
Restaurant/Tavern	35	120
Hotels/Motels	25	250
Warehouse/Wholesale	40	1500
Hospitals	100	250
Nursing Homes	35	200
University/Colleges	25	60
Schools	15	100
High Rise Apts.	15	100
Other	15	500

* CFM = Cubic Feet per Minute

Non-Food Retail, Retail and Restaurant/Taverns - Heating sources are hot air, hot water, and electric. Hot water is generally heated by a gas fired atmospheric boiler(s). Hot air is heated by furnaces in mechanical rooms or in roof top units. Approximately 15% of retail buildings use electric resistance heat as their main heating source. A small percentage use incremental water source heat pumps with a backup heating system (gas or electric). The most common systems are roof top units with gas furnaces (and direct expansion (DX) cooling).

Hotels/Motels - Heating sources are hot air, hot water, and electric. Hot water is generally heated by a gas fired atmospheric or fire tube boiler(s). Hot air is heated by furnaces in mechanical rooms or in roof top units. Electric resistance heat is frequently used as the main heating source for guest rooms. A small percentage use incremental air source heat pumps.

⁸ Wide ranges in ventilation rates were obtained from different sources. There appear to be large differences in both design rates and operational practices. The ventilation rates given in Table 4.1 are typical high end operational rates for each building segment. Some buildings in each segment will have equipment limitations which prevent these rates being achieved.

Warehouses - Heating sources are hot air, hot water, and electric. Hot water is generally heated by a gas fired atmospheric boiler(s). Hot air is heated by furnaces in mechanical rooms, direct fired unit heaters, or in roof top units. Electric resistance heat is usually used as the heating source for office and service areas.

Hospitals - Heating sources are hot water, steam and electric. Hot water and steam are generally heated by gas fired, fire tube or water tube boiler(s). In general, hospitals do not use electric resistance heat as their main heating source; the exception being those on Vancouver Island. Heat pumps, in the form of double bundle chillers, are used in less than 10 percent of the buildings. Less than 5% of hospitals-use incremental water source heat pumps.

University/Colleges and Schools - Heating sources are hot air, hot water, and electric. Hot water is generally heated by a gas fired atmospheric or fire tube boiler(s). Hot air is heated by furnaces in mechanical rooms or in roof top units. Electric resistance heat is seldom used as the main heating source. A small percentage use incremental water source heat pumps with a backup heating system (gas or electric).

High Rise Apartments - The majority of high rise apartments use electric resistance or hot water baseboard heating in the suites. Hot water is generally heated by a gas fired atmospheric boiler(s). A small percentage of new condominium type buildings use through-the-wall heat pumps (with a seasonal coefficient of performance (COP) of 2.3).

Perimeter Space Heating System Descriptions

Large Offices - Most large office buildings have a separate system serving the perimeter to compensate for skin heat losses. The most typical heating system is hot water radiation. Induction units are commonly used to provide both heating and cooling.

Perimeter heating in newer buildings is usually accomplished through the use of terminal reheat coils in the ventilation system. A small percentage use incremental heat pumps for heating and cooling.

Small Offices - Small office buildings usually have a separate system serving the perimeter. The most typical heating systems are hot water radiation and electric baseboards.

Perimeter heating in newer buildings is usually accomplished through the use of terminal reheat coils in the ventilation system. Incremental heat pumps are quite common for heating and cooling.

Non-Food Retail, Retail and Restaurants/Taverns - Perimeter heating via roof top units (hot air) is the most common. Hot water and electric baseboard heating are used for high heat loss areas or in buildings not served by roof top units (RTUs).

Hospitals - Perimeter heating is most typically done by terminal reheat coils in the air handling system, or by hot water radiant panels in the ceiling.

University/Colleges and Schools - Most schools have hot water perimeter radiation or unit ventilators. Electric perimeter heating is not common in schools. Air conditioning is not installed in schools in the coastal regions (as a rule).

High Rise Apartments - Perimeter radiation, either hot water or electric, is the most common type of perimeter heating. Electric heat is prevalent in newer apartments and condominiums where individual utility metering is used. Higher priced units may use heat pumps although cooling is not a priority in coastal locations.

4.1.5 Space Cooling

The Space Cooling load may be broken down into three components, envelope, ventilation and internal loads. The envelope component is determined by the heat gain and transmission characteristics of the building shell, particularly windows. The ventilation component depends on the latent and sensible gains required to meet the outside air requirements of the occupants. The internal load component includes the internal gains from lights, equipment and people. This section describes the typical characteristics of these components and the cooling systems that meet the loads in each building segment.

Envelope Component Description

Envelope heat gains are primarily due to solar gains through windows. Typical glazing type, tint, shading and shading coefficient for commercial market segments are summarized in Table 4.2.

Table 4.2
Typical Window Characteristics in BC Commercial Buildings

Segment	Glazing	Tint	Shading	Shading Coefficient
Large Offices	single	tinted	blinds	0.70
Small Offices	single	tinted	blinds/drapes	0.70
Food Retail	single	clear	none	0.95
Non-Food Retail	single	clear	none	0.95
Hotels/Motel	double	clear	drapes	0.75
Warehouses	single	clear	none	0.95
Restaurant & Tavern	single	clear	blinds/drapes	0.70
Schools + Univ.	single	clear	drapes	0.70
Hospitals	single	clear	drapes	0.59
Nursing Homes	double	clear	drapes	0.75
High Rise Apts	single	clear	blinds/drapes	0.70

Internal Load Component Description

Internal gains are due to lighting and equipment loads and people gains. Table 4.3 shows typical gains in watts per square metre of floor space.

Table 4.3
Typical Cooling Loads in BC Commercial Buildings

Segment	Lighting W/m ²	Equipment W/m ²	People W/m ²
Large Offices	32.2	14.0	10.7
Small Offices	32.2	10.8	10.7
Food Retail	28.8	1.1	8.1
Non-Food Retail	52.4	3.7	4.0
Restaurants & Taverns	19.0	2.6	24.4
Schools Post Secondary	43.7	1.0/9.8	132.4
Hospitals	39.5	21.5	20.2
Nursing Homes	11.2	3.0	7.0
High Rise Apts	15.6	4.0	2.6
Warehouses	11.0	3.3	2.5
Hotels/motels	16.8	20.0	6.4

Cooling System Descriptions

Large Offices, Hospitals and University/Colleges - The building cooling load is usually handled by ventilation air that is supplied to the occupied space at temperatures of 13° to 18° C. These larger buildings will "condition" or cool the ventilation air to meet the required temperature at the main air handling unit by passing the air through a cooling coil that uses chilled water as the cooling medium. The chilled water is produced by a central cooling plant that typically uses centrifugal or screw chillers to cool the water. Approximately 60% of buildings in these segments use centrifugal chillers with average seasonal coefficient of performance (COP) of 4.5. Approximately 15% use double bundle chillers with a COP of 3.5. An equal percentage use screw chillers with an average seasonal COP of 3.9. The remaining 10% use reciprocating chillers with a COP of 3.5. In the majority of cases, heat pump installations use gas heating as a backup.

Small Office, Non-Food Retail and Retail - Smaller buildings in these segments usually condition the air in a roof top unit, using a split or unitary system instead of an air handling unit. The split system is essentially a residential type system that has the evaporator or cooling coil indoors and the compressor and condenser outdoors. A unitary system is essentially a window unit air conditioner or heat pump. The cooling is done by the refrigerant directly rather than by chilled water as is the case in large installations. This type of system is called direct expansion or DX system which implies that the cooling is done by the refrigerant directly. Hermetic or semi-hermetic (not as common) reciprocating compressors are usually used to produce the cooling. This type of unit tends to be much smaller than the central cooling plants of large commercial installations and, although they can approach the cooling capacity of the larger installations, they are usually sized to handle cooling in the immediate area of the unit. This implies that a small retail mall will have multiple roof top units to handle individual stores and each roof top will have its own refrigeration package complete with reciprocating compressor, evaporator, and condenser.

The majority (70%) of cooling for these segments is by DX cooled roof top units with an average seasonal COP of 2.2. Approximately 20% are cooled by air-to-air or water-to-air heat pumps with an average cooling COP of 2.4. The remainder is made up of smaller window or self-contained air cooled DX units with an average COP of 2.1.

Hotel/Motels and High Rise Apartments - These segments use packaged compartmental units for perimeter cooling. Two types of configurations are predominantly used. The first one is a simple electric heating/cooling unit. The second is an air conditioner heat pump configuration with auxiliary electric heat. This type of unit could be a through-the-wall unit with an air cooled condenser or could have a water cooled condenser connected to a common building loop. The compressors in these types of units will be small (less than 2 tons), hermetic reciprocating compressors. Approximately 80% of hotel/motels will have DX air cooled units with an average COP of 2.1. Larger hotels with central centrifugal chillers and distributed cooling systems will account for 10% of hotels and have an average cooling COP of 4.5. The remainder will have air-to-air heat pump units serving the rooms, with a COP of 2.1.

Schools - Buildings in this segment do not usually have cooling. Those that do have air conditioning, typically utilize rooftop units or window mounted units, both using DX cooling, with an average COP of 2.2.

Warehouse - Buildings in this segment are not usually air conditioned. The office area of the warehouse may have either heating and cooling roof top units or simple window air conditioning units, with an overall average cooling COP of 2.1.

4.1.6 HVAC Electric Loads

Heating, ventilation and air conditioning (HVAC) electricity is defined as the electrical energy used by electric motors to run fans and pumps that are related to the HVAC systems. The following systems are commonly present:

- supply and return fans in air handling units
- incremental unit fans
- cooling tower fans
- washroom and general exhaust fans
- heating water circulating pumps
- chilled water circulating pumps
- condenser water circulating pumps, and
- domestic hot water circulating pumps.

The typical sizes of motors that are used in these applications range from fractional to 100 horsepower, with the larger sizes being used in very large commercial buildings to operate fans. In most applications the motors operate at constant speed even though the heating or cooling loads served change in response to occupancy and weather variations. The motors are typically open drip proof with the exception of cooling tower fan motors which use total enclosed fan cooled motors (TEFC).

Office, Hospitals and Universities/Colleges - The majority of the large commercial buildings segments tend to have all the above systems present. The ventilation system is usually constant air volume (CAV) with a terminal reheat system which would have both supply and return fans. The fans operate at a constant speed and supply a constant volume of air to the space. Control of this type of system, to handle occupancy and weather variations, is done in two ways. The first is through temperature reset of the ventilation air in response to either a space sensor or a return air sensor. The second is through room controls which are connected to the terminal reheat coils.

Heating water circulating pumps are present to circulate the water to the perimeter radiation systems, coils on air systems and/or to the terminal reheat coils. Hospitals do not tend to have any perimeter radiation and use the terminal reheat coils to handle the perimeter load.

Chilled water and condenser water circulating pumps are also present since these buildings tend to use a central cooling plant with a chiller.

Non-Food Retail, Food Retail and Restaurants/Taverns - These segments tend to use roof top units to provide space heating and cooling. This type of HVAC system is much simpler than the systems that are present in the large commercial segment. Ventilation is usually accomplished with a single fan in small systems. Pumps are not usually present since heating and cooling is done at the roof top units. An exception to the above is the older small retail stores which tend to use hot water heating systems that have a heating water circulating pump, or forced air residential type systems. Cooling in these older systems will tend to be done by split DX.

High Rise Apartment - This segment will tend to have make-up air units serving the common areas only. These make-up air units have a supply fan to distribute the air to the space. Buildings will tend to have hot water heating systems that require a circulating pump.

Hotel/Motel - This segment displays a wide range of systems. In most cases, packaged terminal air conditioners (PTAC's) providing heating and cooling will be present in the suites. These units will have an integral fan that will distribute the air. Heating may be provided in three different ways:

- hot water heating; in which case a central boiler provides heating with a circulating pump to deliver the water to the compartmental units in the suites,
- electric resistance heating, or
- unitary heat pumps; either through-the-wall air-to-air with auxiliary electric heat or water cooled units with the condenser connected to a common building piping system with a circulating pump to distribute the water to all the units, in newer hotels.

The remainder of the hotel/motel building space is conditioned through an air handling unit or roof top unit (either gas or electric). Large older buildings may have multizone air handling units with both supply and return fans. If the ventilation unit is a make-up air unit only or a roof top unit, only a supply fan will be present. Chilled water and condenser water circulating pumps will be present in those buildings that have central cooling plants only. HVAC systems that use roof top units to provide conditioned air to the common areas will have DX cooling that only have condenser fans.

Schools - This segment will tend to have a central air handling unit with supply and return fans or individual room systems. Space heating will in most cases be hydronic perimeter heating with circulating pumps to distribute the hot water to the perimeter. Cooling, if present, will be

provided by unitary compartmental units, wall units or roof top units. No circulating pumps are present since these air conditioning units use DX cooling.

Warehouses - This segment will tend to have roof top units and unit heaters which use fans to distribute the warm air to the space. Cooling, if present, will be by roof top, split system or unitary air conditioners which have a fan to distribute the air. This fan will be separate from the fan used for heating except in the cases where a roof top unit is used to provide the heating and cooling.

4.1.7 Service Hot Water

Service hot water is used in commercial buildings for washing, cleaning and food preparation. The Office, Non-food Retail and Warehouse sectors have the lowest end-use intensities and tend to use the hot water in two areas almost exclusively. The first entails domestic use such as washing hands in washrooms and light dish washing in office area kitchenettes. The second is for light cleaning services which is typically dependant on the amount of marble or terrazzo floor that is present. The other remaining sectors have much higher end-use intensities. These sectors display a heavier use of hot water in cleaning and food preparation, as well as, for showering services. High rise apartments will have a hot water load similar to a residential dwelling where the highest end-use is showering, followed by clothes washers and dishwashers.

The method used to heat the hot water varies according to the type and age of the facility, as well as, the volume of use. Residential type heaters, either gas or electric are typically used in facilities with low use rates such as Office, Non-food Retail, Warehouses and Schools. A few office buildings might use the central heating plant to supply both space heating and domestic hot water. In this case, a hot water storage tank will be present. The primary heating water is circulated through the storage tank to heat the hot water. This method however is inefficient since the primary heating boiler has to operate during the summer time at a very reduced load with a consequent drop in seasonal efficiency.

The facilities with a higher hot water use load tend to have a dedicated boiler or use a boiler from the central heating plant. In both instances a hot water storage tank is present. Service hot water use may be broken down into two components; a "wetting and shower" service category and an "other" category. The percentage for each varies from segment to segment, as shown in Table 4.4.

Table 4.4
Typical Hot Water Use Patterns in
BC Commercial Buildings

	Percentage of Hot Water Used for Wetting and Showering	Percentage for Other Uses
Large Office	90%	10%
Small Office	90%	10%
Non-Food Retail	90%	10%
Food Retail	90%	10%
Restaurant/Tavern	50%	50%
Hotels/Motels	40%	60%
Warehouse/Wholesale	90%	10%
Hospitals	30%	70%
Nursing Homes	70%	30%
University/Colleges	40%	60%
Schools	50%	50%
High Rise Apts.	70%	30%
Other	90%	10%

The energy intensities for service water heating were derived from data compiled from multiple audits carried out in British Columbia and elsewhere. Refer to Section 6, End-Use Intensities.

4.1.8 Cooking Equipment

Cooking equipment in offices is distributed throughout the building and is primarily electric. It consists of microwave ovens, coffee machines, kettles and stoves. In other segments, cooking is primarily a central kitchen function, such as a restaurant or cafeteria kitchen. Gas is normally available and is the main heating source for the building. Cooking equipment energy intensities are listed in Section 6, End-Use Intensities.

4.1.9 Refrigeration Equipment

Refrigeration equipment is defined as low temperature refrigeration used for food storage. This equipment can be used for direct food storage, such as walk-in refrigerated storage, or for ice production for consumption, such as ice machines in hotels. Specialized equipment such as

display cases and walk-in storage, is found only in Food-Retail and Warehouses. In other segments, the equipment is similar to that found in the residential sector.

4.1.10 Other (Plug-in) Equipment

Other equipment includes portable or semi-portable electrical equipment that is used in commercial and institutional buildings, including the following:

- electric appliances (excluding refrigerators, freezers, dishwashers and clothes washers),
- office equipment (including personal and mainframe computers, printers, photocopiers and cash registers), and
- lab equipment.

Large electrical appliances will be found only in High Rise Apartments. Small electric appliances will tend to be present in all the segments (in differing amounts). Small electric appliances in Offices will tend to be limited to coffee makers, small microwave ovens and refrigerators found in the kitchenettes. These are included in the Cooking load. The other segments will see a more diverse distribution of appliances ranging from residential type loads to pottery kilns, autoclaves and ovens.

Office equipment will be found in all segments with the exception of the High Rise Apartment segment. The Office segment will tend to experience a very high concentration of computers, copiers and printers with a consequently high connected electrical load per unit area of floor space. University/Colleges and Schools will have the second highest load. The remaining segments tend to display smaller connected loads and energy intensities.

Lab equipment will range from equipment used in developing films to X-ray machines, cat and ultrasonic scanners, centrifuges and miscellaneous vital sign scanners. This will be limited to Hospitals and Universities.

The energy intensities were derived through field audits and are summarized in Section 6, End-Use Intensities.

4.1.11 Miscellaneous Equipment

Miscellaneous equipment includes other non-distinct building end-uses such as elevators, escalators, parade lighting and exterior lighting, pipe tracing and slab heating. Previously audited data was used for these intensities.

4.2 New Buildings - 1988

This section reviews end-use technologies found in new buildings in 1988. The descriptions and discussions listed in Section 4.1 for existing buildings are used as a departing point. Only differences between existing and new buildings are given.

4.2.1 General Lighting

In 1988, general lighting practice in new buildings was going through several changes:

- Designers were becoming more prudent with the selection of light levels. This resulted from a combination of a "new" methodology prescribed by the Illuminating Engineering Society (IES) and the raised awareness of energy management in the mid to late eighties in British Columbia.
- The state of the technology provided a broader choice of cost effective alternatives for lamp types and sizes. Shifts were seen towards more efficient fluorescent and high intensity discharge lighting.
- The installation of "local switches" became more common. This alone would not result in an appreciable reduction, but rather it gives the occupant the choice of switching "local" area lights on or off (see Section 5).

The application and cost effectiveness of premium lamps, ballasts, reflectors, occupancy daylight detection, general automation, more innovative design or more prudent social behaviour had not yet gained wide favour or acceptance by 1988.

In some buildings segments, lighting loads in new buildings are higher than those in existing buildings because of a combination of higher light levels and a different mix of lighting systems.

4.2.2 Service Area Lighting

Service area lighting practice in new buildings was also going through several changes in 1988:

- Designers were becoming more prudent with the selection of light levels. The overall affect here was minor and essentially one of aesthetics, and occurred in such applications as hallways which are generally deemed non-critical areas.
- The state of the technology provided a broader choice of cost effective alternatives for lamp types and sizes. Shifts were seen towards more efficient lighting systems including

compact fluorescent and high intensity discharge lighting. The practice was shifting away from using incandescent lighting at all in service areas.

4.2.3 Other (High Bay) Lighting

Other (High Bay) Area Lighting practices in new buildings in 1988 were not affected as much by lighting level selection and new technologies as were other lighting end-uses.

4.2.4 Space Heating

Envelope Heating Component

Building owners and designers began responding to the emphasis on energy conservation in the mid-80's through improvements to the building envelope. In many cases, building owners requested the use of building simulation programs and energy targets with new building designs. Through the mid 80's, one of ASHRAE's key focus areas was the establishment of design standards for new buildings, resulting in ASHRAE/IES Standard 90.1-1989. Although this Standard would not be officially available until 1990, awareness of its development was already influencing new building design on a voluntary basis.

Improvements which help reduce building heat loss include an increase in the use of double glazing (75 percent or more in commercial building sectors), and higher overall U values through increased insulation levels in wall and roof components as well as improved building tightness. Total window area in schools has reduced to an average of 15 to 20 percent of wall area. However, single glazing is still used in the majority of new school buildings, due to cost considerations from breakage.

Typical U Values for buildings built in 1988 are shown in Table 4.5.

Table 4.5
Typical U Values in New BC Commercial Buildings Built in 1988

Building Segment	Wall U Value W/m ² °C	Roof U Value W/m ² °C	Window U Value W/m ² °C
Large Offices	0.51	0.45	3.28
Small Offices	0.45	0.34	3.28
Non-Food Retail	0.45	0.28	3.28
Food Retail	0.23	0.34	3.28
Restaurant/Tavern	0.34	0.19	3.28
Hotels/Motel	0.45	0.28	3.28
Warehouses/Wholesale	1.08	0.40	3.28
Hospitals	0.42	0.40	3.28
Nursing Homes	0.45	0.40	3.28
Universities/College	0.47	0.28	3.28
Schools	0.28	0.23	5.68
High Rise Apts	0.40	0.28	3.28
Other	0.40	0.34	5.68

Ventilation Heating

Mechanical ventilation use is universal in new commercial buildings. ASHRAE recommends minimum rates of about 10 L/s.person to improve air quality. Large commercial buildings began to use computerized building automation systems to control HVAC systems in the 1980s resulting in improved control over outside air use. Operator practice tends to be better in new buildings. Although nominal ventilation rates are higher, ventilation make-up air heating is often lower. Typical ventilation rates for new buildings are shown in Table 4.6.

Table 4.6
Typical Ventilation Rates in New
BC Commercial Buildings

	Ventilation Rate (CFM*/person)	Density (ft²/person)
Large Office	20	300
Small Office	20	300
Non-Food Retail	10	400
Food Retail	15	250
Restaurant/Tavern	35	250
Hotels/Motels	25	250
Warehouse/Wholesale	40	1500
Hospitals	100	250
Nursing Homes	35	200
University/Colleges	20	60
Schools	15	100
High Rise Apts.	15	300
Other	15	300

* CFM: Cubic feet per minute

Variable air volume (VAV) systems and compartmental type systems are being used in most buildings instead of constant air volume (CAV) reheat type systems.

Heating System Types

The electric share of space heating is high in new high rise apartments and leased space because of low initial cost. Triple net leasing, common throughout BC does not encourage developers or owners to install efficient systems which have a higher initial cost. Otherwise space heating fuel shares for new (1988) buildings are similar to existing ones.

4.2.5 Space Cooling

Envelope Cooling

New office buildings began to use tinted windows in the late 1960s, thereby improving the shading coefficient.

Internal Gain/Ventilation Rate

Induction systems are no longer popular. They are being replaced by VAV systems, thereby reducing reheat energy use. As mentioned above, ventilation energy use is better controlled in new buildings resulting in a reduced heating and cooling requirement. The improvements in lighting technology that would reduce cooling loads were not widely used in 1988. These improvements were limited to slightly lower lighting levels and use of lower wattage fluorescent lamps.

Cooling System Equipment

All new small and large offices are equipped with cooling equipment. The incidence of use of cooling equipment in all other segments is higher for new construction vs. existing buildings. System efficiency improvements tend to be very small due to the lack of interest of building owners in energy conservation. Roof top cooling equipment is also found in new construction.

4.2.6 HVAC Electricity

VAV systems have been used in the majority of new offices, hospitals, universities and some schools since the late 1980s. Most VAV systems are compartmentalized so that operation in various areas of the building can be matched to occupancy. Use of VAV systems have significantly reduced the fan energy component and associated operating hours and consumption.

Most larger new buildings were installed with a building automation system, providing the potential for much tighter control on operating hours, use of outdoor air and heating/cooling use assuming that operational practice was adequate (see Section 5).

4.2.7 Water Heating

The majority of new commercial buildings were being built with separate service water heaters in 1988, rather than using a heat exchanger off the main boilers. Low flow shower heads and shower controls were installed in many school showers. However, more general use of low flow shower heads did not occur until after 1988 in new buildings. The fuel share for gas is slightly higher in newer buildings.

4.2.8 Cooking Equipment

There is no difference between new and existing buildings for cooking equipment, neither fuel share nor intensity.

4.2.9 Refrigeration

The only technology change in this area has been the use of multiplex compressors in refrigerated display cases in the Food Retail segment.

4.3 Fuel Share and Market Saturation

Tables 4.7 and 4.8 show estimates of fuel shares and market saturation on a per square metre of floor area basis for space heating, service water heating, cooking, and space cooling in existing and new buildings in 1988.

The fuel share for each segment was assumed to remain constant at their 1988 levels throughout the study period for the whole sector. No allowance was made for any increase in the use of natural gas for new buildings on Vancouver Island due to lack of information⁹. Saturation rates were assumed to remain constant within each end-use, except for office equipment which was assumed to increase 50% during the first five years of the study period and remain constant thereafter.

⁹ With the gas pipeline now in place, a much higher gas fuel share is to be expected in new and existing buildings in Vancouver Island. On a province wide basis, however, this will not have a significant effect.

TABLE 4.7

SPACE HEATING FUEL SHARES IN BC COMMERCIAL BUILDINGS (1988)

EXISTING BUILDINGS	SPACE HEATING FUEL SHARES					
	Fossil	Electric Resistance	Air-to-Air Heat Pump	Water Source Heat Pump	Heat Recovery Chiller	Total Heat Pumps
Large Office (> 3,700 m ²)	83%	2%	0%	5%	10%	15%
Small Office (< 3,700 m ²)	55%	25%	0%	20%	0%	20%
Non-Food Retail	80%	18%	0%	2%	0%	2%
Food Retail	80%	20%	0%	0%	0%	0%
Restaurant/Tavern	60%	40%	0%	0%	0%	0%
Hotels/Motels	40%	50%	10%	0%	0%	10%
Warehouse/Wholesale	85%	15%	0%	0%	0%	0%
Hospitals	90%	0%	0%	2%	8%	10%
Nursing Homes	70%	25%	5%	0%	0%	5%
Universities/Colleges	99%	0%	0%	1%	0%	1%
Schools	78%	20%	0%	2%	0%	2%
High Rise Apartments	55%	40%	0%	5%	0%	5%
Miscellaneous	83%	10%	3%	2%	2%	7%

NEW BUILDINGS	SPACE HEATING FUEL SHARES					
	Fossil	Electric Resistance	Air-to-Air Heat Pump	Water Source Heat Pump	Heat Recovery Chiller	Total Heat Pumps
Large Office (> 3,700 m ²)	83%	2%	0%	5%	10%	15%
Small Office (< 3,700 m ²)	55%	25%	0%	20%	0%	20%
Non-Food Retail	80%	18%	0%	2%	0%	2%
Food Retail	80%	20%	0%	0%	0%	0%
Restaurant/Tavern	70%	25%	5%	0%	0%	5%
Hotels/Motels	40%	50%	10%	0%	0%	10%
Warehouse/Wholesale	90%	10%	0%	0%	0%	0%
Hospitals	90%	0%	0%	2%	8%	10%
Nursing Homes	70%	25%	5%	0%	0%	5%
Universities/Colleges	99%	0%	0%	1%	0%	1%
Schools	78%	20%	0%	2%	0%	2%
High Rise Apartments	40%	55%	0%	5%	0%	5%
Miscellaneous	83%	10%	3%	2%	2%	7%

TABLE 4.8

**SPACE COOLING, SERVICE HOT WATER AND COOKING MARKET SATURATION
AND FUEL SHARES IN BC COMMERCIAL BUILDINGS (1988)**

EXISTING BUILDINGS	SPACE COOLING MARKET SATURATION
Large Office (> 3,700 m ²)	95%
Small Office (< 3,700 m ²)	70%
Non-Food Retail	84%
Food Retail	85%
Restaurant/Tavern	80%
Hotels/Motels	85%
Warehouse/Wholesale	10%
Hospitals	60%
Nursing Homes	60%
Universities/Colleges	75%
Schools	5%
High Rise Apartments	15%
Miscellaneous	75%

NEW BUILDINGS	SPACE COOLING MARKET SATURATION
Large Office (> 3,700 m ²)	100%
Small Office (< 3,700 m ²)	100%
Non-Food Retail	90%
Food Retail	90%
Restaurant/Tavern	90%
Hotels/Motels	90%
Warehouse/Wholesale	10%
Hospitals	100%
Nursing Homes	90%
Universities/Colleges	100%
Schools	25%
High Rise Apartments	25%
Miscellaneous	80%

EXISTING BUILDINGS	SERVICE HOT WATER FUEL SHARE	
	Fossil	Electric
Large Office (> 3,700 m ²)	70%	30%
Small Office (< 3,700 m ²)	70%	30%
Non-Food Retail	70%	30%
Food Retail	70%	30%
Restaurant/Tavern	70%	30%
Hotels/Motels	70%	30%
Warehouse/Wholesale	70%	30%
Hospitals	95%	5%
Nursing Homes	90%	10%
Universities/Colleges	90%	10%
Schools	70%	30%
High Rise Apartments	55%	45%
Miscellaneous	80%	20%

NEW BUILDINGS	SERVICE HOT WATER FUEL SHARE	
	Fossil	Electric
Large Office (> 3,700 m ²)	70%	30%
Small Office (< 3,700 m ²)	65%	35%
Non-Food Retail	70%	30%
Food Retail	70%	30%
Restaurant/Tavern	70%	30%
Hotels/Motels	70%	30%
Warehouse/Wholesale	65%	35%
Hospitals	95%	5%
Nursing Homes	75%	25%
Universities/Colleges	80%	20%
Schools	70%	30%
High Rise Apartments	65%	35%
Miscellaneous	80%	20%

EXISTING BUILDINGS	COOKING FUEL SHARE	
	Fossil	Electric
Large Office (> 3,700 m ²)	50%	50%
Small Office (< 3,700 m ²)	50%	50%
Non-Food Retail	50%	50%
Food Retail	50%	50%
Restaurant/Tavern	50%	50%
Hotels/Motels	50%	50%
Warehouse/Wholesale	50%	50%
Hospitals	50%	50%
Nursing Homes	50%	50%
Universities/Colleges	50%	50%
Schools	50%	50%
High Rise Apartments	50%	50%
Miscellaneous	50%	50%

NEW BUILDINGS	COOKING FUEL SHARE	
	Fossil	Electric
Large Office (> 3,700 m ²)	50%	50%
Small Office (< 3,700 m ²)	50%	50%
Non-Food Retail	50%	50%
Food Retail	50%	50%
Restaurant/Tavern	50%	50%
Hotels/Motels	50%	50%
Warehouse/Wholesale	50%	50%
Hospitals	50%	50%
Nursing Homes	50%	50%
Universities/Colleges	50%	50%
Schools	50%	50%
High Rise Apartments	50%	50%
Miscellaneous	50%	50%

5. OPERATIONAL PRACTICE

5.1 Definition

As outlined in Section 1, operational practice is defined as the way in which energy-using equipment in the commercial sector is maintained and used.

5.2 Literature Review of Operational Practice

As a first-step in the assessment of operational practice, a literature review on maintenance and operation of commercial buildings in British Columbia and elsewhere was carried out. This section includes a précis of that review; full details are included in Appendix 3.

The review distinguished four broad categories of information about maintenance and operational practice. A total of 18 publications were identified and cited, together with the results of unpublished communications that served to supplement the available information. The primary focus of the literature review was operational practice as performed by the building operator as opposed to the occupant.

5.2.1 Evaluation, Case Study and Expert Opinion attesting to the importance of proper maintenance

This section draws from an evaluation, a case study and expert interviews attesting to the importance of proper maintenance and listing incidents where the lack thereof led to inefficient operation. These incidents tend to characterize maintenance and operational practice as either inadequate, incomplete, or impermanent. The assessments generally mixed technical and social concerns, i.e. maintenance practices were grouped with the operation of hardware control systems. In one study, however, there was some assessment of how the useful life of energy-efficient equipment could be extended with proper maintenance procedures.

The studies provided examples of three types of problems associated with transfer of maintenance information to building operators:

- Inadequate Transfer

These are incidents in which training and documentation in maintenance procedures and the operation of control systems was missing, insufficient, provided to too few people

or to the wrong person (e.g. one operator out of five in a complex of buildings; to an energy or building manager rather than to an operator).

- **Incomplete Transfer**

In some cases, maintenance and control practices were affected by anomalies (or a lack of coordination) in the organizational structure. The Operations & Maintenance manual, in one instance, was kept away from the operations crew. An energy manager may have no authority over building managers, or conversely, may decline to delegate existing authority to encourage independent conservation initiatives. There may be no feedback mechanism to inform management where new hardware controls are not improving on former practices (and in fact may be less effective than the best operators). The complex or building may be understaffed with respect to the increased demands of the social conservation measures. Installation of equipment may not have been planned with maintenance in mind, leading to awkward locations of filters or hard-to-clean places. In one case, controls were not extended to space that was formerly unoccupied.

- **Impermanent Transfer**

Conservation or maintenance activity that was geared to one-time incentives were found, in some cases, to lapse after payment was received. Training and documentation might have been supplied once, but not repeated for new staff after those trained were rotated, replaced or retired.

Several U.S. studies indicate that poor operation and maintenance of building equipment is a common cause of less-than-expected conservation program savings, but far from the only cause. Mechanical systems and controls appear most vulnerable, although lighting systems lead to wasted energy when they are left on too long. Several particular opportunities for more efficient use of equipment are identified. One study included expert guesses at how long specific items of equipment would be in place and operating efficiently without versus with proper maintenance. The results are shown below.

HVAC Component	Average Life
Economizer	10-15 years
Chiller Strainer Cycle System	15-25 years
Air-to-Air Heat Pump	5-15 years ¹⁰
Water-to-Air Packaged Heat Pump	11-15 years ⁷
Heat recovery from	
- Refrigerator Condensers	10-15 years
- Low Leakage Dampers	5-11 years

Additional enhanced efficiency may be available from proper operation and efficient system control strategies.

5.2.2 Measured savings from efficiency programs with strong behavioral component; reduced savings from programs due to inefficient operator behaviour

These studies attempted to estimate the sensitivity of savings to building operations. Measurements were gleaned from the sub-optimal performance of equipment due to poor maintenance or monitoring, e.g., dampers stuck open, bad setpoints for night setback, and heating coils with no night or summer shutoff.

A strong pattern of behaviour-related savings was exhibited in one study based on an energy audit loan program, whereby customers were billed for the cost of an energy audit only if they did *not* implement all measures with a payback of one year or less.

The studies do not contain high quality research designs, and they often mix capital investments by the customer with behavioral changes. Some mix electric savings with that from other end-uses. They are generally not useful for identifying savings from specific elements of equipment, however, they provide a range of indicated potential. The following is a summary of the results.

- 16% electric savings could be achieved from proper installation, operations and maintenance of measures which are "active" (require user attention). This inference was extrapolated from evaluated versus estimated savings for two groups of measures which required more rather than less user input. This inference has a weak empirical basis, but is logically sound and consistent with the findings of site visits and billing data.

¹⁰ These items were judged likely to be replaced with similar equipment with similar efficiencies. Thus, there would be a measure replacement cost, but the savings would continue.

- 12% savings from all fuel types were achieved in a group of small institutional buildings where operations manuals were developed and provided. Some of the savings may have resulted from capital investments by the institutions or through other programs. Manuals did not always cover all equipment.
- A building code implementation program which carried out energy simulations was performed. It was found that new building simulations estimated loads significantly lower than they actually were. For example, in large office buildings which were end-use metered, the simulations predicted only 71% to 85% of actual lighting loads, 8% to 31% of actual HVAC loads and 24% to 64% of actual motor and pump loads. Site visits indicated that there were many problems with the simulations, but less-than-optimal systems operation was clearly responsible for some unspecified part of the greater-than-expected use.
- Savings of 6% of electric load resulted from a walk-through energy survey for large buildings and no measurable savings for small buildings. About 2% savings resulted from a more detailed energy audit in commercial buildings. The savings may partially be attributable to capital improvements, but no incentives were offered. The more detailed survey occurred only in larger buildings.
- Another energy audit program, whereby the customer was billed for the audit if measures under a one-year payback (many of them operational in nature) were not performed, resulted in the following electric savings:

<u>Building Type</u>	<u>% Savings</u>	<u># of Facilities Analyzed</u>
Total	10.2%	72
Assembly	9.7%	5
Clinics	8.2%	6
Fast Food	15.5%	2
Restaurant	8.6%	5
Small Retail	14.9%	11
Large Retail	11.7%	2
Small Office	-0.6%	12
Large Office	9.8%	10
Lodging	16.4%	2
Apartments	6.6%	3
Warehouses	16.0%	14

From the measures list, it is clear that behavioral measures and very low cost measures accounted for most of the savings. A few large capital measures were installed, but not in most buildings or building categories.

Overall, even assuming that some of the savings indicated were from installation of equipment, savings averaging in the range of 6% to 10% due to behaviour seems consistent with experience. None of these programs would appear to have been designed to obtain all possible savings.

5.2.3 Market indicators of the level of behavioral conservation activity

Studies in this category attempted to correlate characteristics of the commercial or institutional sector with higher levels of building or equipment efficiency and maintenance.

Several market studies indicate a wide divergence of interest in conservation in general, and efficient building operation in particular. Large businesses (including chains), owner-occupants, long-term lessors who pay energy bills and energy-intensive operations (e.g., grocery stores) were the most interested. Smaller businesses and short-term lessors were less likely to exhibit efficient baseline behaviour.

One study, for example, indicated that there was greater overall interest in management of building energy use in buildings occupied by:

- energy intense businesses. This group may include grocery stores and fast-food restaurants.
- businesses with more floorspace under single management. Managers of large buildings, managers of several properties in a city, and energy managers for chain stores would be included here, along with building complexes such as malls, university campuses, and hospital complexes. Conversely, smaller offices and retail establishments with shared utilities are less likely to initiate or continue improvements in operation or maintenance.
- owner-occupants and long-term lessors. Tenants in this category would be those whose leases require them to pay energy bills directly or through explicit rent adjustments. Conversely, high-turnover retail developments and small offices are unlikely prospects for improved operational practices (on the part of the landlord and the tenant), unless the local space vacancy rate is low (in which case energy management might form part of an incentive package to tenants).

5.2.4 Conservation among BC Hydro customers

One study indicated that building managers in British Columbia are, on average, more careful about energy use than their American counterparts. The better building managers appear to take good management steps (e.g. reduced janitorial shifts) and use control systems to reduce energy use. Contract building managers do not seem to play a creative role in building operation, but they are involved in a decreasing share of the market. Many problems in the market, however, were identified that are similar to those in the U.S. and it is unlikely that BC building practices are much better.

Since the study focused on buildings where there is a building manager, it can only be surmised that practices among smaller rental and other less managed buildings are worse. This would presumably hold true in British Columbia, just like elsewhere.

5.3 Operational Practice in BC as Perceived by Building Managers and Operators

5.3.1 Information Sources

Information on specific operational practice in BC was derived from a questionnaire, a copy of which is provided in Appendix 4. The analysis of the questionnaire was supplemented by local input, plus expert opinion including the literature review discussed in the previous section. Specific attention was focused on ownership patterns in the building segments; on operation and maintenance (O&M) patterns by segment, including the presence of preventive maintenance (PM) programs. In addition, specific operational practices were included by end-use, for example in lighting and hot water use, focusing on both building operator and occupant. A summary of the results of the questionnaire follows.

5.3.2 Summary of British Columbia Interviews Regarding Operational Potential

Respondents

Respondents to three interviews were used; one with an engineering firm with extensive experience with a wide array of BC commercial buildings, one with a facilities manager for a large multiple property owner who is considered to be at the vanguard with regard to efficiency, and the third with a leased property manager. The two property managers focused primarily on experience with their own properties. These were largely offices, with some non-food retail and restaurant space.

Building Ownership Patterns, Equipment Types, and Attention to Conservation in British Columbia

- Small Office - The building stock is fairly evenly distributed between owned and leased buildings, with a little more owner-occupied than leased. Short-term leases (under five years) are slightly more common than long-term leases. The owner-occupied buildings include a significant fraction of government-owned and buildings owned by an investor with multiple buildings. A lesser, but notable fraction is owned by single building owners. The most common HVAC systems are roof top package units, including many heat pumps, and radiators with exhaust fans. The building manager/owner occupant had microprocessor controls and economizers on most units.

Most building operators were thought to at least "do the basics", with a significant minority of single-building and government owner occupants pro-actively managing their buildings. The building manager for the owner-occupant was among these.

- Large Office - Although there is a wide variety of ownership types and leases, there are more owner-occupied buildings than leased buildings, and long term leases are more common than short-term leases. Among the owner-occupied buildings, a large share of owners have multiple buildings. The interviewed property manager deals almost exclusively with buildings on long-term leases. The building manager for the owner-occupant building also managed a small area of long-term leased space. Central HVAC systems are typical, with constant volume, and variable air volume options and terminal reheat all common. Some buildings have perimeter induction and radiant heat. The owner/occupant respondent noted special controls for computer rooms.

There was some disagreement about typical operator practices, with the manager of leased space saying that there is little attention to the issue, the engineering firm indicating that most operators "do the basics", and the owner/occupant building manager saying that most of his buildings are pro-actively managed for energy. The engineer indicated significant minorities who are pro-active or who place little importance on efficiency. He thought the latter constituted about a third of the occupants of leased office space.

- Non-Food Retail - Leased buildings predominate, with slightly more buildings on long-term leases than short-term. Constant volume roof top and compartment HVAC systems are common, along with some package heat pumps. The owner/occupant respondent indicated that economizers and microprocessor controls were used.

About half of the building managers are thought to "do the basics", with the other half equally divided between pro-active managers and those who find energy management less important. The owner/occupant respondent manages his retail space pro-actively.

- Restaurant/Tavern - The majority are owner occupied, with most of these being chains. There are lesser, but significant fractions of single building owner-occupants and short-term leases. Roof top HVAC units with gas-fired heat and reciprocating chillers are most common.

The respondent who managed properties felt that energy issues were not considered important among owners of these buildings. No other responses were provided regarding this issue for restaurants.

- Primary/Secondary School - Most are government-owned with some owning multiple buildings. Constant air volume heat-only systems, many of them roof top units, are common.

Most managers of equipment in schools were thought to ascribe some importance to energy management, with more doing the basics than managing pro-actively.

- Hotel/Motel - The majority are owned and occupied by chains, with a significant minority of franchisees and independents that own their own building. Multi-zone constant volume systems and package units are common.

Among hotel and motel chains, there is a tendency more towards pro-active management in one-third of the chains, with the other two-thirds split between basic management of energy and ascribing less importance to it. Among non-chain hotels and motels, about half of the building managers are thought to "do the basics", with the other half equally divided between pro-active managers and those who find energy management less important.

Overall Level of Attention on Energy Management

Respondents felt that, in the past, there has been some attention to building automation and to lighting use. Users focus on energy costs with respect to the tariff structure, and some have identified major uses and compared bills with competitor's. However, with the exception of the owner/occupant building manager, there was little attention noted to maintenance and operation, understanding equipment performance, energy code requirements, or how equipment should be operating. Focus on management is a relatively recent phenomenon, and there was little activity as recently as 1988. The owner/occupant focuses on lighting equipment and operation by upgrading light sources, paying attention to HVAC controls, and converting plants from oil to gas.

With the exception of the owner/occupant, operator training was described as rudimentary where it exists. Some operator training is provided through BOMA, BCIT, BC Hydro, and through vendors. Most operators are required to understand basic building operation, maintenance, use of the equipment, etc. When staff turns over, new staff are either trained at the "survival level" or not at all. Among customers who have efficient equipment installed, there tend to be complaints from some building operators that they do not understand their equipment and they have no outside support for managing it.

The owner/occupant requires BOMA Service Maintenance Technician training or the equivalent (e.g., fourth class power engineer, etc.) and retrain when operators are replaced. Start-up and administration for computer-based lighting and HVAC controls is very time-consuming.

Lighting Schedules

All respondents saw large opportunities for reducing energy use without inconveniencing users through more management and/or better hardware for controlling when lights are on, although the owner/occupant who already had an extensive building management program, saw more limited opportunities. The potential was considered to be greatest in non-government buildings by one respondent, and in schools and offices by another respondent. A third respondent thought that large office floors with open floor plans had the greatest potential. Indoor lighting offers the greatest potential for end-use energy savings. Two respondents suggested a 30% to 40% reduction in lighting hours for at least half and as much as 80% of the indoor lights (depending on the respondent).

The owner/occupant thought the potential was in the range of 2 to 6 hours/day, depending on the building, for virtually all of their office space. Additional savings might come from standardizing easy-to-use controls and practices across the industry, and reducing lighting needs for janitorial work. Some additional operator training would be needed to reach optimum

savings. In some buildings a key system is used to assure that lights are on only when janitors are present.

One respondent mentioned that about a fourth of external lighting controls are improperly set. Interior lighting timers were in good repair according to both property managers, but one property manager thought that controls vary in the currency of their programming. The engineer did not respond to that question. None had seen many sophisticated lighting control systems in BC.

Individual light switches (or "local switching") are more common in executive offices, schools, small offices, hotels/motels, and non-food retail buildings. Lights are commonly left on in hotels. In other building types, the degree of attention to turning off lights is variable. One building manager noted that individuals control lights well in private offices, but not in common spaces.

A significant fraction of ground floor lighting and exterior lighting is left on for security reasons, with some additional "stumble lighting" in offices. The engineer estimated that 10% of retail lighting is left on at night. The owner/occupant indicated that very little indoor lighting is left on during unoccupied periods.

Lighting Persistence

Cleaning of lights is not common, except in the owner/occupant situation. However, the only complaints cited with regard to lighting maintenance were about reflectors that were flaking, presumably due to age or manufacturer's defects. Most in-house and contract maintenance services are thought to replace efficient lamps with equally efficient lamps upon burnout.

HVAC Scheduling

Regarding the potential for trimming HVAC schedules, neither property manager saw much potential, whereas the engineer saw some significant potential in fan control. The best opportunities were thought by the respondents to include individually leased buildings operated by the tenant, including retail, and restaurant buildings. Estimates of potential savings varied from 4 to 100 hours/week in different circumstances.

The property managers thought that timing controls were well-maintained in most of their buildings. The engineer thought that there was need for periodic re-commissioning which was not being met in many buildings. Total override of HVAC controls is rare, but some respondents observed that the hours are often extended. All of the respondents, except for the

owner/occupant respondent, thought that most operators do not understand HVAC controls to their full potential.

Occupant control of HVAC is most common in small offices, retail food buildings, hotels/motels, and in some buildings with roof top units, single zone systems, unit heat pumps, supplementary systems (e.g., perimeter radiation), VAV in offices, and induction units. However, most users do not take the initiative to turn systems off.

HVAC Operation and Maintenance

The overall level of maintenance was thought to be fair by the property manager and barely adequate by the engineer. Systems are not generally well-balanced. Larger customers, who do most maintenance in-house, are thought to generally do a better job than smaller firms who use contractors.

Large multi-tenant or owner-occupied buildings (particularly offices) will often see periodic maintenance, as will some small office and retail buildings. The owner/occupant respondent uses computerized maintenance scheduling. Maintenance occurs only when equipment is no longer providing adequate service in some small office and retail buildings, and in most schools and hotels.

Excess outside air due to improper damper positioning and non-functional economizers are considered common by all respondents except the owner/occupant.

Shell Measures

Users control doors and windows in some schools and warehouses. The level of attention varies. There were few other perceived opportunities for reducing outside air through user behaviour.

Hot Water

Automatic shutoff is common in schools and occurs sometimes in some other buildings with large hot water loads. There is minor potential to increase savings through wider application of this measure or more careful user behaviour. Water temperature, however, can often be reduced.

Other

No significant other measures were identified.

5.3.3 Quantification of Operational Practice in BC

The final step in the assessment of operational practice in BC was an attempt to estimate the energy performance "penalty" (the additional electricity used) associated with current practice in each end-use and building segment.

The literature review and questionnaire results indicated that the only end-uses where maintenance and other operational problems could be the sources of a significant amount of energy savings on a province-wide level are general lighting and HVAC system operation (space heating, cooling, ventilation, and air and water circulation). The information also indicated that problems were of the following basic types:

Lighting and HVAC:

- poor scheduling of equipment or improper setting of controls, thermostats, etc.

HVAC only:

- poor regular maintenance of the equipment
- improper commissioning and balancing of systems
- inadequate attention to the provision of outside air

The degree to which these problems affect energy use in different building segments appears to depend on several factors:

- the complexity of the control system
- the degree to which building occupants (as opposed to operators) have control over building-wide lighting and HVAC scheduling and control settings
- the degree to which lighting and HVAC controls are automated
- the predominant ownership pattern in the building segment (own, lease, rent, etc.)
- the level of training normally found in building operators.

Table 5.1 presents estimates of the current penalties associated with poor lighting scheduling in each building segment. Table 5.2 shows estimates of the current penalties associated with poor HVAC system operation in each building segment.

The individual building segment lighting penalties in Table 5.1 were derived as follows. The literature survey and questionnaire indicated that in general up to 30% savings could be achieved through more attention to the scheduling of lighting by improved operator/occupant behaviour. The lighting behaviour penalty for each segment was therefore placed in the range of 0% to

Table 5.1 Operational Penalties Associated with Lighting Schedules							
Building Segment	Predominant Ownership (1)	Party in Control	Lighting Automation	Complexity	Training Level	Attentiveness (2)	Behaviour Penalty
Large Offices	Own	Operator	High	Complex	High	Average	1.15
Small Offices	Lease	Occupant	Low	Simple	Low	Low	1.20
Non – Food Retail	Lease	Operator	Average	Complex	Average	Low	1.20
Food Retail	Own	Operator	Average	Complex	Average	High	1.05
Restaurants	Own	Operator	Low	Simple	Low	High	1.05
Hotel/Motel – Suite	Own	Occupant	Low	Simple	Low	Low	1.30
Hotel/Motel – Hallway	Own	Operator	Low	Simple	Low	n/a	1.00
Hotel/Motel – Other	Own	Operator	Low	Simple	Low	High	1.05
Warehouse	Own	Occupant	Low	Simple	Low	Average	1.05
Hospitals/Nursing Homes	Own	Operator	High	Simple	High	Average	1.05
University	Own	Occupant	High	Complex	High	Poor	1.15
Schools	Own	Occupant	Average	Simple	Average	Poor	1.20
Apartments – Suite	Rent/Lease	Occupant	Low	Simple	Low	High	1.05
Apartments – Hallway	Own	Operator	Low	Simple	Low	n/a	1.05

(1) Own means owner works in the building, Lease/Rent means owner does not.

(2) Some buildings in a segment may exhibit higher attentiveness than others eg Government Office buildings

Table 5.2 Operational Penalties Associated with HVAC Scheduling and Maintenance									
Building Segment	Predominant Ownership (1)	Party in Control	HVAC Automation	Complexity	Training Level	Attentiveness	Current Scheduling Practice Efficient:1 Slack:5	Current Maintenance Practice Efficient:1 Slack:5	Behaviour Penalty
Large Offices	Own	Operator	High	Complex	Average	Average	3	3	1.14
Small Offices	Lease	Occupant	Low	Simple	Low	Low	4	4	1.16
Non-Food Retail	Lease	Operator	Average	Complex	Average	Low	4	4	1.16
Food Retail	Own	Operator	High	Complex	Average	High	5	5	1.18
Restaurants	Own	Operator	Low	Simple	Low	High	5	5	1.12
Hotel/Motel - Suite	Own	Occupant	Low	Complex	Low	Low	5	5	1.12
Hotel/Motel - Hallway	Own	Operator	Low	Simple	Low	n/a	3	3	1.12
Hotel/Motel - Other	Own	Operator	Low	Complex (2)	Low	High	3	3	1.12
Warehouse	Own	Operator	Low	Simple	Low	Average	5	5	1.18
Hospitals	Own	Occupant	High	Complex	High	Average	3	3	1.10
Nursing Homes	Own	Operator	Low	Simple	Low	Average	3	3	1.10
University	Own	Operator	High	Complex	High	Low	3	3	1.12
Schools	Own	Operator	Average	Simple	Average	Low	3	3	1.12
High Rise Apartments	Lease/Rent	Occupant	Low	Simple	Low	Low	5	5	1.18

(1) Own means owner works in the building, Lease/Rent means owner does not.

(2) Depends on the size of the Hotel

HVAC: Heating, ventilation and air conditioning

30%, depending on the high or low weight of each of the five dominating factors listed above. If all the factors (leased building, occupant control, complex lighting system, low automation, low attentiveness/training) had a high weight, then a penalty of 30% was assessed. If all factors had a low rate, a zero penalty was assessed. Each factor was given the same high, low or average weight and penalties rounded to the nearest 5%.

The individual building segment HVAC penalties in Table 5.2 were derived in a manner similar to the lighting penalties, except that in this case the factors affect two characteristics of the HVAC system -- scheduling and maintenance. The literature surveys and questionnaires showed that in general 10% to 20% savings could be achieved in HVAC energy consumption (heating, cooling, ventilation air/water circulation) through more attention to maintenance, scheduling, and system balancing by improved occupant/operator behaviour. The HVAC behaviour penalty was therefore estimated to be in the 10% to 20% range, depending on the high or low weight of each of the determining factors on i) scheduling practice and, ii) maintenance practice. Scheduling and maintenance practice were assumed to have equal impact on performance.

The penalties shown in Table 5.1 were applied to each of the lighting end-use intensities in BC buildings (see Section 6 End-Use Intensities). The penalties shown in Table 5.2 were applied to each HVAC end-use intensity (heating, cooling, HVAC electricity) in BC buildings (see Section 6: End-Use Intensities).

6. END-USE INTENSITIES AND BUILDING PROFILES

The end-use intensities (EUI's) for existing (1988) and new stock in the BC Commercial Sector were developed from the building data given in Section 4 and the operational analysis described in Section 5. EUIs are expressed in MJ/m² and kWh/ft², and broken down by building segment and end-use. Typical Building Profiles for each existing and new building segment, which summarize the building details and each EUI, are attached in Appendix 6. The rationale behind selecting the EUI's is explained below.

The typical building profiles given in Appendix 6 are statistical representations of typical existing and new buildings that might be found in each of the 12 building segments analysed. In building segments where a wide variety of envelope and equipment configurations is found in BC, the values for energy loads and end-use intensities in individual buildings may vary significantly from the "representative" values given in the profiles. The representative data is based on the combined experience of BC Hydro and BC energy management experts.

All end-use intensities were derived from engineering principles and supported by audit data from a variety of local BC and regional sources, including numerous field audits conducted by Prism Engineering and validated with other field data provided by BC Hydro and agencies in Canada and the Pacific North West. For example, the lighting end-use intensities were derived on the basis of known equipment efficiencies, accepted application of various lighting systems and prescribed light levels in various building segments. The building and end-use behaviour penalties developed in Section 5: Operational Practice, were also used to determine the final EUIs.

6.1 Lighting

Lighting intensities were derived for prescribed design criteria, observed light levels and the proportion of lighting system types observed in the General, Service and High Bay areas of each building segment. The intensity for this end-use represents a weighted average of lighting system types typically found to illuminate the three different areas of a building segment. The EUIs estimated from lighting levels were each multiplied by the operational "penalty" factor for current lighting scheduling (from Table 5.1) to obtain the final EUI in each segment.

General Lighting refers to the lighting system(s) illuminating the main area of the building or serving the main function of the building and its occupants. Service Lighting includes lighting in hallways and service areas not normally used for specific tasks. High Bay Lighting includes illumination of large inside areas.

6.2 Space Heating

The space heating load was broken down into two components: ventilation heating and envelope heating. The ventilation heating component intensity includes the heating energy required for ventilation air. This is typically driven by the occupant density and the fresh air requirement per occupant. The envelope heating component includes the heating energy required for meeting envelope losses. This is typically driven by the wall, window, roof, and heat transfer characteristics of each. Natural infiltration also provides part of the envelope heating component, depending on the "leakiness" of the building envelope.

Space Heating intensities were derived from the assumptions of insulation levels, air leakage and window characteristics for each building segment (see Building Profiles in Appendix 6). Separate EUIs were estimated for envelope heat loss (window, wall and natural leakage) and ventilation air heating, the sum being the heating (tertiary) load of the building. The fractions of the tertiary space heating associated with envelope heat loss and ventilation make-up air heating are shown in Table 6.1.

The overall heating EUI for electrically heated buildings was then estimated by dividing the total tertiary heating load by the heating equipment efficiency (allowing for the share of heat pumps), and multiplying by the operational "penalty" associated with current HVAC scheduling and maintenance practice (from Table 5.2). The final values were calibrated against local and regional audit data.

6.3 Space Cooling

The space cooling load was divided into three components: ventilation cooling, envelope cooling and internal load cooling. The ventilation cooling component intensity includes the cooling energy required for ventilation air. This is typically driven by the occupant density and the fresh air requirement per occupant. The envelope cooling component includes the cooling energy required for meeting envelope gains, including solar radiation. This is typically driven by the size and type of the windows and the "leakiness" of the building envelope. Internal load cooling is driven by the density of lighting, occupants and plug-in equipment.

The intensities were derived from the assumptions for window characteristics, ventilation requirements, and internal gains described in the Building Profiles in Appendix 6. The sum of these individual loads make up the total cooling (tertiary) load. Fractions of the tertiary cooling load associated with envelope heat gain, make-up air cooling and internal gains are shown in Table 6.2.

Table 6.1 Space Heating Fractions in BC Commercial Buildings		
Building Segment	Envelope Heat Loss %	Ventilation Make-up %
Large Offices	87	13
Small Offices	88	12
Non – Food Retail	94	6
Food Retail	85	15
Restaurant/Tavern	75	25
Hotel/Motel	85	15
Warehouse/Wholesale	97	3
Hospitals	41	59
Nursing Homes	72	28
Universities	43	57
Schools	71	29
High Rise Apts	92	8
Other Buildings	95	5

Table 6.2 Space Cooling Fractions in BC Commercial Buildings			
Building Segment	Envelope Heat Gain %	Ventilation Make-up %	Internal Gain %
Large Offices	34	4	62
Small Offices	31	5	64
Non – Food Retail	19	1	80
Food Retail	22	5	73
Restaurant/Tavern	24	10	66
Hotel/Motel	53	6	40
Warehouse/Wholesale	34	4	62
Hospitals	24	24	52
Nursing Homes	40	11	49
Universities	10	14	76
Schools	22	10	68
High Rise Apts	58	4	38
Other Buildings	28	2	70

The overall cooling EUI was then estimated by dividing the total tertiary cooling load by the seasonal COP of the cooling equipment used in each building segment, and multiplying by the operational penalty associated with current HVAC scheduling and maintenance practice (see Table 5.2). The final values were calibrated against local and regional audit data.

6.4 HVAC Electric Loads

The heating, ventilating and air conditioning electric loads include the electricity for driving motors for fans, pumps and compressors in these HVAC systems.

The pump and fan intensities were computed independently. The pump intensity was derived from a generally accepted engineering estimate of pump load to heating or cooling load, required for various systems. This fraction, along with the effective efficiency of pumping systems, was used to derive the pump intensity for each building segment. The fan intensity was derived from engineering principles which determine the design fanning requirement to meet ventilation, heating, cooling and circulation loads in the building. This fraction, along with the effective efficiency of fanning systems, was used to derive the fan intensity for each building segment.

The intensities were derived from reviews of typical motor types, sizes and operating conditions for driving the systems generally found in BC buildings. Like heating and cooling intensities, the final EUIs reflect the operational penalty associated with current HVAC operational scheduling and maintenance practice (see Table 5.2). The final values were then calibrated against local and regional audit data.

6.5 Service Hot Water

The service hot water load was broken down into two components: wetting & showering hot water and other hot water use. The wetting & showering component includes the water heating energy required for hand washing and showering. This is typically driven by the occupant density and typical use per occupant for different building segments. The other component includes water heating energy required for dishwashing, clothes washing, food preparation and cleaning. This is typically driven by the presence and proliferation of cooking equipment (kitchens, cafeterias, etc.) and laundry facilities. Typical fractions for each component were given in Section 4.1.7.

Hot water intensities from each segment were derived from engineering design, occupant density and hot water use per occupant per day. The final values were calibrated against local and regional audit data.

6.6 Cooking Equipment

The cooking equipment load includes the energy required for cooking equipment found in buildings which have kitchens for cafeterias, restaurants and fast food outlets, plus ranges or microwave ovens used in all building segments. The intensities for each building segment were derived from local and regional audit data.

6.7 Refrigeration

Refrigeration is required for low temperature cooling and ice making equipment in buildings which have refrigerated or frozen food cases, or ice rinks plus conventional refrigerators and freezers in other segments. The intensities for each segment were derived from local and regional audit data.

6.8 Plug-in Equipment

Plug-in equipment includes typewriters, photocopiers, computers, computer peripherals vending machines and appliances (excluding refrigerators, freezers and hot water using appliances). In apartments it includes small appliances and home entertainment equipment. The intensities for each segment were derived from local and regional audit data and, and in the case of apartments, from work carried out in the Residential Sector analysis.

6.9 Miscellaneous Equipment

The miscellaneous equipment refers to the intensity required for the equipment not covered under the other end-uses. This includes elevators, escalators, exterior lighting, pipe tracing cables, slab heating and central computer systems. The intensities were derived from local BC and regional audit data.

6.10 Summary of End-Use Intensities

Table 6.3 contains all EUIs for the end-uses and building segments covered in the study in MJ/m² and kWh/ft². The individual EUIs are those found in buildings where electricity is used for all end-uses. The total EUIs are therefore for all electric buildings.

TABLE 6.3A

SUMMARY OF 1988 END-USE INTENSITIES IN THE BC COMMERCIAL SECTOR (MJ/m².yr) – ALL ELECTRIC BUILDINGS

EXISTING BUILDINGS	General Lighting (MJ/m ² .yr)	Service Area Lighting (MJ/m ² .yr)	Other Lighting (MJ/m ² .yr)	Space Heating (MJ/m ² .yr)	Space Cooling (MJ/m ² .yr)	HVAC Electricity (MJ/m ² .yr)	Service Hot water (MJ/m ² .yr)	Cooking Equipment (MJ/m ² .yr)	Refrig. Equipment (MJ/m ² .yr)	Office Equipment (MJ/m ² .yr)	Misc. Equipment (MJ/m ² .yr)	Total (MJ/m ² .yr)
Large Office (> 3,700 m ²)	334.7	87.2	12.2	160.1	76.0	135.4	4.7	4.0	12.4	113.4	43.2	983.3
Small Office (< 3,700 m ²)	349.2	91.0	12.8	255.2	124.9	112.8	4.7	4.0	12.4	113.4	12.9	1093.2
Non-Food Retail	329.7	296.7	10.2	196.3	169.5	102.3	1.6	4.1	9.5	59.9	6.5	1186.4
Food Retail	348.6	198.6	8.9	448.4	127.1	124.9	19.3	130.0	1492.4	77.3	97.0	3072.5
Restaurant/Tavern	242.8	227.7	0.0	952.8	145.2	394.0	327.0	419.0	220.0	42.1	103.0	3073.6
Hotels/Motels	152.3	57.1	23.7	243.5	74.7	43.3	100.0	67.8	12.6	86.4	14.2	875.7
Warehouse/Wholesale	195.6	24.5	0.0	389.4	94.4	12.9	1.8	4.0	19.0	41.6	19.0	802.2
Hospitals	91.3	118.9	26.1	252.1	110.0	282.0	140.0	61.0	25.0	163.8	20.0	1290.2
Nursing Homes	114.7	106.0	0.0	432.6	84.6	32.6	104.0	12.8	30.0	36.7	12.8	966.8
Universities/Colleges	223.0	71.6	0.0	210.6	53.3	165.7	53.8	22.0	10.0	43.2	15.0	868.2
Schools	129.3	62.3	0.0	219.2	86.2	15.1	22.0	4.8	10.0	9.0	0.4	558.2
High Rise Apartments	68.8	109.1	0.0	454.3	90.8	51.8	100.0	19.0	36.0	54.0	12.8	996.5
Miscellaneous	207.3	38.5	6.9	420.8	90.8	61.6	4.0	0.0	0.0	32.4	12.0	874.2
1. Weighted average of electric resistance + heat pumps												
HVAC: Heating, ventilation and air conditioning												
Refrig.: Refrigeration												
NEW BUILDINGS	General Lighting (MJ/m ² .yr)	Service Area Lighting (MJ/m ² .yr)	Other Lighting (MJ/m ² .yr)	Space Heating (MJ/m ² .yr)	Space Cooling (MJ/m ² .yr)	HVAC Electricity (MJ/m ² .yr)	Service Hot water (MJ/m ² .yr)	Cooking Equipment (MJ/m ² .yr)	Refrig. Equipment (MJ/m ² .yr)	Office Equipment (MJ/m ² .yr)	Misc. Equipment (MJ/m ² .yr)	Total (MJ/m ² .yr)
Large Office (> 3,700 m ²)	317.1	80.5	12.1	54.2	76.0	135.4	4.7	4.0	12.4	189.0	43.2	928.6
Small Office (< 3,700 m ²)	330.8	84.0	12.6	98.7	111.5	145.0	4.7	4.0	12.4	189.0	12.9	1005.6
Non-Food Retail	329.7	254.4	10.2	70.9	169.5	102.3	1.6	4.1	9.5	59.9	6.5	1018.6
Food Retail	363.3	231.7	8.9	23.6	25.0	34.4	19.3	269.0	1492.4	77.3	97.0	2641.9
Restaurant/Tavern	232.7	239.7	0.0	680.9	145.2	160.0	327.0	366.5	220.0	42.1	103.0	2517.1
Hotels/Motels	195.0	57.1	23.7	379.0	74.7	43.3	100.0	67.8	12.6	86.4	14.2	1053.8
Warehouse/Wholesale	187.9	24.5	0.0	236.0	94.4	12.9	1.8	4.0	19.0	41.6	19.0	1390.2
Hospitals	86.5	130.8	27.9	248.1	110.0	282.0	140.0	68.0	25.0	252.0	20.0	1390.2
Nursing Homes	152.9	88.6	0.0	342.7	84.6	32.6	104.0	68.0	30.0	36.7	12.8	952.9
Universities/Colleges	238.2	71.6	0.0	210.6	53.3	165.7	53.8	22.0	10.0	72.0	15.0	912.2
Schools	139.4	53.4	0.0	217.1	86.2	15.1	22.0	4.8	10.0	13.5	0.4	561.8
High Rise Apartments	88.2	47.7	0.0	224.2	90.8	51.8	100.0	19.0	36.0	36.0	12.8	706.5
Miscellaneous	327.0	48.1	6.9	263.0	90.8	61.6	4.0	0.0	0.0	32.4	12.0	845.8
1. Weighted average of electric resistance + heat pumps												
HVAC: Heating, ventilation and air conditioning												
Refrig.: Refrigeration												

TABLE 6.3B

SUMMARY OF 1988 END-USE INTENSITIES IN THE BC COMMERCIAL SECTOR (kWh/ft².yr) – ALL ELECTRIC BUILDINGS

EXISTING BUILDINGS	General Lighting (kWh/ft ² .yr)	Service Area Lighting (kWh/ft ² .yr)	Other Lighting (kWh/ft ² .yr)	Space Heating (kWh/ft ² .yr)	Space Cooling (kWh/ft ² .yr)	HVAC Electricity (kWh/ft ² .yr)	Service Hot water (kWh/ft ² .yr)	Cooking Equipment (kWh/ft ² .yr)	Refrig. Equipment (kWh/ft ² .yr)	Office Equipment (kWh/ft ² .yr)	Misc. Equipment (kWh/ft ² .yr)	Total (kWh/ft ² .yr)
Large Office (> 3,700 m ²)	8.6	2.3	0.3	4.1	2.0	3.5	0.1	0.1	0.3	2.9	1.1	25.4
Small Office (< 3,700 m ²)	9.0	2.3	0.3	6.6	3.2	2.9	0.1	0.1	0.3	2.9	0.3	28.2
Non-Food Retail	8.5	7.7	0.3	5.1	4.4	2.6	0.0	0.1	0.2	1.5	0.2	30.6
Food Retail	9.0	5.1	0.2	11.6	3.3	3.2	0.5	3.4	38.5	2.0	2.5	79.3
Restaurant/Tavern	6.3	5.9	0.0	24.6	3.7	10.2	8.4	10.8	5.7	1.1	2.7	79.3
Hotels/Motels	3.9	1.5	0.6	6.3	1.9	1.1	2.6	1.8	0.3	2.2	0.4	22.6
Warehouse/Wholesale	5.0	0.6	0.0	10.1	0.2	0.3	0.0	0.1	0.5	1.1	0.5	20.7
Hospitals	2.4	3.1	0.7	6.5	2.8	7.3	3.6	1.6	0.6	4.2	0.5	33.3
Nursing Homes	3.0	2.7	0.0	11.2	2.2	0.8	2.7	0.3	0.8	0.9	0.3	25.0
Universities/Colleges	5.8	1.8	0.0	5.4	1.4	4.3	1.4	0.6	0.3	1.1	0.4	22.4
Schools	3.3	1.6	0.0	5.7	2.2	0.4	0.6	0.1	0.3	0.2	0.0	14.4
High Rise Apartments	1.8	2.8	0.0	11.7	2.3	1.3	2.6	0.5	0.9	1.4	0.3	25.7
Miscellaneous	5.4	1.0	0.2	10.9	2.3	1.6	0.1	0.0	0.0	0.8	0.3	22.6
1. Weighted average of electric resistance + heat pumps												
HVAC: Heating, ventilation and air conditioning												
Refrig.: Refrigeration												
NEW BUILDINGS	General Lighting (kWh/ft ² .yr)	Service Area Lighting (kWh/ft ² .yr)	Other Lighting (kWh/ft ² .yr)	Space Heating (kWh/ft ² .yr)	Space Cooling (kWh/ft ² .yr)	HVAC Electricity (kWh/ft ² .yr)	Service Hot water (kWh/ft ² .yr)	Cooking Equipment (kWh/ft ² .yr)	Refrig. Equipment (kWh/ft ² .yr)	Office Equipment (kWh/ft ² .yr)	Misc. Equipment (kWh/ft ² .yr)	Total (kWh/ft ² .yr)
Large Office (> 3,700 m ²)	8.2	2.1	0.3	1.4	2.0	3.5	0.1	0.1	0.3	4.9	1.1	24.0
Small Office (< 3,700 m ²)	8.5	2.2	0.3	2.5	2.9	3.7	0.1	0.1	0.3	4.9	0.3	26.0
Non-Food Retail	8.5	6.6	0.3	1.8	4.4	2.6	0.0	0.1	0.2	1.5	0.2	26.3
Food Retail	9.4	6.0	0.2	0.6	0.6	0.9	0.5	6.9	38.5	2.0	2.5	68.2
Restaurant/Tavern	6.0	6.2	0.0	17.6	3.7	4.1	8.4	9.5	5.7	1.1	2.7	65.0
Hotels/Motels	5.0	1.5	0.6	9.8	1.9	1.1	2.6	1.8	0.3	2.2	0.4	27.2
Warehouse/Wholesale	4.8	0.6	0.0	6.1	2.4	0.3	0.0	0.1	0.5	1.1	0.5	16.5
Hospitals	2.2	3.4	0.7	6.4	2.8	7.3	3.6	1.8	0.6	6.5	0.5	35.9
Nursing Homes	3.9	2.3	0.0	8.8	2.2	0.8	2.7	1.8	0.8	0.9	0.3	24.6
Universities/Colleges	6.1	1.8	0.0	5.4	1.4	4.3	1.4	0.6	0.3	1.9	0.4	23.5
Schools	3.6	1.4	0.0	5.6	2.2	0.4	0.6	0.1	0.3	0.3	0.0	14.5
High Rise Apartments	2.3	1.2	0.0	5.8	2.3	1.3	2.6	0.5	0.9	0.9	0.3	18.2
Miscellaneous	8.4	1.2	0.2	6.8	2.3	1.6	0.1	0.0	0.0	0.8	0.3	21.8
1. Weighted average of electric resistance + heat pumps												
HVAC: Heating, ventilation and air conditioning												
Refrig.: Refrigeration												

PART III

**ENERGY EFFICIENT
TECHNOLOGIES AND MEASURES**

7. SUMMARY OF TECHNICAL AND OPERATIONAL UPGRADES

This chapter takes an unconstrained look at energy efficient technologies and operational (social) improvements that could be used in the commercial sector over the next 20 years. Interactive affects between technologies were not taken into account at this stage nor were the impacts of one technology or measure on the costs of another technology.

Table 7.1 provides a list of technical measures to be assessed in the study, following the same framework of end-uses laid out in Table 1.1. Specific operational characteristics that will affect operational practice when the technical measure is used are also shown in Table 7.1. Some measures would be used more easily in new buildings. Several of the measures may be packaged together more easily resulting in an overall improvement in building design.

Table 7.2 shows the types of operational measures assessed in the study for each end-use, including such measures as maintenance improvements, optimum scheduling, air and water balancing, and general know-how regarding HVAC and control systems. These measures can be divided into three categories: i) those which eliminate the current penalties associated with poor overall equipment maintenance and scheduling as shown in Tables 5.1 and 5.2, ii) those actions by building occupants which would reduce local energy use in the building, e.g. local switching and task tuning of lighting, and iii) those actions which ensure more efficient technologies are used to their fullest advantage, e.g. cleaning of lighting fixtures, particularly those with dimming systems.

A more detailed list of measures, for each end-use, collected together under the three major headings of scheduling, maintenance and other, is given in Appendix 5.

Section 7.1 provides estimates of the operational improvements that could be made in commercial buildings. The following sub-sections address each end-use in turn, providing a description of each of the technical options, their affect on performance, their cost and other relevant information.

The cost information provided is representative of large scale commercial production. It may also be conservatively assumed that these prices do not change in real terms over the study period. Unless otherwise indicated, cost/m² means cost per square metre of floor area.

7.1 Operational Improvements

Operational improvements can be divided into these under the control of building operators and those under the control of building occupants. Those under control of the building operator are primarily concerned with "tightening up" existing practice i.e., removing the penalties in energy use associated with current practice:

BC Hydro Conservation Potential Review		Table 7.1 – Commercial Sector Technical Upgrades	
Energy End–Use	End–Use Component	Technical Upgrades	Operational Aspects of Technical Upgrades
Lighting	Fluorescent Lighting	F 34, T8 etc Efficient core/coil, electronic ballasts Reflectors Rewiring for individual switching Occupancy control Lighting automation systems Photocell control (daylight or lumen) Daylighting enhancement Add–on devices	Maintenance/contractor knowledge Electronic ballast maintenance/calibration Cleaning more important Highly dependent on user behaviour Maintenance Knowledgeable users/operators Regular calibration required Maintenance/contractor knowledge
	Incandescent Lighting	Compact Fluorescent. Efficient PAR Occupancy sensors	Maintenance
	HID Lighting (interior)	Metal Halide, HPS Occupancy control Daylighting enhancement	Knowledgeable users/operators Maintenance
	HID Lighting (exterior)	HPS, LPS Photocell control	Knowledgeable users/operators Maintenance
Space Heating	Envelope heat loss	Retrofit (insulation) Improved window Reduce window/wall ratio Air sealing/vestibule Shading devices	Highly dependent on user behaviour
	Make–up air heating	Heat recovery Compartmental and/or VAV DDC	Maintenance of heat recovery equipment
	Heating System	Heat pump upgrade or conversion Improved system control BAS	Calibration, maintenance, knowledgeable user Calibration, maintenance, knowledgeable user
Cooling	Envelope heat gain	Improved shading coeff Window shades Reduce window/wall ratio Air sealing/vestibule	Highly dependent on user behaviour
	Make–up air cooling + internal gain	Economizer Compartmental Ventilation DDC	Maintenance
	Cooling System	Chiller/cooler upgrade Improved system control Water side economizer BAS	Calibration, maintenance, knowledgeable user Calibration, maintenance, knowledgeable user

BC Hydro Conservation Potential Review		Table 7.1 -- Commercial Sector Technical Upgrades	
Energy End-Use	End-Use Component	Technical Upgrades	Operational Aspects of Technical Upgrades
HVAC Electricity	Fans	Low Temperature Distribution Displacement ventilation Energy efficient motors BAS VAV/Compartmental Localized venting control Open windows	Highly dependent on user behaviour Highly dependent on user behaviour
	Pumps	Energy Efficient motors VFDs BAS	
Service Hot Water	Hot Water Loads	Efficient shower/faucet Auto shut off Set backs	Maintenance Maintenance Maintenance
	Water Heating Sys.	Efficient unit or Jacket Heat recovery	Maintenance of jacket Maintenance
Refrigeration		Doors and covers Integrated compressors Unequal capacity multi-plex compressors Floating head pressure control Suction pressure reset Hot gas defrost	Highly dependent on user behaviour
Cooking			
Plug in equipment		More efficient equipment	
Misellaneous		More efficient equipment	

HVAC: Heating, ventilation and air conditioning
 VAV: Variable air volume
 BAS: Building automated systems
 VFD: Variable frequency drives
 PAR: Parabolic aluminized reflector
 HPS: High pressure sodium
 LPS: Low pressure sodium
 DDC: Direct digital control

BC Hydro Conservation Potential Review		Table 7.2 – Commercial Sector Operational Upgrades
Energy End–Use	End–Use Component	Operational Upgrades
Lighting	Fluorescent Lighting	Optimum light levels (delamping/downlamping) Optimum scheduling (lighting control settings) Optimum rescheduling of cleaning/building maintenance etc Regular cleaning of fixtures Turn off local lighting when areas unoccupied Task tune dimminable lighting
	Incandescent Lighting	Optimum scheduling (lighting control settings) Optimum rescheduling of cleaning/building maintenance etc Turn off local lighting when areas unoccupied
	HID Lighting (interior)	Turn off local lighting when areas unoccupied
	HID Lighting (exterior)	
Space Heating	Envelope heat loss	Regular cleaning of windows Maintenance of seals, closures etc on openable windows
	Make–up air heating	Regular maintenance of economizers and dampers
	Heating System	Optimum settings of thermostats/setbacks Regular maintenance of heat pumps Air filter/water strainer cleaning Optimum seasonal scheduling Information/manuals on systems and controls Regular operator training/Service contracts Regular cleaning and maintenance of heat recovery system
Cooling	Envelope heat gain	Regular use of blinds Maintenance of seals, closures etc on openable windows
	Make–up air cooling + internal gain	Regular maintenance of economizers and dampers
	Cooling System	Optimum settings of thermostats/setbacks Regular maintenance of chillers and heat pumps Air filter/water strainer/cleaning Optimum seasonal scheduling Information/manuals on systems and controls Regular operator training/Service contracts

BC Hydro Conservation Potential Review		Table 7.2 – Commercial Sector Operational Upgrades
Energy End–Use	End–Use Component	Operational Upgrades
HVAC Electricity	Fans	Air balancing/system load matching Air filter cleaning Information/manuals on systems and controls Regular operator training/Service contracts
	Pumps	Water balancing/system load matching Water strainer cleaning
Service Hot Water	Hot Water Loads	Faucet/shower/dishwasher maintenance Optimum scheduling of hot water use
	Water Heating Sys.	Regular maintenance of hot water system
Refrigeration		Regular maintenance and cleaning of refrigeration equipment
Cooking		Regular cleaning and maintenance
Plug in equipment		Regular cleaning and maintenance + Turn off when not in use
Misellaneous		Regular cleaning and maintenance

HID: High intensity discharge
HVAC: Heating, ventilation and air conditioning

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- *Improved scheduling of lighting.* The possible reduction in the hours of operation of lighting in commercial buildings depends on the type of building and ranges from less than 5% in high use buildings such as hospitals to 20% in small offices and schools.
- *Cleaning of lighting fixtures.* When electronic dimmable ballasts are used in lighting, (see Section 7.2 below), regular cleaning of the reflectors will result in additional savings.
- *Improved scheduling and maintenance of HVAC system.* The savings potential will vary with building type, but can range from a low of 10% in already well maintained segments, to close to 20% in small offices and retail.

The only significant practices under the direct control of an occupant are as follows:

- *Switching off lighting in individual offices.* As shown below in Section 7.2, occupancy sensors can reduce general lighting use by 50% in those offices or areas that are equipped with individual switching. Manual operation would achieve the same savings, i.e. approximately 20% reduction in hours of operation overall, assuming about 40% of lighting can be individually switched.
- *Closing blinds to reduce solar gain.* Since solar gains represent a maximum of 35% of a building cooling load (see Table 6.2), the use of high shading coefficient windows will greatly reduce these loads. Action by building occupants would therefore not have a significant impact on cooling loads.
- *Turning off and proper use of office equipment.* Office equipment is often used only for part of the workday. Use of timers on photocopiers, and getting into the habit of turning off monitors and/or computers when not in use, could reduce office equipment loads by up to 50 %, i.e. from the current average of 13 hours per day to 6.5 hours per day in the Office, Schools and Universities building segments.

A summary of operational improvements is given in Table 7.3.

Table 7.3
Potential Savings Achievable
Through Operational (Social) Improvements

	Lighting*	HVAC	Office Equipment
Large Offices	32%	14%	50%
Small Offices	36%	16%	50%
Non-food Retail	20%	16%	n/a
Food Retail	65%	18%	n/a
Restaurants	5%	12%	n/a
Hotel/Motel	30%	12%	n/a
Warehouse	5%	18%	n/a
Hospital/Nursing Home	25%	10%	n/a
Universities/Colleges	32%	12%	50%
Schools	36%	12%	50%
Apartments	5%	18%	n/a

* When electronic dimmable ballasts are used in lighting, regular cleaning of the fixtures will result in additional savings in lighting electricity. The coefficient of utilization (CU), and therefore connected loads, can be reduced by a further 10% to 15%.

There are three types of costs associated with the upgrading of maintenance and scheduling in commercial buildings:

- *The cost of basic training for building operators.* This is usually borne by society, and involves improving building technicians courses, certification, etc.
- *The cost of institution building.* This includes establishment of better networks of qualified technicians and service personnel to advise building owners, etc. Its cost would often be borne by utilities.
- *The cost to the building owner.* This includes the direct costs of hiring staff or upgrading their capabilities. Existing maintenance contracts or direct employment of an operator often ensures that an HVAC system or other equipment operates, but it does not ensure that it operates efficiently. A premium is required to achieve this, but also assumes that appropriately trained personnel are available. Many owners of large buildings employ permanent maintenance staff or can afford to have maintenance contracts. They could upgrade these to achieve efficient operation for a relatively small premium. Small building owners would find things more difficult. In many cases, they have no permanent systems maintenance staff, and owners must rely on service contracts which are only

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called on only annually, or when a system fails¹¹. The cost of employing or hiring special expertise to make systems run efficiently will be much higher.

If an overall improvement is to be achieved in HVAC and other system operating capabilities, a comprehensive program, starting at the basic training level and including service to small building owners, must be put in place by utilities and other institutions.

The following information provides typical costs of maintenance and scheduling in the BC commercial sector, based on information obtained from building owners and contractors.

Scheduling costs are not easily quantifiable. The cost and benefit would be derived from the practices and diligence employed by the building operator and occupants.

Maintenance and Other costs on average for Vancouver office buildings range from \$ 0.46 to \$ 0.76 per sq.ft. for repair and maintenance of structure, roof and other general maintenance concerns; from \$ 0.21 to \$ 0.43 per sq.ft. for repair and maintenance of HVAC equipment; from \$ 0.02 to \$ 0.03 per sq.ft. for repair and maintenance of plumbing equipment; and from \$ 0.17 to \$ 0.18 per sq.ft. for repair and maintenance of lighting and power equipment.

7.2 Lighting Technology

7.2.1 Fluorescent Lamps

F34, F32 Four Foot Fluorescent Lamps

The two lamp types F32 and F34 are known as reduced wattage or energy saving lamps. The lamps have been designed to replace standard F40 40W fluorescent lamps. These lamps provide energy savings over F40 lamps due to a higher efficacy (lumen/watt) and reduced light output. The F32 lamp achieves additional savings of 2W/lamp over the F34 due to a switch that disconnects the cathodes when the lamp has reached operating temperature.

<i>Performance (lamp efficacy)</i>		59	lumens/watt baseline F40 and F34
		62	lumens/watt for F32 lamps
<i>Energy Savings over baseline</i>	F34	15%	
	F32	20%	
<i>Cost (\$/lamp)</i>	F40	\$1.75	
	F34	\$2.00	

¹¹ In New England it was found that buildings with systems smaller than 50 to 110 kW could not afford their own operator.

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F32 \$2.50

Life (hrs) 15,000 - 20,000

Applicability/Availability

This technology can be applied to existing and new buildings. The lamps have been available in the market for approximately 10 years.

Reduced Diameter Lamps (T8/T10)

T8 and T10 lamps are reduced diameter lamps that have a diameter of 25 mm (1 ") as opposed to the standard T12 lamp which has a diameter of 37.5 mm (1.5"). The lower diameter results in a higher surface to volume ratio which increases the proportion of ultraviolet energy striking the phosphor coating. The lamp displays the highest efficacy of any fluorescent lighting system. These lamps were designed as part of a system to deliver full light output compared to a F34 or F40 fluorescent lamp system while consuming 20% to 25% less energy.

<i>Performance (lamp efficacy)</i>	59	lumens/watt baseline F40
	80-90 ¹²	lumens/watt for T8 lamps

<i>Energy Savings over baseline</i>	25%

<i>Cost (\$/lamp)</i>	F40	\$1.75
	T8	\$3.00 - \$6.00

<i>Life (hrs)</i>	20,000

¹² i) Competitek, "The State of the Art, Lighting", p.123. T8 envelopes display efficacies of 78-95 Lumens/W.

ii) Competitek, "The State of the Art, Lighting", APPENDIX H, P. 290, 292, GE & Sylvania T8 lamps display initial efficacies of 90-95 Lumens/W.

iii) Advance Transformer Co., "Realities in Retrofitting", p. 11 F32T8 + ballast display efficacies of 84-86 Lumens/W.

iv) National Lighting Product Information Program, *Specifier Report*, "Electronic Ballasts", p. 3 Table 1, efficacy of 2-32W F32T8 lamps with electronic ballast displays an efficacy of 90 Lumens/W.

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Applicability/Availability

This technology can be applied to existing and new buildings. The lamps have been available in the market for approximately 10 years.¹³

Compact Fluorescent Lamps

Self ballasted compact fluorescent (CFL) lamps are available in the range of 8 to 28W. They are designed to replace 40 to 100 W incandescent lamps used in recessed fixtures or spot lighting applications. CFLs offer, in addition to the higher efficacy, a longer life expectancy.

Remote ballasted and higher wattage CFLs have recently been introduced. Remote ballasted lamps expand the uses of CFL as replacements for incandescents.

<i>Performance (lamp efficacy)</i>	16	lumens/watt baseline incandescent
	53	lumens/watt for CFL lamps

<i>Energy Savings over baseline</i>	75 %

<i>Cost (\$/lamp)</i>	Incandescent	\$0.50 - \$1.50
	CFL	\$15 - \$25 (lamp \$4 - \$8, ballast \$10 - \$20)

<i>Life (hrs)</i>	10,000

Applicability/Availability

This technology can be applied to existing and new buildings. Self-ballasted CFLs were introduced in 1981. Remote ballasted were introduced in 1988.

7.2.2 Incandescent Lamps

Tungsten-Halogen Lamps

Tungsten-halogen (T-H) incandescent lamps are energy efficient lamps to which a halogen gas is added to the filling gas. They are used to replace high wattage incandescent PAR (Parabolic Aluminized Reflector) lamps. The halogen gas causes evaporated tungsten to be redeposited on the filament thereby increasing life expectancy and light output. A low emissivity coating is also applied to the outside of the bulb to further increase the efficacy of the lamp.

¹³ Available in 8 ft. lengths in 1981 and in shorter lengths in later years.

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<i>Performance (lamp efficacy)</i>	12	lumens/watt baseline 150 W PAR
	21	lumens/watt for T-H
<i>Energy Savings over baseline</i>	40%	
<i>Cost (\$/lamp)</i>	150W PAR	\$2.00
	T-H	\$4.50
<i>Life (hrs)</i>	2,000	

Applicability/Availability

This technology can be applied to existing and new buildings. Tungsten-halogen lamps represent a mature technology and thus are quite readily available.

7.2.3 High Intensity Discharge Lamps

Metal Halide Lamps

Metal halide (MH) lamps are very similar to the conventional mercury vapour (MV) lamps. An inner arc tube is present which contains mercury vapour and argon gas. The addition of metallic salts in the arc tube increases the light output of the metal halide lamp to approximately 65 lumens/watt vs. 45 lumens/watt for mercury vapour.

<i>Performance (lamp efficacy)</i>	45	lumens/watt baseline mercury vapour
	65 ¹⁴	lumens/watt for metal halide
<i>Energy Savings over baseline</i>	30%	
<i>Cost (\$/fixture (includes bulb, ballast & lamp))</i>	MV	\$450 ¹⁵ (lamp \$25 + fixture \$425)
	MH	\$480 ⁵ (lamp \$40 + fixture \$440)

¹⁴ IES Lighting Handbook - Reference Volume, 1981. Fig. 8-120, pg. 8-112. MH lamps ranging from 175-400 watts display efficacies of 55 to 65 lumens/watt. Thousand watt lamps display efficacies of 80 lumens per watt.

¹⁵ Costs shown are list prices provided by Sylvania Products, Montreal.

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<i>Life (hrs)</i>	<i>Bulb:</i>	10,000 ¹⁶
	<i>Ballast</i>	20,000

Applicability/Availability

This technology can be applied to existing and new buildings. Metal halide lamps represent a mature technology and thus are quite readily available.

High Pressure Sodium Lamps

High pressure sodium (HPS) lamps are of similar construction to mercury vapour lamps. In addition to the mercury vapour, the HPS arc tube contains sodium. The starting gas is xenon rather than argon. These differences combine to produce a much higher light output (efficacy) than that of mercury vapour or metal halide. One undesirable characteristic of HPS is its yellow colour which limits its use in indoor applications. Applications of HPS lighting is undesirable to situations where colour rendition or contrast is very important. Manufacturers recognized this from the beginning and have attempted to offset this disadvantage by offering a colour corrected HPS lamp.

<i>Performance (lamp efficacy)</i>	45	lumens/watt baseline mercury vapour
	90	lumens/watt for high pressure sodium

<i>Energy Savings over baseline</i>	50%

<i>Cost (\$/fixture (includes bulb, ballast & lamp))</i>	MV	\$450 ¹⁷	(see above)
	HPS	\$470 ⁷	(lamp \$30 + fixture \$440)

<i>Life (hrs)</i>	<i>Bulb</i>	24,000
	<i>Ballast</i>	20,000

Applicability/Availability

This technology can be applied to existing and new buildings. High Pressure Sodium lamps represent a mature technology and thus are quite readily available.

¹⁶ IES Lighting Handbook - Reference Volume, 1981. Fig. 8-120, pg. 8-112. The average life for MH lamps of between 175 and 1000 watts is 10,000 hours. The only lamps listed having a higher life (15-20,000 hrs) are 400W.

¹⁷ Costs shown are list prices provided by Sylvania Products, Montreal. Local (BC) discounted prices can be less than half these prices.

Low Pressure Sodium Lamps

Low pressure sodium lamps (LPS) are similar to high pressure sodium lamps in that they produce light by passing an electrical arc through vaporized sodium. One major difference however is that the sodium is contained in an envelope under extreme vacuum. The light emitted is monochromatic which washes away all colour, making objects appear grey. Its use is consequently limited to exterior lighting.

<i>Performance (lamp efficacy)</i>	45	lumens/watt baseline mercury vapour
	130	lumens/watt for low pressure sodium

<i>Energy Savings over baseline</i>	70%

<i>Cost (\$/fixture (includes bulb, ballast & lamp)</i>	MV	\$450 ¹⁸ (see above)
	LPS	\$470 ¹⁷ (lamp \$30 + fixture \$440)

<i>Life (hrs)</i>	<i>Bulb</i>	24,000
	<i>Ballast</i>	20,000

Applicability/Availability

This technology can be applied to existing and new buildings. Low pressure sodium lamps represent a mature technology and thus are quite readily available.

7.2.4 Induction Lamps

The induction lamp is similar to a fluorescent lamp with the exception that there are no electrodes. A high frequency current of approximately 2.5 MHz is injected into the lamp which creates a rapidly fluctuating magnetic field that makes the electrons in the fluorescent powder "rub themselves warm". This lamp offers the advantage of a higher life expectancy estimated at 60,000 hours since there are no electrodes to wear out.

A second type of induction lamp is called the "two-photon" lamp which operates at a frequency of 1,000 MHz which is high enough to make the fluorescent powder give off two-photons in the visible spectrum for every one-photon that is generated in the ultraviolet spectrum. The lamps can be shaped in the form of an incandescent (point source) or fluorescent (line source) lamp due to the lack of electrodes and thus can be used to replace both fluorescent and incandescent

¹⁸ Costs shown are list prices provided by Sylvania Products, Montreal.

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lighting systems. Very high efficacies are expected from these lamps (over 200 lumens/watt^{19,20}).

<i>Performance (lamp efficacy)</i>	65 lumens/watt baseline F40
	200 lumens/watt for two-photon lamps

<i>Energy Savings over baseline</i>	70%

<i>Cost</i>	Presently unknown

<i>Life (hrs)</i>	60,000

Applicability/Availability

This technology is still in the laboratory stage and not expected to be commercially available until the turn of the century.

7.2.5 Ballasts

Energy Efficient Core & Coil Ballast

Energy efficient (EE) core & coil ballasts achieve the improvement in efficiency due to the use of better materials and tighter manufacturing tolerances to reduce the core and coil losses.

<i>Performance (ballast wattage)</i>	15 ²¹ W/ballast standard
	8 ²² W/ballast EE ballast

<i>Energy Savings over baseline</i>	33%

¹⁹ Alan Ottoson, "Right Light, Bright Light", Royal Institute of Technology, Stockholm, Sweden at 1st Evergreen Conference on Energy Efficient Lighting, May 1991.

²⁰ Competitek, *The State of the Art, Lighting*, p. 136.

²¹ Standard magnetic core and coil ballasts are rated at 15W. Measurements and testing, however, show a typical consumption of 12W.

²² According to IES Lighting Handbook - Reference Volume, 1981, energy saving electro-magnetic ballasts will consume between 6 and 10 watts. Page 8-35 suggests that this energy saving ballast will consume 4 or 5 watts per lamp or 5 to 7 watts. Table 8-105 states ballast consumption to be 7 watts. This is a conservative estimate. Alliance brochure on Watt-Miser ballast lists power consumption of 8 watts.

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<i>Cost (\$/ballast)</i>	Standard ballast	\$15 - \$30
	EE ballast	\$18 - \$35

Life (yrs) 15-25

Applicability/Availability

EE ballasts have been readily available since the late 1970's. They represent a mature technology and are available from multiple manufacturers.

Electronic Ballasts

Electronic ballasts (EB) represent a complete departure from the electromagnetic ballasts. EB's use solid state circuitry instead of an inductive choke to regulate the current eliminating the inherent core and coil magnetic losses associated with electromagnetic ballasts. EB's also operate at much higher frequencies than electromagnetic ballasts increasing the lamp light output and efficacy by 10% to 15%.²³

Dimmable EB's (EB_D) represent the second generation of electronic ballasts. They have the additional feature of varying the current to enable dimming of the lamps. (See Dimming Systems in Section 7.1.7 below).

<i>Performance (ballast wattage)</i>	15	W/ballast standard
	4-6 ²⁴	W/ballast for EB & EB _D

Energy Savings over baseline 65% (without dimming)

<i>Cost (\$/ballast)</i>	EB	\$40 - \$70 ²⁵
	EB _D	\$70 - \$110

Life (yrs) 20 -30

²³ The IES Lighting Handbook: 1984 Reference Volume, p.8-39. Also, "Benefits of Energy Efficient Lighting" by N.C. Bleeker, pg. 70, appearing in Strategic Planning for Energy and the Environment.

²⁴ Competitek. *The State of the Art: Lighting*, March 1988 Edition, pg. 167. Also, Advance Transformer Co., 1989, "The ABC's of Electronic Ballasts", pg. 5.

²⁵ List price local BC costs are often up to 30% lower than list prices.

Applicability/Availability

EB were introduced in the late 1980. EB_D followed shortly after. The first generation of EB's displayed reliability problems such as high failure rates, excessive harmonic distortion and flickering problems. The improved version that started appearing in the market in the early 1990's have solved all these problems. The technology can be applied to both existing and new buildings. There are approximately 6 to 10 small specialized ballast manufacturers in the U.S. Availability is not as widespread in Canada as it is in the U.S., due to the predominance of 347 volt circuits.

7.2.6 Reflectors

A specular optical reflector is an add-on sheet of aluminum or other material with a very high polished finish that increases the reflectivity of the fixture. The polished aluminum finish provides a reflectivity of 90% to 95% (coefficient of utilization between 0.8 and 0.9) compared with a regular reflector which has a reflection of 84% to 88% (coefficient of utilization 0.7 to 0.8). In a typical two- or four-lamp fixture, some of the lamps in a fixture are removed, a reflector is installed, and the remaining lamps are re-positioned in a symmetric arrangement to produce an optimum redirection of the light emanating from the fixture without significant loss in light levels. In some new buildings with three-lamp-fixtures, the reflectors would only allow removal of one tube. The use of reflectors normally produces a net light loss of 10% to 25% due to the removal of lamps not being fully compensated by the improvement in coefficient of utilization of the fixture. Any additional drop in light levels due to the aging of a reflector and build up of dirt is normally allowed for, as in conventional fixtures, by over design. It can, however, also be mitigated using a dimmable electronic ballast (see Section 7.1.9 below) but this will result in an increase in electricity use unless the fixture is regularly cleaned.

<i>Energy Savings over baseline</i>	25% to 33% for a two- or four-lamp fixture

<i>Cost (excluding installation)</i>	2x4 Reflector	\$65
	1x4 Reflector	\$30

<i>Life (yrs)</i>	15

Applicability/Availability

Optical specular reflectors can be applied to both existing and new buildings. The product has been available in the market since 1986. Although they are readily available, their use has been very limited in Canada.

7.2.7 Controls

Automated Lighting Control Systems

An automated lighting control system (ALC) is a microprocessor based lighting control system that controls the lighting system according to an occupancy schedule or tenant input through a telephone interface. Additional features such as limited override time for after hours use are normally present. ALCs in many cases are more cost effective than local low voltage switching since all wiring is localized in the electrical room where the lighting breaker panel is present.

Performance

<i>Energy Savings over baseline</i>	15%	(Typical hours of operation of commercial buildings are reduced by 15%) ²⁶
<i>Cost</i> Existing Bldgs.	\$5.00	/m ² of floor area
New Bldgs.	\$4.25	/m ² of floor area
<i>Life (yrs)</i>	20	

Applicability/Availability

ALC systems can be applied to most existing and new buildings, but are most applicable in offices, and educational buildings where there are large intermittently used areas. The product has been available since the mid 1980's. It is currently available from most major lighting and control manufacturers. ALCs can be used as a means of improving operational practice in lighting.

Occupancy Sensors

Occupancy sensors use either infrared or ultrasonic sensors which detect motion in a room to control the operation of the lighting system. The sensors are essentially a relay that is triggered by either body heat (infrared) or the Doppler shift (ultrasonic) to close a lighting circuit that turns the lights on. In absence of motion or infrared light, the sensor contacts open turning the lights off. Sensors are available in different configurations and can be mounted on a wall or ceiling. Some sensors are designed to replace a wall switch while others are designed to be mounted on the ceiling and display a much larger sweep area than a wall mounted sensor. A sensor can normally be used to control about 25 m² of floor area.

²⁶ Engineering Interface Ltd., Toronto. It is assumed that the ALC would control the lights directly at the breaker panel. Multiple zoning under such an installation is very simple to achieve.

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*Performance**Energy Savings
baseline*Up to 50%^{27, 28}

Hours of operation for lighting in commercial buildings are typically reduced by 50% in those areas that are equipped with sensors. On a full floor basis, savings are therefore in the order of 10% to 30%.

Cost Existing Bldgs.
New Bldgs.

\$125²⁹

/sensor

\$100¹⁵

/sensor

Life (yrs)

20

Applicability/Availability

Occupancy sensors can be installed in both existing and new buildings. As with ALCs they are mostly applicable in building segments with individual rooms (offices and educational institutions). They are available from a very wide range of manufacturers.

Dimming Systems

Dimming systems consist of photocell controlled ballasts that can modulate the output of fixtures in response to daylighting. Photocells are usually installed near the perimeter of the building where natural lighting is available. Electronic ballasts serving the lighting fixtures that have been connected to the photocell can cut light output by half in response to the quantity of daylighting available. The number of fixtures is not reduced, but the light output from each is controlled. In typical North American large buildings with average floor plates between 1,000 m² to 2,000 m², this perimeter area can be between 30% to 50% of the total floor area. Dimming systems also allow the light system connected load to respond to fixture cleaning, whereby the cleaner fixture would require a lower power level.

²⁷ Well designed installations in large commercial buildings have shown that up to 50% savings are possible with occupancy sensors. American Council for an Energy-Efficient Economy, The Potential for Electricity Conservation in New York State, prepared for the NYS Energy Research and Development Authority Sept. 1989.

²⁸ Lower savings would be expected in small commercial and institutional buildings. Design guidelines for all builders, are in the order of 30%.

²⁹ Energy User News, Sept. 1991, pg. 28 Occupancy Sensor Product Guide

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Energy Savings over baseline

15%
to 20%³⁰

(Electronic ballast and daylighting only)

The potential reduction in power output from perimeter lamps is 50% to 70%. Perimeter lighting represents approx. 30% of the total floor plate. The overall savings as a function of the total floor plate are in the range of 15-20%.

Cost (\$/fixture)

\$150

(Dimmable electronic ballasts \$110 + photocell \$40)

Life (yrs)

30

Applicability/Availability

Dimming systems are applicable to existing and new buildings. Both photocells and dimmable electronic ballasts are available from a wide range of manufacturers.

7.2.8 Add-On Devices

Current limiters are sometimes referred to as add-on devices which can be connected between the ballast and the lamp. Some devices can be inserted directly onto the lamp with no wiring required. The current limiters consist of a resistor or capacitor (depending on manufacturers) circuit that limits the amount of current through the lamp and ballast. Units are available in 25%, 33%, 40%, and 50% reduction levels. Manufacturers of current limiters claim that they extend both the ballast and lamp life. Ballast and lamp manufacturers on the other hand may not honour their warranties if current limiters have been connected to their equipment.

Energy Savings over baseline

25% to 50% depending on current limiter chosen

Cost Current reducers

\$20

/device

Life (yrs)

20

³⁰ Competitek. *The State of the Art: Lighting*; Rocky Mountain Institute; 1988, pg. 180. Also, ASHRAE Journal Nov. 1991, pg. 31, "Daylighting Controls: orphan of HVAC design".

Applicability/Availability

Current limiters can be installed in existing buildings. Initial good lighting design, however, obviates the need for current limiters.

7.2.9 Daylighting Enhancement (New Buildings only)

Daylighting enhancement consists of architectural and lighting hardware features that allow a new building to take maximum advantage of daylighting. Lightshelves, roof monitors, atria, skylights and light pipes are used to inject natural lighting as far as possible into the interior of the building. The first four techniques are architectural methods to provide daylighting. A light pipe is a sealed acrylic tube that due to the shape of the internal wall causes total internal reflection. This allows transportation of natural light from the roof of a building down to each floor with very little light loss. The light provides uniform illumination in its path because it glows like a fluorescent lamp. TIR Systems from Burnaby, BC holds the patent for the concept and has used it in demonstration projects and as architectural lighting. Dimmable lighting systems (see 7.1.7 above) can be used to take advantage of this additional natural lighting. In commercial buildings, this consists of the latest state of the art fluorescent lighting systems with dimmable electronic ballasts and photocells. Daylight enhancement allows the dimming system to be applicable in as much as 100% of the floor area. Shading from adjacent buildings may reduce savings.

Energy Savings
over baseline

50% (electronic ballast and daylighting only)
to 75%³¹

Cost (\$/m²)

(Light shelves, skylights and atria have low³² or no³³ cost premiums in new construction. The cost of light pipes are unknown at this time.)

Life (yrs)

30

³¹ Competitek. *The State of the Art: Lighting*; Rocky Mountain Institute; 1988, pgs. 51-67. Solar Energy Research Institute (SERI) analysis found savings from full daylighting to be 80%.

³² Energy and Economics: Strategies for Office building design, North-East Utilities, pg. 61. "The use of light shelves and monitors show no increase in construction costs".

³³ Competitek. *The State of the Art: Lighting*; 1988, pg. 180. More than 2000 buildings in the U.S.A. with full daylighting show paybacks of 2-8 yrs. which is equivalent to 4-12 \$/m². Also, ASHRAE Journal, Nov. 1991, pg. 31, "Daylighting Controls: Orphan of HVAC design".

Applicability/Availability

Daylighting enhancement is only applicable to new construction. Design techniques and artificial lighting hardware are currently available to achieve a building design that is 100% natural lighting enhanced.

7.1.10 Optimum Light Levels/Task Tuning

Most commercial lighting applications have traditionally (with a few exceptions) been specified or designed for 700 - 1000 lux. Such high light levels are not required in over 90% of applications and exceed the IES lighting level guidelines. The design practices that produce designs with such high levels are, as with the oversizing of HVAC equipment, a result of established behavioral patterns of the construction industry that tend to repeat (use off-the-shelf) inefficient designs over and over again. IES for example, specifies 750 to 1500 lux for drafting; 750 lux for medium contrast or small size (mail sorting, map reading, telephone book reading) 300 lux for general reading tasks; 150 lux for reception areas, corridors and lounges; and 75 lux for CRT screens³⁴. (IES provides a test procedure by which these levels may be adjusted within a predefined range.)

Current BC Workers Compensation Board (WCB) (sections 5.015 & 5.016 of the WORKPLACE ACT) guidelines require levels of 1000 lux where IES recommends a range of 500 to 1000, and 700 lux where IES recommends a range of 300 to 700 lux. Similarly, WCB requirements regarding light level uniformity or "brightness ratios" (as WCB defines it) is not to exceed a ratio of 3:1 within a workstation or office (immediate worker environment) and a 40:1 ratio anywhere else (this is defined as corridors, utility areas, lobbies, reception areas). IES has less stringent illumination ratios than WCB (see p5.3 IES Applications Volume). The WCB light levels and ratios were derived at a time when higher light levels were perceived to be necessary for safe work. These levels are not in line with the current IES recommendations. It may be assumed that WCB levels will be brought in line with IES in the next 20 years.

Lighting levels in daylit perimeter areas are unlikely to exceed 1000 lux with modern commercial fenestration (shading coefficients are typically 0.4 to 0.7). A core light level of 350 lux is therefore still within the WCB and IES illumination ratio requirements.

In an average office (general lighting area), the tasks that are typically present may be distributed over an average floor plate as follows:

medium contrast/small size	15% to 25% of floor area
reading	40% to 50% of floor area
reception, lounge, meeting rooms	25% to 35% of floor area

³⁴ These light levels assume illuminance target values in the range -1 to +1 as defined on p.2-21 of IES Applications Volume.

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This distribution of tasks produces a weighted average of approximately 300 to 350 lux. Properly designed or optimized lighting systems would achieve these levels in a task sensitive manner. While optimum light levels are much lower than presently experienced, the light for each task in each location is sufficient for that task. This is not therefore a change in the level of service provided by the lighting. These optimum light levels and the resulting brightness ratios also meet the IES illumination guidelines and the WCB brightness ratios.

For example, a typical building having a floor plate of 930 m² (10,000 ft²) could have the general lighting floor space broken down as follows:

drafting 45 m ²	@ 1000 lux
office working space 211 m ²	@ 300 lux
office working space 98 m ²	@ 750 lux
meeting room 135 m ²	@ 300 lux
kitchen 37 m ²	@ 150 lux
storage/utility 37 m ²	@ 150 lux
clerical 37 m ²	@ 750 lux
reception 90 m ²	@ 150 lux
other office areas 222 m ²	@ 150 lux

This produces the following distribution:

5% of space	@ 1000 lux
20% of space	@ 750 lux
40% of space	@ 300 lux
35% of space	@ 150 lux

The average illumination or weighted average illumination for general lighting based on this distribution is 360 lux. This level would drop to 310 lux without a high illuminance drafting need. Manual drafting already forms a diminishing fraction of commercial space and will likely disappear by 2010.

Task sensitive efficient lighting designs can be achieved either through:

- low ambient light levels & CFL task lighting in new buildings, or
- task tuning with T8 lamps and dimming systems (EB_{DIMMABLE} and photocell) in existing & new buildings.

Applying these techniques to existing and new buildings would lower general lighting electricity requirements by 55% to 65% with current lighting technology.

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In service areas, no lighting levels greater than 150 to 200 lux would be required. Existing levels are in 200 to 300 lux range, therefore, in this case only a 25% to 30% reduction could be achieved.

<i>Performance (conn. load (UPD))</i>	25 - 30	W/m ² baseline (800 lux)
	10 - 11	W/m ² upgrade (350 lux)
<i>Energy Savings over baseline</i>	60%	
<i>Design Cost (\$/fixture)³⁵</i>	Exist. Bldgs. \$0	(when carried out as part of regular lighting renovation)
	New Bldgs. \$0	
<i>Life (yrs)</i>	30	

Applicability/Availability

Optimum light level design can be applied to existing and new buildings. IES has for years provided light level guidelines that are task dependant. The necessary techniques and procedures are therefore readily available. The major impediment to the proper use of the light level guidelines has been the designer's tendency to always design entire floors for the highest light level requirement. This is partly due to the lack of hardware that would allow task tuned lighting, and partly due to the behavioral patterns (i.e. established design practices) and the nature of commercial space rental (i.e. what was a foyer with one tenant might become a drafting room with another). It may be assumed that over the next 20 years, photocell and lighting control technology will allow each lighting system to be both adaptable and easily optimized.

7.2.11 High Efficiency Light Diffusers/Lenses

An increase in the efficiency of diffusers or lenses can be achieved through the use of:

- polarized diffusers, or
- deep cell parabolic diffusers.

³⁵ Excluding cost of fixtures and dimmable ballasts (see above).

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These types of diffusers increase the equivalent sphere illumination (ESI)³⁶ due to the reduction in ceiling glare. Both devices essentially redirect the light downward at very shallow angles from the vertical plane. Manufacturers claim that the gain in illumination by eliminating the high angle lighting is in the range of 30% to 50%³⁷. Parabolic diffusers also display higher optical efficiencies (i.e. transmit more light) which results in higher coefficients of utilization (CU's) (0.8 vs. 0.7) over conventional diffusers. The open design of parabolic diffusers also results in less dirt accumulation with consequent higher dirt depreciation factors. One disadvantage common to both types of diffusers, is that they give rooms a very sterile quality (such as that found in computer rooms).

<i>Performance (fixture wattage)</i>	92	W/two - lamp fixture
	48	W/one - lamp fixture
<i>Energy Savings over baseline</i>	30% to 50%	for a 2, 3, or 4 lamp fixture
<i>Cost (excluding installation)</i>	\$12 - \$15	/fixture
<i>Life (yrs)</i>	15	

Applicability/Availability

High Efficiency diffusers/lenses can be applied to existing and new buildings. The product has been available for over 15 years and is readily available in the BC market. Its use to date has been limited mostly to computer rooms.

7.3 Building Envelope Improvements

7.3.1 Walls/Roofs

Existing Buildings

Additional insulation can be applied to the walls and roofs of existing masonry commercial buildings to reduce the heat loss through the building envelope. The insulation can be applied

³⁶ The equivalent sphere illumination (ESI) is defined as the level of sphere illumination which would produce task visibility equivalent to that produced by a specific lighting environment (taken from 1981 IES LIGHTING HANDBOOK "Reference Volume", Chapter 1, Definitions).

³⁷ Competitek, "The State of the Art Lighting", p. 153-160. The author provides examples where polarized lenses and parabolic diffusers have been installed at the Los Angeles Department of Water & Power showing a 33% lighting savings. Also tests performed by the Lawrence Berkeley Lighting Research Laboratory corroborated that a standard 2x4 fixture using 4 lamps with a conventional diffuser displayed approximately the same ESI as a 2x4 fixture with two lamps and a polarized diffuser. It is also important to note here that California Edison currently offers rebates for the use of polarized lenses.

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to the exterior or interior of the walls. Practical limits of how much insulation can be added exist for both cases. Application of insulation to the exterior of the building is limited to a maximum overall insulation level of approximately RSI 2.45 - 2.80 (R14 - R16). Rigid insulation is normally applied to the existing building exterior followed by exterior cladding (new skin).

Interior insulation normally consists of 25 mm (1") of fibreglass together with a new vapour barrier and new plasterboard (drywall). This method although more practical since it can be done during normal space renovations at little or no extra cost, meets with some resistance since it may affect the net leasable area. It too is therefore practically limited to RSI 2.5-2.8 (R14-R16). A second problem with this method is that it would normally be done piecemeal as tenant spaces come up for renovation.

In both instances, whether insulation is applied to the interior or exterior, the airtightness of the wall system is increased to a "High" ASHRAE rating. This is equivalent to an infiltration rate of 0.51 L/s.m² (0.10 CFM/ft²).

A very important benefit that is derived from an insulation upgrade, if performed properly, is the reduction in the thermal bridging that is normally present in insulated wall systems. It is assumed here that buildings with traditionally high thermal bridging will be insulated in such a manner as to reduce the thermal bridging. Buildings insulated from the inside would normally achieve this. This will ensure that thermal bridging reduces the effective RSI value by no more than 30% of the nominal RSI value.

Roof insulation is relatively straightforward and easy because it is not normally disruptive for tenants nor is it costly (as compared to exterior applied wall insulation). Additional roof insulation is normally applied to the existing insulation after the built-up roofing (gravel and waterproofing membrane) has been removed. A new roofing system is applied over the additional insulation.

Insulation can be added to curtain wall type buildings either in the wall cavity or in the interior of the walls. Insulation applied to the wall cavity is limited to a maximum overall insulation level of approximately RSI 2.11 (R12). The exterior panel normally has to be replaced after application of insulation in the wall cavity.

Application of interior insulation is carried out in the same way as it is done in masonry type buildings.

New Buildings

New masonry type commercial buildings that display a 75 - 100 mm (3 - 4") rigid exterior insulation would normally add additional insulation to the interior of the space by adding a

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maximum of 37 mm (1.5") of fibreglass insulation. A maximum overall insulation level of RSI 5.63 (R32) can be attained.

New curtain wall buildings can attain a slightly lower value than masonry type buildings through application of a maximum of 175 mm (7") of insulation to the exterior of the building followed by a cladding panel (glass, metal, thin stone). The maximum insulation level attainable is approximately RSI 5.28 (R30).

The increased insulation levels, whether applied to the inside or outside of the wall, would have the additional benefit of increasing the airtightness of the wall and reducing the thermal bridging that tends to reduce the effective RSI of the wall system.

Maximum Practical Levels

The maximum practical values given above are much higher than the minimum level of wall insulation dictated by ASHRAE Standard 90.1, which for the city of Vancouver dictates a minimum wall insulation level of RSI 1.94 (R11).

<i>Performance</i>	Exist. Bldgs.	R5 - R12	baseline (RSI 0.88 - 2.11)
		R14 - R16	upgrade (RSI 2.45 - 2.80)
	New Buildings	R5 - R20	baseline (RSI 0.88 - 3.52)
		R30.0 - R30.3	upgrade (RSI 5.28 - 5.33)
<i>Airtightness</i>		1.52 L/s.m ²	baseline
		0.51 L/s.m ²	upgrade
<i>Energy Savings over baseline</i>	Exist. Bldgs.	25% to 65%	
	New Bldgs.	33% to 65%	
<i>Cost (\$/m² of wall area per R)³⁸</i>			
	Exist. Bldgs.	\$45.00 per m ² of wall area + \$1.25 per m ² per R (\$7.00/m ² /RSI)	
	Exist. Bldgs. (cavity only)	\$1.40 per m ² per R (\$8.00/m ² /RSI)	
	New Bldgs.	\$1.06 per m ² per R (\$6.00/m ² /RSI)	
<i>Life (yrs)</i>		40	

³⁸ Costs are for rigid or batt insulation and include costs of new interior plaster board or drywall.

Applicability/Availability

Upgrading insulation levels and airtightness in both existing and new construction is relatively straightforward as the technology required is generally readily available and well understood.

7.3.2 Windows

Window Film (low-e Coating)

The low emissivity film coating was developed in the early 1980's as a more economical single pane window upgrade in commercial buildings. The film is a polyester based film with a thin coating of metals and oxides that reduces the emissivity and the transmittance of long wave (infrared) radiation through the glass. The insulation value increases and the shading coefficient decreases as a result. This film can only be applied to single pane windows.

<i>Performance (R)</i>	R1.0	$\text{m}^2 \cdot ^\circ\text{K}/\text{W}$ baseline single glazing (RSI 0.18)
	R1.4	$\text{m}^2 \cdot ^\circ\text{K}/\text{W}$ low-e film (RSI 0.24)

<i>Shading Coefficient (SC)</i>	0.94	clear single pane window
	0.45	single pane plus low-e film

<i>Energy Savings (heating) over baseline</i>	25%

<i>Cost (\$/m² of window area) Low-e film</i>	\$32

<i>Life (yrs)</i>	5-10

Applicability/Availability

This technology can only be applied to existing buildings with single pane windows. The technology is readily available and has been in the market since the early 1980's. 3M has a virtual monopoly of this market, offering a fairly large selection of films that can meet a wide range of applications.

Super Double Glazing

"Super double" glazed windows have two panes, are gas filled, with a thermally broken frame and a low-e coating. The gas used between the panes is argon which because of its higher atomic weight (40 vs. 16 for O_2 & 28 for N_2) reduces convective heat flow. A low-e film is added to further increase the insulation value of the window.

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<i>Performance (R)</i>	R1.0	$\text{m}^2\text{K/W}$ baseline single pane (RSI 0.18)
	R2.4	$\text{m}^2\text{K/W}$ super double window (RSI 0.42)
<i>Shading Coefficient (SC)</i>	0.94	clear single pane
	0.40	double glazing + low-e coating
<i>Energy Savings (heating) over baseline</i>	55%	
<i>Cost (\$/m² of window area)</i>	single pane	\$150
	super double	\$250 - \$300
<i>Life (yrs)</i>	20	

Applicability/Availability

This technology can be applied to both existing and new buildings. The technology is readily available from multiple manufacturers.

Insulated Super Double Glazing

Insulated or "upgraded" super double glazed windows are similar to the super double glazed windows in that they are gas filled in a thermally broken frame with a low-e coating. The difference consists of insulated spacers which increase the window system's overall insulation value. Additionally, a wavelength selective coating improves the shading coefficient for further reductions in cooling load.

<i>Performance (R)</i>	R1.0	$\text{m}^2\text{K/W}$ baseline single pane (RSI 0.18)
	R4.4	$\text{m}^2\text{K/W}$ insul. super double (RSI 0.77)
<i>Shading Coefficient (SC)</i>	0.94	clear single pane window
	0.40	double glazing + low-e coating
<i>Energy Savings (heating) over baseline</i>	75%	
<i>Cost (\$/m² of window area)</i>	single pane	\$150
	insul. super double	\$360
<i>Life (yrs)</i>	20	

Applicability/Availability

This technology can be applied to both existing and new buildings. The technologies are readily available from multiple manufacturers.

High Insulation Technology Windows

The high insulation (HIT) technology window consists of a double pane window with a spacing of 70 mm between the two panes of glass and multiple (up to 3) low emissivity films equally spaced and suspended between the two panes. In addition, an advanced design thermally broken frame with insulated spacers provides an extremely tight seal and high insulation value. The result is a window system with a high overall thermal resistance value.

<i>Performance (R)</i>	R1.0	m ² .°K/W baseline (RSI 0.18)
	R6.5	m ² .°K/W HIT window (RSI 1.15)
<i>Shading Coefficient (SC)</i>	0.94	clear single pane window
	0.40	HIT window
<i>Energy Savings (heating) over baseline</i>	85 %	
<i>Cost (\$/m² of window area)</i>	single pane	\$150
	HIT window	\$400
<i>Life (yrs)</i>	20	

Applicability/Availability

This technology can be applied to both existing and new buildings. The technology has existed in Europe for over 10 years but has only been introduced to North America in the last two years. Only a handful of companies presently exist that manufacture these types of windows.

7.3.3 Building Design

Buildings can take advantage of efficient design practices to minimize the impact of heating and cooling loads on their energy consumption. The design considerations that will be briefly mentioned in this section are:

- Building Configuration (Shape) & Orientation
- Landscaping

- Optimum (reduced) Window Area

Building Configuration/Orientation

In northern climates where the heating season is much longer than the cooling season, space heating tends to be the dominant energy end-use in most buildings. Cooling has very little impact on the overall energy use due to the short duration and relatively mild temperatures (very rarely above 35 °C). This is particularly true of the BC climate which tends to have temperate summers. As a result of the above conditions, building orientation and configuration will be dictated almost exclusively by the heating load.

Normally the configuration chosen dictates whether orientation is important or not. Generally speaking a square building will display the lowest surface to volume ratio representing the ideal shape and consequently have the lowest space heating requirements. Orientation for this configuration type makes little difference provided the glazed facades are of equal area. Large buildings that are internal load dominated, are affected the least. If the building has different facades, the glazing should be oriented south in order to reduce the heating and cooling loads (the glazing is assumed to have low shading coefficients of < 0.5 plus wavelength selective coatings to maximize daylighting and minimize absorption of solar energy in the infrared spectrum).

If the building is an elongated shape, however, it should be oriented so that exposures to the east and west are minimized. From an energy consumption standpoint, the impact of configuration/orientation increases with an increase in the volume to surface ratio. Specifically, large buildings with the smallest surface to volume ratio experience very little change in energy use because they are internal load dominated ($< 1\%$ decrease in space heating energy use from proper orientation/configuration). Smaller buildings such as strip non-food retail, will be affected to a higher degree.

Landscaping

The use of effective landscaping to minimize the solar gain and infiltration heat loss due to winds in the winter time has very little effect on the energy use of buildings. This is due to the fact that advanced glazings that display low shading coefficients and are equipped with wavelength selective coatings, are currently available and can achieve the same result as effective landscaping.

Optimum Window Area

If new construction is built following ASHRAE Standard 90.1, the Envelope System Performance Compliance Calculation Program (ENVSTD V2.2) states what the required minimum envelope construction (including wall/window insulation levels and window/wall

ratios) characteristics can be to meet the standard. A double pane window with a shading coefficient of 0.5 requires a window/wall ratio of no more than 30% to 35% in order to meet the standard (see Appendix 6 for typical window/wall ratios in existing buildings). This could reduce daylighting potential. Use of an HIT window, however, permits much higher window/wall ratios.

7.4 Heating Equipment Improvements

7.4.1 Heat Pump Upgrade

Existing space heating systems that use air, water source or heat recovery heat pumps can be replaced with upgraded or improved efficiency heat pump systems when the existing systems reach their end of life. The upgraded heat pumps achieve a higher seasonal energy efficiency rating (EER) or coefficient of performance (COP) through the use of extended surface evaporators/condensers, compressor oversizing and compressors with a small clearance volume ratio. More advanced techniques to improve the seasonal performance include the use of multispeed compressors, or the use of efficient helical/screw scroll compressors.

<i>Performance (COP_{SEASONAL})</i>	2.2	baseline air source heat pump (HP)
	2.5	baseline water source HP
	4.5	baseline heat recovery HP
	2.7	upgrade air source HP
	3.0	upgrade water source HP
	5.4	upgrade heat recovery HP
<i>Energy Savings</i>	19%	upgrade air source HP
	17%	upgrade water source HP
	17%	upgrade heat recovery HP
<i>Cost (\$/Ton)³⁹</i>	\$300 - \$600	baseline air source HP
	\$300 - \$600	baseline water source HP
	\$250 - \$300	baseline heat recovery HP
	\$375 - \$675	upgrade air source HP
	\$375 - \$675	upgrade water source HP
	\$325 - \$350	upgrade heat recovery HP

³⁹ The cost of small to medium sized (<250 tons) heat pump equipment will vary from \$300/ton for centrifugal heat recovery chillers to \$600/ton for small through-the-wall or water source unitary heat pumps. The cost of large heat recovery equipment over 250 tons does not vary as much.

Life (yrs)	10	upgrade air source HP
	25	upgrade water source HP
	25	upgrade heat recovery HP

Applicability/Availability

Efficient heat pumps are applicable to both existing and new buildings and are now available worldwide. Heat pump systems are available in a range of sizes; from fractional tonnage, in both air and water source versions, up to 1,500 tons. Heat recovery heat pumps are available starting at 30 tons for reciprocating compressors and 150 tons for centrifugal compressors. Heat pump technology is well understood and has been available for over 15 years. Heat Pumps are available from a wide range of manufacturers.

7.4.2 Conversion to Heat Pumps

Electric resistance baseboards or unit heating systems can be converted to one of three high efficiency (HE) heat pump systems listed below:

Type	Configuration
HE air source heat pump (COP 2.7)	reciprocating through-the-wall unitary or roof top with gas or electric back-up
HE water source heat pump system (COP 3.0)	unitary with gas or electric back-up
HE heat recovery heat pump system (COP 5.4)	centrifugal chiller with double bundle with gas back-up

The advantage of a heat pump system over conventional electric resistance is the higher efficiency possible. In particular, the mild weather of BC lends itself to the use of such systems with little need for auxiliary heat which translates into very high seasonal COP's compared to other geographical areas with more severe winters.

Performance (COP _{SEASONAL})	1	baseline (electric resistance)
	2.7	HE air source HP + electric backup
	3.0	HE water source HP + gas backup
	5.4	HE heat recovery HP
Energy Savings	63%	HE air source HP + electric backup
	66%	HE water source HP + gas backup
	81%	HE heat recovery HP

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<i>Cost (\$/Ton)</i>	Exist. Buildings	\$450	baseline (electric resistance) replacement only
	Exist. Buildings	\$1600 - \$2000	HE air source HP + electric backup
	Exist. Buildings	\$2700 - \$3500	HE water source HP + gas backup
	Exist. Buildings	\$3500	HE heat recovery HP
	New Buildings	\$900	baseline (electric resistance) includes wiring and electric services
	New Buildings	\$900 - \$1200	HE air source HP + electric backup
	New Buildings	\$2000 - \$2500	HE water source HP + gas backup
	New Buildings	\$2500	HE heat recovery HP
<i>Life (yrs)</i>		40	baseline (electric resistance)
		10	HE air source HP
		25	HE water source HP
		25	HE heat recovery HP

Applicability/Availability

A heat pump upgrade is applicable to both existing and new buildings. Addition of heat pumps to existing buildings which use individual water source heat recovery baseboard or unit heaters, requires the installation of piping and circulation pumps. Heat pump systems are available in a range of sizes from fractional tonnage in both air and water source versions, up to 1,500 tons. Heat recovery heat pumps are available starting at 30 tons for reciprocating compressors and 150 tons for centrifugal compressors. Heat pump technology is well understood and it has been available for over 15 years. Heat pumps are available from a wide range of manufacturers.

7.4.3 Heat Recovery

Heat exchangers or recuperators can be used to recover and transfer the heat present in building exhaust air to the incoming fresh air. A plate or heat pipe type heat exchanger can be used to transfer the heat from one stream to the other. Plate type exchangers are typically bulkier than heat pipe systems, as well as more expensive. Heat pipes are the preferred choice for their better heat transfer capacity per unit volume. A third choice can be a glycol run-around loop which requires piping and a pump. They also tend to be more economical than plate type units. Both designs keep the air streams physically apart, preventing any cross contamination problems.

<i>Performance (recovery efficiency)</i>		60% to 70% ⁴⁰	
<i>Energy Savings</i>		7%	
<i>ventilation heat savings</i>			
<i>Cost (\$/m² of floor area)</i>	Existing Bldgs.	\$65	(\$17/L/s @ 3.81 L/s. m ²)
	New Bldgs.	\$50	(\$13/L/s @ 3.81 L/s. m ²)
<i>Life (yrs)</i>		30	

Applicability/Availability

Heat exchangers can be installed in existing and new buildings. The technology is well understood and has been available for over 50 years. The products are available from a very wide range of manufacturers.

7.5 Cooling Equipment Improvements

7.5.1 High Efficiency Chillers/Air Conditioners

Existing air conditioners can be replaced with upgraded or improved efficiency air conditioners when the existing systems reach their end of life. The upgraded air conditioning systems achieve a higher seasonal EER or COP through the use of extended surface condensers, better designed, better quality compressors (i.e. reduced manufacturing tolerances, efficient electric motors) and improved controls. Controls, in particular, can provide a very large gain in efficiency through improved load matching operation. Examples of this are condenser head pressure control and chilled water and condenser water reset strategies. More advanced techniques include multispeed (through use of variable frequency drives) compressors, and advanced helical or scroll compressors.

<i>Performance (COP_{SEASONAL})</i>	2.5	baseline (DX equipment reciprocating compressor)
	4.5	baseline (centrifugal chillers)
	3.2	upgrade (DX equipment reciprocating compressor)
	6.1	upgrade (centrifugal chillers)
<i>Energy Savings</i>	22%	DX equipment reciprocating compressor
	26%	centrifugal chiller

⁴⁰ Performance will depend on climate.

<i>Cost</i> ⁴¹ (\$/ton)	\$300 - \$600	baseline (DX equipment reciprocating compressor)
	\$250	baseline (centrifugal chillers)
	\$375 - \$700	upgrade (DX equipment reciprocating compressor)
	\$325	upgrade (centrifugal chillers)
<i>Life (yrs)</i>	15	DX equipment reciprocating compressor
	25	centrifugal chiller

Applicability/Availability

High efficiency air conditioners/chillers can be applied to both existing and new buildings. Efficient air conditioning equipment has been available for over 30 years. The products are available from a wide range of manufacturers. See Appendix 6 for the type of air conditioning equipment that applies to each building segment.

7.5.2 Air/Water Side Economizers & Evaporative Cooling

The overall electrical energy consumption of air conditioning equipment can be reduced with the use of economizers. Economizers take advantage of cold outside air temperatures to provide as much "passive" cooling as possible and minimize the requirement of mechanical (electrical) cooling. Three economizer types can be applied to different building segments. They are:

- air side economizer or free cooling package,
- water side economizer, and
- evaporative cooling.

Air Side Economizer (Free Cooling)

The free cooling package or air side economizer is the most commonly known economizer type. It simply uses outside air to meet the building cooling load when either the outside air temperature (dry bulb based economizer) or its heat content (enthalpy based economizer) is below a preset maximum (i.e. 18°C. or 22.5 Btu/lbm_{dry air}). Below the maximum setting (commonly referred as the switch over point) the fresh air dampers in air handling units modulate to meet the supply air or space temperature set point. In greater Vancouver for example, free cooling can be used approximately 65% of the time. In other words, for only 35%

⁴¹ The cost of reciprocating equipment will vary from 300-700/ton depending on size. Small and medium tonnage equipment (<100 tons) will be in the upper part of the price range. Large equipment over 100 tons will be in the lower part of the range.

of the day summer time hours is the outside air temperature above the switch over point when free cooling cannot be used (see below).

VANCOUVER BIN WEATHER DATA
PERIOD 8 AM - 4 PM

	Free Cooling		Mechanical Cooling		
Temperature Bin (° C)	16	18	21	24	27
Hours of Occurrence	410	415	316	131	21
<i>Energy Savings over baseline</i>	30%				
<i>Cost⁴² (\$/ton)</i> Exist. Bldgs.	\$200				
New Bldgs.	\$100				
<i>Life (yrs)</i>	15				

Applicability/Availability

Economizers are normally present in close to 100% of all large commercial buildings with built-up air handling units (AHU's). Penetration of this technology has traditionally been weak in the light commercial market which use packaged roof top heating/cooling units. This technology and the costs shown therefore apply to the light commercial market composed of Non-Food/Food Retail, Restaurants/Taverns, Small Offices, Miscellaneous and Warehouse/Wholesale where it is estimated that roof top heating/cooling units with economizers account for only 20% of the market. Economizers can be applied as a retrofit to most existing buildings, as well as all new buildings. All roof top equipment manufacturers offer economizers as an add-on option to their equipment.

Water Side Economizer

A water side economizer uses the cooling tower to directly cool the chilled water bypassing the chiller. This is done whenever the outside air temperature is available at lower than the desired chilled water temperature. Assuming a cooling tower approach temperature of 4.5 °C (8 °F) and a chilled water temperature of 5.5 - 7°C (42 - 45°F), this translates into a required outside air temperature 1 - 3 °C or less to meet the chilled water set point. Obviously, water side economizers are restricted to a very limited application where mechanical cooling is required in

⁴² Costs shown are per a local BC supplier.

the wintertime and where it cannot be met with an air side economizer. This applies specifically to large commercial office buildings that typically have a cooling load year round and use compartmental ventilation systems on every floor. The compartmental systems are normally connected to a make-up air unit in the penthouse that is sized to handle the minimum fresh air requirements only, and thus, is unable to provide free cooling. In these building types, the chiller normally operates year round and designers tend to specify double bundle condensers to take advantage of the condenser heat for space heating. In BC, this type of large office building is estimated to represent approximately 10% of the large office floor space. From a hardware standpoint, water side economizers normally require a separate heat exchanger that is installed between the chiller and the cooling tower to cool the chilled water directly with condenser water.

Energy Savings 12%
over baseline

<i>Cost (\$/ton)</i>	<i>Exist. Bldgs.</i>	\$200 - \$300
	<i>New Bldgs.</i>	\$200 - \$300

Life (yrs) 20

Applicability/Availability

Water side economizers are applicable only to large commercial buildings that run their chillers in the winter time. This is assumed to be 10% of the existing large offices. The water side economizers can be applied to existing buildings as a retrofit or to new buildings. Water side economizers are normally engineered requiring chiller piping by-pass and a water-water heat exchanger. Exchangers are available from a large number of manufacturers.

Indirect Evaporative Cooling

Evaporative cooling uses water as a cooling medium to cool the air. This can be done directly by exposing the air to be cooled to a water spray or indirectly by using two air streams and a heat exchanger. Energy savings are realized because the evaporative cooling cools the air by "passive" means rather than mechanical means. In dry climates, direct evaporative cooling systems can be utilized. In humid climates, direct evaporative systems are undesirable because they add too much humidity increasing the total heat content of the air. Outside air is the typical chosen air stream rather than total building air, due to the design of evaporative cooling systems. Their design makes it very difficult to install an evaporative cooler inside the air handling unit. This technology, as a result, is normally applied to buildings with 100% outside air systems such as hospitals and laboratories/clean rooms.

<i>Energy Savings over baseline</i>		30%
<i>Cost (\$/ton)</i>	Exist. Bldgs.	\$1500
	New Bldgs.	\$1000
<i>Life (yrs)</i>		20

Applicability/Availability

Indirect evaporative cooling systems are restricted to large commercial buildings with 100% outside air systems. These include hospitals and laboratories/clean rooms. The technology can be applied to existing and new buildings. Although the technology has been known for over 50 years its relative high cost as compared to standard mechanical systems has limited its use. Higher energy costs in the U.S. make this technology more widespread.

7.5.3 Desiccant Cooling

Desiccant cooling systems use a lithium chloride (LiCl) moisture absorbent (desiccant) material to dehumidify fresh air. The desiccant absorbs the moisture present in the air thereby removing the latent heat load. Conventional mechanical cooling systems can then be used to remove the remaining sensible cooling load. Once the desiccant becomes saturated with moisture it must be regenerated by heating with warm air using either a gas burner or possibly solar energy.

<i>Energy Savings over baseline cooling energy</i>	13%
<i>Cost (\$/ton)</i>	costs unknown at this time
<i>Life (yrs)</i>	20

Applicability/Availability

Desiccant cooling can be applied to all existing and new commercial buildings. The technology is relatively new and has only been commercially available since 1985. Two companies in the U.S. in co-operation with the Gas Research Institute (GRI) have developed roof top type desiccant/evaporative cooling systems.

7.5.4 Solar Driven Absorption Cooling

Cooling loads in commercial buildings can be met with solar powered lithium bromide (LiBr) absorption refrigeration systems. Single-effect absorption systems can, depending on the load and ambient temperatures, use flat plate or evacuated solar collectors to effectively meet the air conditioning loads in commercial buildings. This technology is still under development. Performance (solar fraction) and expected commercial production costs are unknown at this time.

7.6 HVAC/Ventilation Equipment Improvements

7.6.1 Variable Air Volume Systems (VAV) - Variable Inlet Vanes & Variable Speed Fans

A VAV ventilation system varies the air flow delivered to the space in response to the actual cooling/heating load sensed by "zones" located in the space. The "zones" which can serve areas ranging from 50 m² - 200 m² are served by VAV ventilation "boxes". The boxes contain a modulating air flow damper that is controlled by thermostats located in the space. Their task is to provide the largest volume of air at summer design conditions and the lowest at winter design conditions. As the outside air temperatures drop and the boxes close their dampers, the total ductwork pressure rises which signals the main fans to throttle back. This last action provides energy savings since the energy consumption by fans varies in proportion to the cube of the air flowrate. The reduction in air flow can be attained through either variable inlet guide vanes or variable frequency drives. The last method is more efficient and provides a higher modulation range but is difficult to retrofit on buildings which already use variable inlet guide vanes. The use of a synchronous belt can provide additional energy savings because of the reduced slip which normally represents 3% to 5% of the fan energy.

<i>Energy Savings</i> ⁴³	20%	HVAC Electricity Energy (fan energy savings)
	20%	Ventilation Heating Energy
	10%	Ventilation Cooling Energy

<i>Cost (\$/m²)</i>	Exist. Bldgs.	\$20
	New Bldgs.	\$8

<i>Life (yrs)</i>	30-40

Applicability/Availability

VAV systems are applicable to existing and new buildings. The technology is limited to air handling systems of more than 2,500 L/s. (5,000 CFM). The technology has been in use for

⁴³ Energy savings over conventional CAV assuming variable frequency drive.

over 15 years and is well understood. Manufacturers of fans and roof top equipment carry a wide selection of VAV products. Reliable variable frequency drives are available to serve motors as low as 3.7 kW (5 HP).

7.6.2 Compartmental VAV Systems

Compartmental VAV systems can be considered a generation above or evolution beyond central VAV systems. In a compartmental VAV configuration, individual air handling units are installed on every floor rather than a single large air handling unit located on the roof. The advantage of compartmental systems are:

- lower overall ductwork static pressures since supply and return ducts have shorter runs (no supply and return risers going up to the AHU located in the penthouse) with consequent lower connected fan loads,
- increased flexibility in speculative type buildings or buildings with a diverse occupancy schedule (only fans serving floors with diverse/extended schedules have to operate as opposed to an entire AHU), and
- increased flexibility to meet tenants' comfort needs more effectively.

<i>Energy Savings</i>	40%	HVAC Electricity Energy (fan energy savings)
	20%	Ventilation Heating Energy
	10%	Ventilation Cooling Energy

<i>Cost (\$/m²)</i>	Exist. Bldgs.	\$90
	New Bldgs.	\$45

<i>Life (yrs)</i>	30-40

Applicability/Availability

Compartmental VAV systems are applicable to new and large renovations. This technology is limited to large commercial buildings. The technology has been in use for over 15 years and is well understood. Manufacturers of fans and roof top equipment carry a wide selection of VAV products. Reliable variable frequency drives are available to serve motors as low as 3.7 kW (5 HP).

7.6.3 Low Temperature Distribution

Low temperature distribution (LTD) is simply the use of supply air at temperatures of 7 - 11°C (44 - 52 °F) rather than 13 - 16 °C (55 - 60 °F) used by conventional ventilation systems. The

lower temperatures translate into lower air flows to meet a given cooling load. This translates into fan and pump energy savings. A second benefit derives from construction costs savings associated with smaller ductwork, smaller fans and pumps, and smaller air handling units. Best results are obtained if some form of thermal (cold) storage (e.g., thermal energy storage -- TES) is used with LTD.

<i>Energy Savings</i>	25 % HVAC Electricity Energy (fan energy savings)
	25 % ⁴⁴ Ventilation Cooling Energy

<i>Cost (\$/m²)</i>	Exist. Bldgs.	\$15
	New Bldgs.	\$0

<i>Life (yrs)</i>	40

Applicability/Availability

LTD can be applied to new buildings and large renovations in existing buildings. The technology is relatively new and presently not well understood by HVAC designers. Although in principle the technology is very simple, it requires designers to move away from their current off-the-shelf designs and perform LTD designs from first principles in order to achieve the savings claimed.

7.6.4 Displacement Ventilation

Displacement ventilation systems are 100% outside air systems. This type of air distribution system provides the occupied space with only the minimum required volume of fresh air (0.25 - 0.4 L/s.m²) rather than the more common 3.8 - 5.1 L/s.m² used by conventional return air systems. Substantial savings in fan energy result since only one-fifth the volume of air has to be moved. Other features of the system include heat exchangers between the exhaust and supply air streams to preheat the outside air in the wintertime and precool it in the summertime. The smaller air flows also translate into smaller ductwork with hardware cost savings (less sheetmetal, smaller AHU's, smaller fans) and lower heights between floor plates with a possible increase in revenue. Displacement ventilation systems demand an extremely efficient lighting system (< 8 W/m² connected lighting load). This system is an ideal candidate for super efficient buildings.

⁴⁴ Net of lower reduction in chiller performance.

<i>Energy Savings</i>	85%	HVAC Electricity Energy (fan energy savings)
<i>Cost (\$/m²)</i> New Bldgs.	It is difficult to estimate the additional cost (if any) associated with this technology under North American conditions.	
<i>Life (yrs)</i>	40	

Applicability/Availability

Displacement ventilation is only applicable to new construction due to the extreme design differences over conventional systems. Air is distributed through the floor instead of the ceiling. Radiant cooling panels are also required in the space to effectively meet the cooling load. The technology is only known in Europe. There are probably only a few small scale examples of this technology in North America. The very different design of this ventilation system represents the biggest availability barrier.

7.6.5 Air/Water Balancing

The common practice of using repeated off-the-shelf designs and safety factors by HVAC designers tends to produce oversized systems that normally provide higher ventilation rates than needed. A second problem that compounds this is repeated tenant fit-ups. Careful air balancing and water balancing are essential steps in reducing air flows and water flows in most existing commercial buildings.

<i>Energy Savings</i>	27%	HVAC Electricity Energy (fan energy savings)
	10%	Ventilation Cooling Energy
<i>Cost (\$/m²)</i> Exist. Bldgs.	\$2.50	
<i>Life (yrs)</i>	20	in a well maintained building

Applicability/Availability

Air and water balancing is only applicable to existing buildings.

7.6.6 Building Automated Systems & Direct Digital Control (BAS & DDC)

Energy savings are possible through integration of all operation and control of building HVAC systems via a building automated system (BAS). The BAS provides energy savings in three areas as follows:

- optimized scheduling (time of day use, duty cycling, optimal start/stop) of fans and pumps,
- optimized operation of dampers, valves and other modulation flow control devices through the use of proportional- integral control (PI) as opposed to proportional only control, and
- enhanced control strategies such as discharge air reset, chilled water reset, condenser water reset, demand limiting control, night flushing, optional start-stop, duty cycling.

<i>Energy Savings</i> ⁴⁵	20%	HVAC Electricity Energy (fan energy savings)
	5%	Ventilation Heating
	5%	Ventilation Cooling Energy

<i>Cost</i> ⁴⁶ (\$/m ²)	Exist. Bldgs.	\$18
	New Bldgs.	\$6

<i>Life (yrs)</i>	10

Applicability/Availability

BAS can be installed in existing and new buildings. The technology is limited to large commercial buildings. The technology has been in use for approximately 10 years and is widely available from a large number of manufacturers.

⁴⁵ Energy Savings are for a conventional VAV or CAV HVAC system with pneumatic controls. The savings shown are a result of replacing proportional control with proportional integral control. This reduces the OFFSET an estimated 0.5 to 1.0°C (1 to 2°F). All the savings would occur at the main air handling unit.

⁴⁶ Costs of direct digital control (DDC) systems are higher for newer buildings because the trend is to "full DDC" which includes the mechanical room and the occupied space. This is tripling the point count over the existing building. A point is defined as a piece of equipment that is controlled/monitored by a centralized facility management system such as fan, pump, lights, dampers, valves. It can also be a condition such as space temperature, relative humidity, pressure, flow etc.

7.6.7 Energy Efficient Motors

Energy efficient (EE) motors exhibit a more efficient conversion of electrical energy to mechanical energy than standard motors. The increase in efficiency is typically achieved through reduction in the magnetic and resistive losses by using better grades of steel and more copper in stators and rotors. Typically the smaller the motor the higher the gain in efficiency.

Performance (Efficiency)

	Standard Efficiency	Enhanced Efficiency
1 - 5 HP	80%	85%
5 - 20 HP	86%	90%
20 - 50 HP	88%	92%
> 50 HP	92%	94%

Energy Savings 3-6% over standard efficiency motors

Cost (\$/HP) 1 - 10 HP	\$75	standard efficiency motors
	\$100	enhanced efficiency
10 - 50 HP	\$50	standard efficiency
	\$60	enhanced efficiency
> 50 HP	\$35	standard efficiency
	\$40	enhanced efficiency

Life (yrs) 25

Applicability/Availability

EE motors can be applied to existing and new buildings. They are available from a large number of manufacturers.

7.6.8 Variable Speed Pumping

The use of variable speed pumping (VSP) enables the flow of chilled or hot water in HVAC applications to be varied in response to the actual space load. Most commercial applications can benefit from variable speed pumping in hot water applications. Energy savings are realized through optimization of the flow since the pumping energy varies as the cube of the flow rate. From a hardware standpoint a variable speed pumping system requires a variable frequency drive (VFD) and a control loop to control the VFD.

<i>Energy Savings</i>	30%	HVAC Pump Electricity Energy (pump energy savings)
<i>Cost (\$/m²)</i>	\$4	
<i>Life (yrs)</i>	20	

Applicability/Availability

The technology can be applied to existing and new buildings. It is restricted however to large commercial facilities that will have pumps over 10 HP. VSP has been used in industrial applications for quite sometime. Its use in commercial HVAC applications was introduced less than 10 years ago. Both VFD and controls necessary to produce a VSP system are available from multiple vendors.

7.7 Service Water Heating Equipment

7.7.1 Low Flow Shower Heads & Faucet Aerators

Service hot water use in commercial buildings can be reduced with faucet aerators and low flow shower heads. These devices are screw-in inserts that deliver a stream of "aerated" water. The aerated water stream is generated by passing the water through a narrow flow restrictor and onto a spray plate where it mixes with incoming air. Both faucet aerators and low flow shower heads can reduce flow rates by 50% to 60% with little or no perceptible reduction in service usefulness. The energy savings only apply to the portion of service hot water used for wetting and shower services. Other services such as food preparation and dishwashing cannot tolerate the reduction in actual flow rates.

<i>Energy Savings</i>	50%	service hot water wetting use
<i>Cost (\$/fixture)</i>	\$5	faucet aerator
	\$11	low flow shower head
<i>Life (yrs)</i>	10	

Applicability/Availability

Both the faucet aerators and low flow shower heads are screw-in units that can easily be installed in existing and new facilities. The products are available in a very extensive number of models from a large number of manufacturers

7.7.2 Refrigerant Heat Recovery

Commercial buildings that have a large refrigeration load or that use air conditioning year round can take advantage of the heat available from the refrigeration equipment to preheat service hot water. The refrigerant heat recovery or desuperheater heat recovery, consists of a heat exchanger that recovers the refrigerating cycle heat that is normally rejected to the atmosphere via the condenser. This requires the installation of an additional condenser or pre-condenser (heat exchanger) between the compressor and the existing condenser to transfer the heat present in the high pressure refrigerant to service hot water. Buildings that can take advantage of this heat are normally buildings with large refrigeration loads such as large supermarkets, large hotels and refrigerated warehouses. Ice skating arenas are another segment that can take advantage of desuperheaters during the skating season. In BC there are few buildings that require air conditioning year round. The energy savings attainable are a function of the available refrigeration load, number of hours of operation and service hot water use, and as a result can range from 20% to 90%.

7.8 Refrigeration Equipment

7.8.1 Unequal Capacity Multiplexed Compressors

Large supermarkets and refrigerated warehouses with single dedicated compressors serving individual refrigerated cases or walk-in coolers can realize energy savings through the use of central unequal capacity multiplexed compressors with state-of-the-art controls. The central multiplexed compressors are normally installed with other advanced features such as hot gas defrost (as opposed to the more conventional electric defrost) and floating head pressure control.

Energy Savings 20% refrigeration energy use

Cost (\$/m²) \$12

Life (yrs) 20

Applicability/Availability

The centralized refrigeration system described can be applied to existing and new construction. In BC, the penetration of this technology in new construction is presently very high, especially in large supermarkets.

7.8.2 Door/Cover Upgrade

Glass doors installed in open and multideck reach-in refrigerated cases will reduce the total cooling load imposed on the case. The glass doors are normally double or quadruple pane systems mounted in an insulated metal frame. Savings that can typically be achieved are 25% of the energy used by the case. Open and multideck cases represent approximately 40% of the total refrigeration load in a typical 3,000 m² supermarket. Based on this, the net energy savings are 10% (0.25 X 0.4) of the total refrigeration load.

<i>Energy Savings</i>	10-15%	refrigeration energy use

<i>Cost (\$/m²)</i>	\$12	

<i>Life (yrs)</i>	15	

Applicability/Availability

Glass door technology can be applied to new and existing buildings. The product is available from multiple manufacturers.

7.9 Office Equipment

Energy use by office equipment can be reduced, in most cases at no cost, by specifying more efficient equipment when it is purchased. The technologies used to achieve a reduction in office equipment energy use are as follows:

- *Use of efficient desktop computers with power management software.* This software is the same software used in laptops to minimize energy use in the input/output devices. The software is available from manufacturers for a nominal fee. Another avenue to reduce energy use is through a more widespread use of laptop computers in the office space. They use a fraction of the electrical energy that desktop computers use. Forecasts indicate that as the laptop desktop price differential narrows, the incidence of use of laptops in the office space will accelerate due to their higher versatility. The last avenue that offers savings in energy use by computers is the introduction of large scale efficient flat screens such as LCD and electroluminescent screens which will reduce the CRT consumption by over 90%. The above three avenues are estimated to reduce consumption by 50%. The net savings, taking into account that computers represent approximately 30% of the total office equipment energy use, is 15%.

- *Use of ion deposition photocopiers with high "turn-down" power use ratios or efficient power management software.* Historically such products have been available at virtually no cost increment. The only requirement is a careful/wise buyer. A second area of savings is with the use of ion deposition photocopying as opposed to the more conventional hot fuse or xerographic process for large capacity photocopying. The ion deposition technology uses 50% less energy than the hot fuse process.
- *Use of high quality ink-jet printers to replace low volume low quality laser printers.* The savings from the use of efficient photocopiers plus a more widespread use of ink-jet printers will reduce energy consumption by "reproduction" components of office equipment by an estimated 30%. This represents a net 3% savings of the office equipment energy use (reproduction by copiers and printers represents 10% of the total office equipment use).

PART IV

CONSERVATION POTENTIAL

8. FROZEN EFFICIENCY

8.1 Calibration of End-Use Model Against BC Hydro Sales

The first step in estimating Frozen Efficiency and Conservation Potential was to calibrate the computer model used for this analysis.

Table 8.1 provides a summary of annual electricity use by building segment and end-use in 1988 which was estimated by multiplying end-use intensities (EUI) for existing buildings by fuel share, saturation and floor area. The average intensity (total electricity use divided by floor area) is also shown for each building segment. The estimates were made using a spreadsheet model which uses EUIs for each end-use, building segment and vintage drawn from the Typical Building Profiles given in Appendix 6.

Table 8.2 compares these model estimates with BC Hydro sales for 1988 from Table 2.3. Note that high rise (> 4 stories) apartment consumption includes 400 GWh/year of electricity for suite electricity in high rise apartments, whereas BC Hydro includes this in the residential sector.

Electricity consumption predicted by the end-use model for 1988 agreed well with BC Hydro sales data on a sectoral basis. There were, however, wide variations for certain sectors such as Hotel and Motel (-16%), Nursing Homes (32%) and Non-Food Retail (20%) which reflects the inadequate floor space estimates available for the analysis.

Because of the wide variations apparent on a building segment by building segment basis, no attempt was made to calibrate the computer model results against 1988 BC Hydro sales.

The estimates of Frozen Efficiency electricity consumption and Conservation Potential in the following four chapters are based on model predictions (including high rise suite electricity). The percentage reductions in electricity use for each set of conservation assumptions are then applied to actual BC Hydro sales in Chapter 12 to provide comparable forecasts.

TABLE 8.1

1988 ELECTRICITY USE IN THE BC COMMERCIAL SECTOR (EUI X FS X SAT. FLOOR AREA) -- MODEL ESTIMATE

	General Lighting (GWh)	Service Area Lighting (GWh)	Other Lighting (GWh)	Space Heating (GWh)	Space Cooling (GWh)	HVAC Electricity (GWh)	Service Hot water (GWh)	Cooking Equipment (GWh)	Refrig. Equipment (GWh)	Office Equipment (GWh)	Misc. Equipment (GWh)	Total (GWh)	Average Intensity (kWh/ft ²)
Large Office (> 3,700 m ²)	90.6	23.6	3.3	7.4	19.6	36.7	0.4	0.5	3.4	30.7	11.7	227.9	21.7
Small Office (< 3,700 m ²)	708.6	184.6	25.9	233.0	177.4	228.8	2.9	4.1	25.2	230.1	26.2	1846.7	23.5
Non-Food Retail	618.1	556.4	19.2	73.6	270.2	191.8	0.9	3.8	17.8	112.4	12.2	1876.5	25.8
Food Retail	96.8	55.2	2.5	24.9	30.0	34.7	1.6	18.1	414.6	21.5	26.9	726.7	67.5
Restaurant/Tavern	60.7	56.9	0.0	95.3	29.0	98.5	24.5	52.4	55.0	10.5	25.8	508.6	52.5
Hotels/Motels	103.7	38.9	16.1	99.4	43.2	29.5	20.4	23.1	8.6	58.8	9.7	451.3	17.1
Warehouse/Wholesale	360.8	45.2	0.0	107.7	17.4	23.8	1.0	3.7	35.0	76.7	35.0	706.4	9.9
Hospitals	31.7	41.3	9.1	8.8	22.9	97.9	2.4	10.6	8.7	56.9	6.9	297.1	22.1
Nursing Homes	31.1	28.7	0.0	35.1	13.8	8.8	2.8	1.7	8.1	9.9	3.5	143.6	13.7
Universities/Colleges	115.8	37.2	0.0	1.1	20.8	86.1	2.8	5.7	5.2	22.4	7.8	304.9	15.2
Schools	209.7	101.0	0.0	78.2	7.0	24.5	10.7	3.9	16.2	14.6	0.6	466.5	7.4
High Rise Apartments	88.8	140.7	0.0	263.8	17.6	66.9	58.1	12.3	46.5	69.7	16.5	780.6	15.6
Miscellaneous	201.5	37.4	6.7	69.5	66.2	59.9	0.8	0.0	0.0	31.5	11.7	485.2	12.9
Total	2,717.9	1,347.0	82.8	1,097.9	735.0	987.9	129.3	139.8	644.2	745.7	194.5	8,822.0	18.6

EUI: End-Use Intensity
 FS: Fuel Share
 SAT: Saturation

Refrig.: Refrigeration
 HVAC: Heating, ventilation and air conditioning

Table 8.2 Comparison of 1988 Commercial Sector Electricity Sales Data with Model Estimate			
Conservation Review Segments	BC Hydro Sales (GWh)	Model Estimate (GWh)	Difference %
Office (large)	n/a	227.9	
Office (small)	n/a	1,846.7	
Office (total)		2,074.6	-5.8%
Non - Food Retail	2,202.9	1,876.5	19.6%
Food Retail	1,568.3	726.7	1.6%
Retail (total)	715.3	2,603.2	14.0%
Restaurant and Tavern	2,283.6	508.6	-5.9%
Hotel and Motel	540.6	451.3	-15.6%
Warehouse and Wholesale	534.5	706.4	13.4%
Hospitals	622.7	297.1	14.3%
Nursing Homes	260.1	143.6	32.3%
Universities and Colleges	108.5	304.9	14.8%
Schools	265.5	466.5	-3.7%
High Rise Apartments (common areas only)	484.6		
High Rise Apartments (suites only) ¹	192.5	n/a	
High Rise Apartments (total)	400.0	n/a	
	592.5	780.6	31.7%
Other Buildings	439.4	485.2	10.4%
Total	8,335.1	8,822.0	5.8%

¹ It was not possible to separate common area and suite electricity use when modelling high rise apartments. To allow a proper comparison with BC Hydro sales, about 400 GWh/yr, the estimated suite electricity use in high rise buildings (see Residential Study and Table 2.2) was added to the total apartment electricity sales.

8.2 Common Assumptions Employed for Modelling Frozen Efficiency and Conservation Potential

The assumptions used for the modelling analysis were as follows:

- Growth rates for each commercial and institutional building segment are those given in Tables 3.7 and 3.8.
- Space heating, space cooling, service hot water and cooking fuel shares and market saturation remain constant at their 1988 levels for new and existing buildings throughout the study period as per Tables 4.7 and 4.8.
- The use of plug-in equipment increases at the rate of 10% per year for the first five years of the study period, after which it remains constant.
- End-use intensities (EUIs) for all building segments and end-uses in the base year (1988) reflect both 1988 technical and operational practice.

8.3 Description of Frozen Efficiency

A Frozen Efficiency estimate of future electricity consumption assumes that no additional energy efficiency improvements, beyond those which are occurring in the base year, are incorporated into existing and new stock. The Frozen Efficiency forecast therefore established a "worst case" or base level of energy use against which conservation potential can be compared.

Efficiency levels of new equipment being purchased as new or replacement equipment throughout the study period are assumed to remain constant at their 1988 levels. The average cooling intensity in all stock will, therefore, gradually decline over the study period as the percentage of these more efficient units increases.

Assumptions unique to Frozen Efficiency are as follows:

- End-use intensities (EUIs) for all building segments and end-uses in existing and new buildings remain constant at their 1988 levels throughout the study period as per the Typical Building Profiles given Appendix 6.
- Operational practice as described in Section 5 remains at 1988 levels throughout the study period.

- Service levels (e.g. lighting levels) that existed in new and existing buildings in 1988 remain at those levels throughout the study period.
- Equipment, insulation levels and windows in existing (1988) buildings are maintained as is or replaced with equipment with the same efficiency throughout the study period. Equipment, insulation levels and windows in new buildings are the same as in new 1988 buildings throughout the study period.

8.4 Frozen Efficiency Electricity Consumption in BC

Tables 8.3 and 8.4 provide estimates of electricity consumption in 2000 and 2010 assuming Frozen Efficiency broken down by building segment and end-use, respectively. The results were produced using the spreadsheet model described above. All EUIs, fuel shares and saturations were kept constant, while the floor areas were increased in each target year as per Table 3.8. The demolition rate assumed in each building segment were as per in Table 3.9.

The model estimates in Tables 8.3 and 8.4 show that under Frozen Efficiency by 2010, electricity consumption would rise by 74% with high growth, and 42% with low growth. The proportions of electricity used by each building segment are similar to 1988, with Small Office (22%) and Non-Food Retail (21%) having the highest consumption. On an end-use basis, while lighting still represents the highest consumption (45%), plug-in office equipment moves into second place (14%), followed by HVAC electricity (11%).

TABLE 8.3
FROZEN EFFICIENCY MODEL ESTIMATE BY BUILDING SEGMENT

BUILDING SEGMENT	YEAR 1988 ELECTRICITY CONSUMPTION (GWh)	YEAR 2000 ELECTRICITY CONSUMPTION		YEAR 2010 ELECTRICITY CONSUMPTION	
		Low Growth (GWh)	High Growth (GWh)	Low Growth (GWh)	High Growth (GWh)
Large Office (> 3,700 m ²)	227.9	330.8	347.6	391.7	428.6
Small Office (< 3,700 m ²)	1,846.7	2,638.1	2,768.2	3,108.3	3,394.6
Non-Food Retail	1,876.5	2,195.4	2,685.9	2,316.7	3,210.8
Food Retail	726.7	823.3	1,008.8	869.5	1,207.7
Restaurant/Tavern	508.6	602.0	657.9	658.5	759.7
Hotels/Motels	451.3	655.3	736.9	753.7	901.6
Warehouse/Wholesale	706.4	832.9	1,115.6	907.9	1,377.3
Hospitals	297.1	410.8	445.4	468.2	547.2
Nursing Homes	143.6	183.9	198.1	206.9	239.4
Universities/Colleges	304.9	391.8	422.8	442.7	513.4
Schools	466.5	576.5	619.6	645.2	743.5
High Rise Apartments	780.6	942.4	997.6	1,024.7	1,150.8
Miscellaneous	485.2	634.7	687.9	725.2	846.7
Total Consumption	8,822.0	11,217.9	12,692.3	12,519.1	15,321.3
Percent increase over 1988		27%	44%	42%	74%

TABLE 8.4
FROZEN EFFICIENCY MODEL ESTIMATE BY END-USE

END-USE	YEAR 1988 ELECTRICITY CONSUMPTION (GWh)	YEAR 2000 ELECTRICITY CONSUMPTION		YEAR 2010 ELECTRICITY CONSUMPTION	
		Low Growth (GWh)	High Growth (GWh)	Low Growth (GWh)	High Growth (GWh)
General Lighting	2,717.9	3,343.1	3,831.5	3,766.3	4,685.5
Service Area Lighting	1,347.0	1,564.5	1,780.3	1,702.8	2,109.7
Other Lighting	82.8	102.3	113.6	115.3	137.1
Space Heating	1,097.9	1,237.4	1,327.0	1,328.4	1,504.1
Space Cooling	735.0	881.4	998.1	976.5	1,198.9
HVAC Electricity	987.9	1,285.9	1,424.3	1,441.2	1,713.7
Service Hot Water	129.3	158.4	172.5	177.1	205.9
Cooking Equipment	139.8	173.7	199.8	195.8	244.9
Refrigeration Equipment	644.2	746.3	894.3	808.8	1,080.2
Office Equipment	745.7	1,489.8	1,679.0	1,744.0	2,110.9
Misc. Equipment	194.5	235.2	271.9	262.9	330.2
Total Consumption	8,822.0	11,217.9	12,692.3	12,519.1	15,321.3
Percent increase over 1988		27%	44%	42%	74%

HVAC: Heating, ventilation and air conditioning

9. TECHNOLOGICAL POTENTIAL

9.1 Description of Technological Potential

Technological Potential represents an unconstrained look at energy efficiency potential assuming full utilization of all known commercially available and emerging technologies.

Under Technological Potential, all energy using equipment is replaced during the study period with the most efficient options possible. In addition, all existing building envelopes are assumed to be upgraded to the highest practical levels. All new buildings are assumed to be designed and built with the best practical wall and window characteristics and to incorporate any other design features that reduce energy use. Finally, it was assumed that all lighting levels are reduced to their optimum levels during lighting retrofit of existing buildings and in construction of new buildings.

It was assumed, however, that operational practices remain unchanged at their 1988 levels during the study period, i.e. with the operational penalties derived in Section 5 still in place. This is assumed to be true, even where automatic controls are added. Without proper training, there is still the possibility of not achieving the savings because of uninformed staff.

Descriptions of the various technological options for reducing energy use in commercial buildings were given in Section 7. The following sub-sections summarize the "packages" of these technologies and measures which could obtain the largest reduction in energy use. Each end-use is addressed in turn, and the reduced Energy Use Index (EUI) is derived in each case. Interactive effects such as the impact of reduced lighting and plug loads on heating and cooling loads, are taken into account where they are significant.

Where the most efficient technologies are still under development, their use is assumed not to occur until after 2000. A two stage implementation process is assumed to occur, such that all currently available technology is in use by 2000, and new technology is added before 2010. This approach may over estimate the savings in 2000 because some equipment will not have been replaced by then. By 2010, however, all equipment should have been replaced at least once.

All building features that are not related to efficient technologies and measures are assumed to remain as set out in the Typical Building Profiles described in Section 6. All fuel shares remain constant as described in Section 4.

9.1.1 Lighting

Efficient lighting technologies were assumed to be implemented in two stages. The first stage includes currently available technologies and measures which will be implemented starting immediately until the year 2000. These technologies are:

- T8 envelopes + specular reflectors + dimmable electronic ballasts (with photo-sensors) + optimum light levels/task tuning
- Automatic lighting control systems + occupancy sensors
- Replacement of incandescent lamps with CFL
- Replacement of MV and MH HID lamps with HPS HID lamps

The second stage assumes that induction lamps and "Two-Photon" lamps (which are now under development) will be implemented after the year 2000 and before 2010. All lighting applications will use the "Two-Photon" lamps. Dimmable electronic ballasts, daylight enhancement and optimum light levels will also form part of the upgrade. All of the above technologies were described in Section 7.2.

The following three subsections show how the "packages" of the above technologies reduce the EUIs of fluorescent, incandescent and HID lighting in a typical office building.

Fluorescent Lighting for General Lighting

Summary:

The use of state-of-the-art lighting systems in existing and new buildings is estimated to reduce connected lighting loads by approximately 75% to 80%. Dimmable electronic ballasts allow "task tuned" light levels of approximately 300 lux as opposed to the baseline 900 to 1000 lux OVERALL light levels, and allow use of daylighting in perimeter areas. After the year 2000, T8 envelopes are assumed to be replaced with "Two-Photon" lamps.

The example below shows how the reductions in connected load and EUIs are achieved.



Baseline System:

The baseline system is a fixture with two 4 foot T12 F40 40W lamps with a standard core and coil ballast drawing 12 W. This combination displays an efficacy of 70 lumens/Watt (3,300⁴⁷ initial lumens * 2 lamps & 92W input power). A coefficient of utilization (CU), and light loss factor (LLF) of 0.7 are assumed. Illumination is assumed to be 95 foot candles (1000 lux). The scheduling factor is assumed to be 1.15, the floor fraction 0.75, and the hours of operation 3,100 hours/year.

$$\begin{aligned}\text{Baseline Connected Light Load (W/m}^2\text{)} &= 95/70/0.7/0.7*10.76 \\ &= 29.6 \text{ W/m}^2\end{aligned}$$

$$\begin{aligned}\text{Baseline EUI (MJ/m}^2\text{.yr)} &= 29.6*3,100*3.6/1000*1.15*0.75 \\ &= 284.9 \text{ MJ/m}^2\text{.yr}\end{aligned}$$

1st Technology Change: Specular Reflectors

Use of specular reflectors improves the efficiency of the fixture 10% to 15%⁴⁸. This is equivalent to increasing the CU by 10% to 15% which allows the removal of some lamps without sacrificing light levels more than 25%. In the analysis, the CU is assumed to increase from 0.7 to 0.8 which is a 14% increase. The light level is also reduced by an estimated 25% to 71.2 foot candles (fc) (95*0.75). The reflector will cut the number of lights from 30% to 50% depending on fixture type. The new connected light load as a result of the changes is:

$$\begin{aligned}\text{Revised connected load} &= 71.2/70/0.8/0.7*10.76 \\ &= 19.5 \text{ W/m}^2\end{aligned}$$

$$\begin{aligned}\text{Revised EUI (MJ/m}^2\text{.yr)} &= 19.5*3,100*3.6/1000*1.15*0.75 \\ &= 187.7 \text{ MJ/m}^2\text{.yr}\end{aligned}$$

This represents a 34% reduction in connected load and energy consumption over the baseline fixture.

⁴⁷ The initial lumens for F40 lamps range from 3100 to 3500 lumens. An intermediate value was chosen as a conservative estimate. Lamps that display 3300 initial lumens are available from all manufacturers as follows: GE Maximiser Series F40SP30, SP35; GTE Designer Series F40D40, D35; Philips Ultralume F4030U, 35U.

⁴⁸ See the following two references:

Competitek, "The State of the Art Lighting", p. 137-138.

National Lighting Product Information, *Specifier Reports*, "Electronic Ballasts", The Lighting Research Center, Rensselaer Polytechnic Institute, Dec., 1991.

2nd Technology Change: T8 envelopes and Daylighting

The use of T8 envelopes plus daylighting for the perimeter of the building is assumed to increase the efficacy from the baseline 70 Lumens/W to 100 Lumens/W. Note that the efficacy of T8 envelopes is approximately 80 to 90 Lumens/W ⁴⁹. The additional increase in efficacy to 100 Lumens/W is a surrogate method ⁵⁰ to show the contribution from daylighting which allows the use of less power (through proportional dimming of ballasts) while maintaining the same light level. For example, if daylighting contribution to the perimeter allows the reduction in the light output from the perimeter lighting by 50% while maintaining the same light level⁵¹, and the building perimeter represents 30% of the total floor area, the resulting new efficacy is determined as follows:

Assume T8 envelope with an efficacy of 85 Lumens/W, light level of 71.2 foot candles
0.8 CU and 0.7 LLF.

$$\begin{aligned}\text{Connected light load} &= 71.2/85/0.8/0.7*10.76 \\ &= 16.1 \text{ W/m}^2\end{aligned}$$

Effective connected load or power draw with daylighting contribution

$$\begin{aligned}&= 16.1*0.7 + 16.1*.5*.3 \\ &= 13.7 \text{ W/m}^2\end{aligned}$$

$$\begin{aligned}\text{Effective efficacy} &= 71.2/13.7/0.8/0.7*10.76 \\ &= 100 \text{ Lumens/W}\end{aligned}$$

$$\begin{aligned}\text{EUI} &= 13.7*3,100*3.6/1000*1.15*0.75 \\ &= 131.9 \text{ MJ/m}^2.\text{yr}\end{aligned}$$

This represents a 54% reduction in connected load and energy consumption over the baseline fixture.

⁴⁹ i) Competitek, *"The State of the Art, Lighting"*, p. 123. T8 envelopes display efficacies of 78-95 Lumens/W.

ii) Competitek, *"The State of the Art, Lighting"*, APPENDIX H, P. 290, 292, GE & Sylvania T8 lamps display initial efficacies of 90-95 Lumens/W.

iii) Advance Transformer Co., *"Realities in Retrofitting"*, p. 11, F32T8 + ballast display efficacies of 84-86 Lumens/W.

iv) National Lighting Product Information Program, *"Specifier Report, "Electronic Ballasts"*, p. 3 Table 1, efficacy of 2-32W F32 T8 lamps with electronic ballast displays an efficacy of 90 Lumens/W.

⁵⁰ Competitek, *The State of the Art Lighting*, p. 196

⁵¹ In this analysis, it is assumed that perimeter lighting systems are dimmed to 50%. At this level, the ratio of power reduction to the reduction in lumen output is 1:1.



3rd Technology Change: Optimum Light Levels

Optimum light levels are made possible through the use of dimmable electronic ballasts which allow task tuning of each fixture through adjustment of the ballast max/min outputs. This reduces light levels to a weighted average of 35 fc. The reduction in connected load is proportional to the reduction in light levels which is equal to:

$$\begin{aligned}\text{connected load} &= 35/71.2*13.7 \\ &= 6.7 \text{ W/m}^2 \\ \text{EUI} &= 6.7*3,100*3.6/1000*1.15*0.75 \\ &= 64.5 \text{ MJ/m}^2.\text{yr}\end{aligned}$$

This represents a 77% reduction in connected load and energy consumption over the baseline system. Note that daylighting contributes the same percentage at the reduced light levels, but a lower absolute amount of light.

4th Technology Change: 2-Photon Lamps

The use of 2-Photon Lamps which are predicted to be available in the late 1990's will provide additional savings due to the much higher efficacy that these lamps display over T8 lamps (see Section 7). These lamps are expected to display efficacies of 200 Lumens/W or more. Including perimeter daylighting will increase this value to an effective 230 Lumens/W. The resulting connected load and EUI is:

$$\begin{aligned}\text{connected load} &= 35/230/0.8/0.7*10.76 \\ &= 2.9 \text{ W/m}^2 \\ \text{EUI} &= 2.9*3,100*3.6/1000*1.15*0.75 \\ &= 27.9 \text{ MJ/m}^2.\text{yr}\end{aligned}$$

This represents a 90% reduction in connected load and energy consumption over the baseline system.

5th Technology Change: Automatic Lighting Controls and Occupancy Sensors

The use of ALC's and occupancy sensors will reduce the hours of operation during the occupied period (due to intermittent use of the space) and the unoccupied period by shutting off lights completely when not needed. The reduction in operating time is estimated to be 20%. The new EUI's for the T8 lighting systems and 2-Photon Lamps would be:

	EUI (MJ/m ² .yr.) (no ALC's or Sensors)	EUI (MJ/m ² .yr.) (ALC's + Sensors)
T8 System	64.5	52
2-Photon Lamps	27.9	22.5

The reduction in energy consumption that results from the use of ALC's and occupancy sensors in addition to the systems above would therefore be 82% for T8 lighting systems and 92% for 2-Photon Lamps.

Incandescent Lighting for Service Area Lighting

All incandescent lamps are assumed to be replaced with CFL envelopes. Optimum light levels are also used to ensure that CFL's can meet all applications. After the year 2000, all CFL's and incandescent lamps are assumed to be replaced with "Two-Photon" lamps. The example below shows how the reduction in connected load and EUI are achieved.

Baseline System: 75W incandescent recessed lighting systems (efficacy of 15 lumens/watt)
Light level = 300 lux
Connected light load: 20 W/m² (service area use)
Hours of operation: 5800
Scheduling factor = 1.15
Floor fraction = 20%
Baseline EUI = 96 MJ/m². yr

Compact Fluorescent

Lamp: Light level = 300 lux
Efficacy = 55 lumens/watt
Connected load = 6 W/m²
EUI = 28.8 MJ/m².yr
Reduction = 70%

2-Photon Lamp: Efficacy = 200 lux
Light level = 300 lux
Connected load = 1.5 W/m²
EUI = 7.2 MJ/m².yr
Reduction = 92%

HID Lighting for High Bay Lighting

All MV and MH HID lamps are replaced with colour corrected HPS lamps. After the year 2000, all MH and HPS lamps are assumed to be replaced with "Two-Photon" lamps.

The example below shows how the reduction in connected load and EUI are achieved

Baseline System:

The baseline system for large offices is MV lamps displaying an efficacy of 65 Lumens/W. Illumination is assumed to be 30 foot candles, a CU equal to 0.6, and LLF is 0.7. A scheduling factor is assumed to be 1.15, the floor fraction 0.05, and hours of operation 5,000 hrs./yr.

$$\begin{aligned}\text{Baseline Light Load (W/m}^2\text{)} &= 30/65/0.7/0.6*10.76 \\ &= 11.8 \text{ W/m}^2\end{aligned}$$

$$\begin{aligned}\text{Baseline EUI (MJ/m}^2\text{.yr)} &= 11.8*5,000*3.6/1000*1.15*0.05 \\ &= 12.2 \text{ MJ/m}^2\text{.yr}\end{aligned}$$

Technology Change: Replace MH with colour corrected HPS

The MH lamps are replaced with colour corrected HPS lamps which display a better CRI than MH. The efficacy rises from 65 Lumens/W to 90 Lumens/W. All other parameters remain the same. The new connected light load and EUI are:

$$\begin{aligned}\text{New Connected Load (W/m}^2\text{)} &= 30/90/0.7/0.6*10.76 \\ &= 8.5 \text{ W/m}^2\end{aligned}$$

$$\begin{aligned}\text{New EUI (MJ/m}^2\text{.yr)} &= 8.5*5,000*3.6/1000*1.15*0.05 \\ &= 8.8 \text{ MJ/m}^2\text{.yr}\end{aligned}$$

This represents a reduction of 28% over the baseline system.

Technology Change: Replace MH with 2-Photon Lamp

The last technology change is to replace the HPS with the 2-Photon lamp which has an efficacy of 230 Lumens/W. This will be done in the year 2010. The new connected load and EUI are:

$$\begin{aligned}\text{New Connected Load (W/m}^2\text{)} &= 30/230/0.7/0.6*10.76 \\ &= 3.3 \text{ W/m}^2\end{aligned}$$

$$\begin{aligned}\text{New EUI (MJ/m}^2\text{.yr)} &= 3.3 * 5,000 * 3.6 / 1000 * 1.15 * 0.05 \\ &= 3.4 \text{ MJ/m}^2\text{.yr}\end{aligned}$$

This is a 72% reduction over the baseline system.

Table 9.1 shows the comparison in connected light loads between baseline and the technical potential for the three lighting applications under study: general, service and high bay. The proportions of fluorescent, incandescent and HID lighting used in each lighting application are assumed to remain constant over the study period as given in the Typical Building Profiles described in Appendix 6.

Tables showing the calculation of lighting loads for each lighting application and building segment are given in Appendix 7. The tables show how the light level, lamp efficacy, coefficient of utilization, and proportion of each lamp type are used to calculate lighting loads.

The resulting lighting EUIs for the years 2000 and 2010 are given in Table 9.2 along with the baseline (1988 and Frozen Efficiency) EUIs for comparison.

Note that in some building segments, lighting loads in new buildings are higher than those in existing buildings because of a combination of higher light levels and a different mix of lighting systems.

9.1.2 Space Heating

The technologies used to reduce building space heating energy use to a minimum were as follows:

- upgrade building envelope to maximum practical levels (retrofit existing)
- install heat recovery ventilation equipment
- replace electric resistance and air source heat pumps with unitary water source heat pumps

These technologies and measures were described in Section 7.3.

The space heating energy load (tertiary load) is the sum of the heat loss through the envelope and the energy required to heat makeup ventilation air, net of the useable internal gains from lighting and office equipment, etc. The heating energy requirement (secondary load) is the heating load divided by the heating equipment efficiency.



TABLE 9.1
TECHNOLOGICAL POTENTIAL
COMPARISON OF BASELINE & UPGRADE CONNECTED LIGHT LOADS

EXISTING BUILDINGS	BASELINE			UPGRADE 2000			UPGRADE 2010		
	General Lighting (W/m ²)	Service Area Lighting (W/m ²)	High Bay Lighting (W/m ²)	General Lighting (W/m ²)	Service Area Lighting (W/m ²)	High Bay Lighting (W/m ²)	General Lighting (W/m ²)	Service Area Lighting (W/m ²)	High Bay Lighting (W/m ²)
Large Office (> 3,700 m ²)	34.8	17.8	11.8	6.7	5.1	8.5	2.9	1.7	3.3
Small Office (< 3,700 m ²)	34.8	17.8	11.8	6.7	5.1	8.5	2.9	1.7	3.3
Non-Food Retail	44.4	19.2	11.8	14.1	5.3	8.5	4.6	1.7	3.3
Food Retail	39.8	16.5	11.8	6.3	4.8	8.5	2.2	1.7	3.3
Restaurant/Tavern	22.0	26.1	0.0	7.8	6.6	0.0	1.9	1.8	0.0
Hotels/Motels	15.8	25.6	14.3	5.8	8.8	8.4	1.4	1.9	3.1
Warehouse/Wholesale	19.2	11.0	0.0	10.1	3.8	0.0	3.6	1.7	0.0
Hospitals	27.4	11.4	7.9	8.5	4.3	5.7	3.0	1.7	2.2
Nursing Homes	13.7	9.1	0.0	6.0	4.3	0.0	2.1	1.7	0.0
Universities/Colleges	20.7	11.0	0.0	8.4	4.8	0.0	3.1	1.7	0.0
Schools	18.4	9.1	0.0	8.3	4.3	0.0	3.1	1.7	0.0
High Rise Apartments	17.8	22.0	0.0	6.2	7.8	0.0	1.4	1.9	0.0
Miscellaneous	21.8	11.0	11.7	8.5	4.8	8.0	3.2	1.7	3.2
NEW BUILDINGS									
Large Office (> 3,700 m ²)	32.9	16.5	11.7	6.7	4.8	8.5	2.9	1.7	3.3
Small Office (< 3,700 m ²)	32.9	16.5	11.7	6.7	4.8	8.5	2.9	1.7	3.3
Non-Food Retail	44.4	16.5	11.8	14.1	4.8	10.2	4.6	1.7	3.3
Food Retail	41.4	19.2	11.8	5.9	4.8	8.5	2.2	1.7	3.3
Restaurant/Tavern	21.0	27.4	0.0	7.5	7.8	0.0	1.8	1.9	0.0
Hotels/Motels	20.2	25.6	14.3	5.8	8.8	8.4	1.4	1.9	3.1
Warehouse/Wholesale	18.4	11.0	0.0	10.4	3.8	0.0	3.6	1.7	0.0
Hospitals	22.9	12.6	8.4	7.6	4.6	5.7	3.0	1.7	2.2
Nursing Homes	18.3	11.0	0.0	6.8	4.8	0.0	1.8	1.7	0.0
Universities/Colleges	22.1	11.0	0.0	7.4	4.8	0.0	3.0	1.7	0.0
Schools	18.4	9.1	0.0	7.4	4.3	0.0	3.0	1.7	0.0
High Rise Apartments	22.9	9.6	0.0	4.0	4.0	0.0	0.9	1.3	0.0
Miscellaneous	34.4	13.7	11.7	11.3	5.1	8.0	3.4	1.4	3.2

TABLE 9.2
TECHNOLOGICAL POTENTIAL
COMPARISON OF BASELINE & UPGRADE LIGHTING ENERGY INTENSITIES

	BASELINE			UPGRADE 2000			UPGRADE 2010		
	General Lighting (MJ/m ² .yr)	Service Area Lighting (MJ/m ² .yr)	High Bay Lighting (MJ/m ² .yr)	General Lighting (MJ/m ² .yr)	Service Area Lighting (MJ/m ² .yr)	High Bay Lighting (MJ/m ² .yr)	General Lighting (MJ/m ² .yr)	Service Area Lighting (MJ/m ² .yr)	High Bay Lighting (MJ/m ² .yr)
EXISTING BUILDINGS									
Large Office (> 3,700 m ²)	334.7	87.2	12.2	52.2	19.8	8.8	22.7	6.7	3.5
Small Office (< 3,700 m ²)	349.2	91.0	12.8	54.5	20.6	9.2	23.7	7.0	3.6
Non - Food Retail	329.7	296.7	10.2	104.8	82.2	7.4	34.0	26.9	2.9
Food Retail	348.6	198.6	8.9	54.9	58.3	6.5	19.3	20.7	2.5
Restaurant/Tavern	242.8	227.7	0.0	86.2	57.3	0.0	20.6	15.7	0.0
Hotels/Motels	152.3	57.1	23.7	56.0	19.6	14.0	13.6	4.3	5.2
Warehouse/Wholesale	195.6	24.5	0.0	103.0	8.6	0.0	36.9	3.7	0.0
Hospitals	91.3	118.9	26.1	28.1	45.1	18.9	10.0	17.6	7.4
Nursing Homes	114.7	106.0	0.0	50.4	50.3	0.0	17.9	19.6	0.0
Universities/Colleges	223.0	71.6	0.0	72.5	25.2	0.0	26.4	9.0	0.0
Schools	129.3	62.3	0.0	46.6	23.6	0.0	17.2	9.2	0.0
High Rise Apartments	68.8	109.1	0.0	24.0	38.7	0.0	5.5	9.2	0.0
Miscellaneous	207.3	38.5	6.9	81.2	16.9	4.7	30.0	6.0	1.9
NEW BUILDINGS									
Large Office (> 3,700 m ²)	317.1	80.5	12.1	52.2	18.8	8.8	22.7	6.7	3.5
Small Office (< 3,700 m ²)	330.8	84.0	12.6	54.5	19.6	9.2	23.7	7.0	3.6
Non - Food Retail	329.7	254.4	10.2	104.8	74.6	8.8	34.0	26.5	2.9
Food Retail	363.3	231.7	8.9	52.0	58.3	6.5	19.2	20.7	2.5
Restaurant/Tavern	232.7	239.7	0.0	83.5	68.1	0.0	20.5	16.3	0.0
Hotels/Motels	195.0	57.1	23.7	56.0	19.6	14.0	13.6	4.3	5.2
Warehouse/Wholesale	187.9	24.5	0.0	106.0	8.6	0.0	37.2	3.7	0.0
Hospitals	86.5	130.8	27.9	28.7	47.7	18.9	11.2	17.7	7.4
Nursing Homes	152.9	88.6	0.0	56.9	39.0	0.0	15.2	13.9	0.0
Universities/Colleges	238.2	71.6	0.0	71.6	25.2	0.0	26.0	9.0	0.0
Schools	139.4	53.4	0.0	44.9	20.2	0.0	18.3	7.9	0.0
High Rise Apartments	88.2	47.7	0.0	15.5	19.8	0.0	3.6	6.5	0.0
Miscellaneous	327.0	48.1	6.9	107.0	17.9	4.7	32.0	4.8	1.9

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Each of the above technologies will have an impact on different components of the space heating load, and the overall impact will include the reduced contribution from lighting and office equipment.

Envelope Upgrade

Wall insulation levels are increased by applying exterior and interior insulation. Single and double pane windows are replaced with HIT windows. The wall and window insulation upgrade is also assumed to increase the building airtightness, and reduce thermal bridging through the building structural components. Table 9.3 provides a comparison of effective U values between the baseline and the maximum practical levels.

The percent savings in heat loss through the building envelope from using higher insulation levels and high efficiency windows is proportional to the reduction in the OVERALL effective U values (wall plus roof plus windows) between the upgrade and the baseline. The reduction in envelope heat loss that results from upgrading the insulation and windows are in the range of 60% to 80% and are also shown in Table 9.3 for each building segment.

Window to wall ratios used in the calculation of overall U values are those given in the Typical Building Profiles described in Section 6.

Heat Recovery

A heat recovery unit with an efficiency of 60% is assumed to be used to preheat the fresh air. The 60% energy savings are assumed to be applicable only to the portion of the space heating energy that is used to heat ventilation air.

Net Reduction in Tertiary Load

The reduced space heating (tertiary) load after application of the above technical measures, allowing for the decreased contribution from lighting, is as follows:

Tertiary Load (Technological Potential) =

(Baseline Tertiary Load + Decrease in Lighting Contribution)

x Net Heating Savings

where Net Heating Savings =

(Envelope Heating Fraction x Reduction in Envelope Heat Loss) +

(Ventilation Heating Fraction x 60%)

TABLE 9.3
TECHNOLOGICAL POTENTIAL
ENVELOPE HEAT LOSS ENERGY SAVINGS

EXISTING BUILDINGS	BASELINE		MAXIMUM PRACTICAL LEVELS		SAVINGS Reduction in Envelope Heat Loss
	Wall U value (W/m ² .°C)	Glazing U value (W/m ² .°C)	Wall U value (W/m ² .°C)	Glazing U value (W/m ² .°C)	
Large Office (> 3,700 m ²)	0.95	5.68	0.47	0.87	76.5%
Small Office (< 3,700 m ²)	0.81	5.68	0.41	0.87	75.9%
Non-Food Retail	0.85	5.68	0.41	0.87	72.5%
Food Retail	0.81	5.68	0.41	0.87	64.9%
Restaurant/Tavern	0.85	5.68	0.41	0.87	74.6%
Hotels/Motels	0.57	5.68	0.41	0.87	75.8%
Warehouse/Wholesale	1.14	5.68	0.41	0.87	68.4%
Hospitals	0.42	5.68	0.41	0.87	72.6%
Nursing Homes	0.57	3.28	0.41	0.87	60.4%
Universities/Colleges	0.47	5.68	0.41	0.87	75.2%
Schools	0.47	5.68	0.41	0.87	75.2%
High Rise Apartments	0.57	4.54	0.41	0.87	69.0%
Miscellaneous	0.85	4.20	0.41	0.87	69.0%
NEW BUILDINGS					
Large Office (> 3,700 m ²)	0.51	3.28	0.19	0.87	71.1%
Small Office (< 3,700 m ²)	0.45	3.28	0.18	0.87	70.4%
Non-Food Retail	0.45	3.28	0.18	0.87	69.0%
Food Retail	0.23	3.28	0.18	0.87	53.6%
Restaurant/Tavern	0.34	3.28	0.18	0.87	67.4%
Hotels/Motels	0.45	3.28	0.18	0.87	70.9%
Warehouse/Wholesale	1.08	3.28	0.18	0.87	82.2%
Hospitals	0.42	3.28	0.18	0.87	69.9%
Nursing Homes	0.45	3.28	0.18	0.87	70.4%
Universities/Colleges	0.47	3.28	0.18	0.87	71.1%
Schools	0.28	5.68	0.18	0.87	80.7%
High Rise Apartments	0.40	3.28	0.18	0.87	69.5%
Miscellaneous	0.40	5.68	0.18	0.87	79.6%

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Typical heating fractions for envelope heat loss and ventilation make-up heating were given in Table 6.1. The decreased contribution of lighting to the heating load is assumed to be 30 % of the reduction in lighting energy use (see Table 9.2). Table 9.4 shows the baseline and the resulting reduced tertiary loads. The upgrades described plus the interactive effect of the lighting upgrade have the NET effect of reducing the space heating energy load by 68% to 73%.

The resulting tertiary and secondary heating loads are different for each building segment even though the upgrade to the envelope is similar for all buildings. This is due to the interaction of various elements. Among them are:

1. The different envelope to ventilation heating ratios between buildings. Some buildings are envelope dominated. Hospitals for example have a very substantial ventilation heating load due to the use of 100% outside air. See Table 6.1.
2. The increase in space heating is due to lighting energy reduction. This varies depending on the reduction of the lighting connected load.

In new food retail stores, where heat recovery from ventilation is widely used, tertiary heating loads are already very low. In fact in this segment, envelope improvements are not sufficient to counteract the loss in heat contribution from lighting and the resulting tertiary load is higher than the baseline.

Heat Pump Conversion/Upgrade

Electric resistance heating and air source heat pumps are all assumed to be converted to high efficiency water source unitary heat pumps. Existing water source unitary heat pumps are assumed to be converted to the same high efficiency heat pumps. Table 9.5 provides a comparison of baseline and upgrade COP's.

Table 9.5
Technological Potential
Comparison of Baseline and Upgrade Heating COP's

Original Equipment	COP	Upgrade	COP
Resistance heating	1.0	Water source H.P.	2.7
Air source H.P.	2.3	Water source H.P.	2.7
Water source H.P.	2.5	Water source H.P.	3.0
Heat Recovery chiller	4.5	Heat Recovery chiller	5.4

TABLE 9.4
TECHNOLOGICAL POTENTIAL
COMPARISON OF BASELINE & UPGRADE TERTIARY HEATING LOADS

EXISTING BUILDINGS	BASELINE Tertiary Heating Load (MJ/m².yr)	Space Heating Increase due to Light Retrofit (MJ/m².yr)	Net Heating ¹ Savings	UPGRADE Tertiary Heating Load (MJ/m².yr)
Large Office (> 3,700 m ²)	383.8	68.3	73.4%	120.5
Small Office (< 3,700 m ²)	300.0	68.3	74.2%	95.2
Non—Food Retail	180.0	83.1	71.7%	74.4
Food Retail	380.0	100.5	64.5%	170.6
Restaurant/Tavern	807.5	67.6	71.7%	248.0
Hotels/Motels	240.0	26.2	73.9%	69.4
Warehouse/Wholesale	330.0	20.7	68.1%	111.9
Hospitals	889.2	39.1	66.2%	313.8
Nursing Homes	434.2	30.4	60.3%	184.3
Universities/Colleges	470.0	40.1	66.1%	173.1
Schools	207.0	14.8	72.6%	60.8
High Rise Apartments	412.5	21.3	68.3%	137.4
Miscellaneous	500.0	34.1	68.6%	167.9
NEW BUILDINGS				
Large Office (> 3,700 m ²)	130.0	64.8	69.7%	59.1
Small Office (< 3,700 m ²)	116.0	64.8	69.2%	55.8
Non—Food Retail	65.0	78.2	68.5%	45.2
Food Retail ²	20.0	91.2	54.6%	50.5
Restaurant/Tavern	637.0	76.5	65.6%	245.8
Hotels/Motels	373.6	32.9	69.3%	124.9
Warehouse/Wholesale	200.0	17.1	81.5%	40.2
Hospitals	875.0	37.7	64.0%	328.2
Nursing Homes	343.9	42.9	67.5%	125.7
Universities/Colleges	470.0	42.8	64.8%	180.6
Schools	205.0	18.4	74.7%	56.6
High Rise Apartments	250.0	1.1	68.7%	78.5
Miscellaneous	312.5	64.8	78.6%	80.7

1. Net Heating Savings = (Reduction in Envelope Heat Loss) x (Envelope Heating Fraction)
+ (Reduction in Ventilation Heat Loss) x (Ventilation Heating Fraction)

where: Envelope Heating Fraction = Heating energy required to meet envelope losses.

Ventilation Heating Fraction = Heating energy required for ventilation air

2. In most new food retail stores, heat recovery from refrigeration results in a very low baseline tertiary heating load. Envelope and ventilation improvements are not sufficient to counteract the large increase in heat-load due to lighting improvements.

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The secondary energy space heating intensity was calculated using the above COPs and the equation below.

$$\begin{aligned} \text{EUI} &= [\text{Tertiary}_{\text{er}} * (\text{FS}_{\text{er}}/\text{FS}_{\text{Total Elec}}) \\ &+ \text{Tertiary}_{\text{AA}} * (\text{FS}_{\text{AA}}/\text{FS}_{\text{Total Elec}}) \\ &+ \text{Tertiary}_{\text{WS}} * (\text{FS}_{\text{WS}}/\text{FS}_{\text{Total Elec}}) \\ &+ \text{Tertiary}_{\text{HRC}} * (\text{FS}_{\text{HRC}}/\text{FS}_{\text{Total Elec}}) \end{aligned}$$

Where: ER is electric resistance
FS is fuel share
AA is air-to-air heat pump
WS is water source heat pump
HRC is heat recovery chiller

For example, the secondary space heating energy unit for existing large offices is calculated as follows:

$$\text{EUI} = 438 (2/17) + 190(0/17) + 175(5/17) + 97(10/17) = 160.1 \text{ MJ/m}^2 \text{ yr.}$$

Table 9.6 shows the resulting secondary space heating requirements for baseline (Frozen Efficiency) and upgrade (Technological Potential).

9.1.3 Space Cooling

The technologies used to reduce the building space cooling energy end-use were as follows:

- use of HIT windows with a wavelength selective coating to minimize the solar gain
- use of free cooling in small commercial buildings
- use of enhanced efficiency chillers including optimized control

In addition to the above technologies, the cooling load is also reduced as a result of lighting upgrades and efficient office equipment.

These technologies were described in Section 7.4.

The space cooling load (tertiary load) is the sum of the cooling requirements resulting from solar gain through windows, cooling ventilation make-up air, and eliminating excess internal heat from lighting and plug loads. The actual cooling energy requirement (secondary load) is the tertiary load divided by the cooling equipment COP. Each of the above measures will have an impact on different components of the cooling load.

TABLE 9.6
TECHNOLOGICAL POTENTIAL
COMPARISON OF BASELINE & UPGRADE SECONDARY HEATING ENERGY (HEATING EUI)

EXISTING BUILDINGS	BASELINE Secondary Heating Load (MJ/m².yr)	UPGRADE Secondary Heating Load (MJ/m².yr)
Large Office (> 3,700 m ²)	160.1	33.8
Small Office (< 3,700 m ²)	255.2	36.8
Non—Food Retail	196.3	28.8
Food Retail	448.4	67.1
Restaurant/Tavern	952.8	97.6
Hotels/Motels	243.5	25.9
Warehouse/Wholesale	389.4	44.0
Hospitals	252.1	74.2
Nursing Homes	432.6	67.6
Universities/Colleges	210.6	64.6
Schools	219.2	22.7
High Rise Apartments	454.3	54.0
Miscellaneous	420.8	60.5
NEW BUILDINGS		
Large Office (> 3,700 m ²)	54.2	19.9
Small Office (< 3,700 m ²)	98.7	25.9
Non—Food Retail	70.9	21.0
Food Retail	23.6	23.8
Restaurant/Tavern	680.9	116.0
Hotels/Motels	379.0	55.9
Warehouse/Wholesale	236.0	19.0
Hospitals	248.1	93.1
Nursing Homes	342.7	55.3
Universities/Colleges	210.6	80.9
Schools	217.1	25.3
High Rise Apartments	220.3	37.1
Miscellaneous	263.0	34.9

EUI: End—use intensity

Window Upgrade

The window upgrade described under space heating will help reduce the cooling load due to solar heat gain. Table 9.7 provides a comparison of the baseline shading coefficient against that of HIT windows. The savings from the reduction in the solar heat gain are applied to the building envelope portion of the total cooling load only.

Economizer (Free Cooling)

Air side economizers or free cooling packages are assumed to be installed in all small commercial buildings that use roof top heating/cooling equipment and currently have an estimated incidence of use of only 20%. The 30% savings derived from the use of the economizer are applied only to the ventilation portion of the total cooling load.

Net Reduction in Tertiary Load

The reduced space cooling (tertiary) load after application of the window and economizer upgrades, allowing also for the decreased internal loads from lighting and plug loads, is as follows:

Tertiary Load (Technological Potential) =

(Baseline Tertiary Load - Decrease in Internal Lighting/Plug Loads)

x Net Cooling Savings

where Net Cooling Savings =

(Envelope Cooling Fraction x Reduction in Envelope Heat Gain) +

(Ventilation Cooling Fraction x 30%)

Cooling fractions for envelope heat gain and ventilation make-up cooling were derived in Section 6. Table 9.8 shows the baseline and the resulting new tertiary cooling loads for each building segment. The upgrades described above plus the reduction in lighting and office equipment loads have the net effect of reducing the space cooling energy end-use by 20% to 60%.

TABLE 9.7
TECHNOLOGICAL POTENTIAL
COMPARISON OF BASELINE & UPGRADE SHADING COEFFICIENTS

EXISTING BUILDINGS	BASELINE Shading Coefficient	UPGRADE Shading Coefficient	Reduction in Envelope Heat Gain
Large Office (> 3,700 m ²)	0.70	0.40	14.1%
Small Office (< 3,700 m ²)	0.70	0.40	13.3%
Non-Food Retail	0.95	0.40	10.4%
Food Retail	0.95	0.40	16.8%
Restaurant/Tavern	0.70	0.40	11.6%
Hotels/Motels	0.50	0.40	11.2%
Warehouse/Wholesale	0.95	0.40	20.8%
Hospitals	0.59	0.40	6.4%
Nursing Homes	0.50	0.40	8.8%
Universities/Colleges	0.70	0.40	4.3%
Schools	0.70	0.40	9.9%
High Rise Apartments	0.70	0.40	22.7%
Miscellaneous	0.70	0.40	12.4%
NEW BUILDINGS			
Large Office (> 3,700 m ²)	0.59	0.40	10.9%
Small Office (< 3,700 m ²)	0.59	0.40	10.0%
Non-Food Retail	0.80	0.40	9.5%
Food Retail	0.80	0.40	11.0%
Restaurant/Tavern	0.59	0.40	7.7%
Hotels/Motels	0.83	0.40	27.5%
Warehouse/Wholesale	0.83	0.40	17.6%
Hospitals	0.59	0.40	7.7%
Nursing Homes	0.59	0.40	12.9%
Universities/Colleges	0.59	0.40	3.2%
Schools	0.59	0.40	7.1%
High Rise Apartments	0.59	0.40	18.7%
Miscellaneous	0.59	0.40	9.0%

TABLE 9.8
TECHNOLOGICAL POTENTIAL
COMPARISON OF BASELINE & UPGRADE TERTIARY COOLING LOAD

EXISTING BUILDINGS	BASELINE¹ Tertiary Cooling Load (MJ/m².yr)	Space Cooling Decrease due to Light Retrofit (MJ/m².yr)	Space Cooling Decrease due to Plug Load Retrofit (MJ/m².yr)	NET Tertiary Cooling Load (MJ/m².yr)	Net Cooling² Savings	UPGRADE Tertiary Cooling Load (MJ/m².yr)
Large Office (> 3,700 m ²)	336.7	91.1	11.6	234.0	14.1%	200.9
Small Office (< 3,700 m ²)	336.7	91.1	11.6	234.0	34.0%	154.5
Non-Food Retail	410.0	110.8	6.1	293.0	35.0%	190.4
Food Retail	318.6	134.0	7.9	176.7	38.1%	109.4
Restaurant/Tavern	341.1	90.1	4.3	246.6	33.5%	164.1
Hotels/Motels	243.2	34.9	8.9	199.4	11.2%	177.1
Warehouse/Wholesale	220.8	27.7	4.3	188.9	40.0%	113.2
Hospitals	531.9	52.2	16.8	462.9	6.4%	433.1
Nursing Homes	218.4	40.6	3.8	174.0	8.8%	158.7
Universities/Colleges	221.6	53.5	4.4	163.7	4.3%	156.6
Schools	204.5	19.7	0.9	183.8	9.9%	165.7
High Rise Apartments	227.0	28.4	5.5	193.1	22.7%	149.2
Miscellaneous	216.2	45.4	3.3	167.5	33.7%	111.0
NEW BUILDINGS						
Large Office (> 3,700 m ²)	374.5	86.5	19.4	268.7	10.9%	239.2
Small Office (< 3,700 m ²)	344.5	86.5	19.4	238.7	30.7%	165.4
Non-Food Retail	410.0	104.3	6.1	299.5	33.8%	198.3
Food Retail	93.6	20.0	7.9	65.7	11.0%	58.5
Restaurant/Tavern	341.1	102.0	4.3	234.7	30.5%	163.1
Hotels/Motels	243.2	43.9	8.9	190.5	27.5%	138.2
Warehouse/Wholesale	220.8	22.8	4.3	193.7	37.4%	121.3
Hospitals	576.0	50.3	25.9	499.8	7.7%	461.2
Nursing Homes	218.4	57.2	3.8	157.4	12.9%	137.1
Universities/Colleges	236.0	57.1	7.4	171.6	3.2%	166.0
Schools	206.8	24.5	1.4	180.8	7.1%	168.0
High Rise Apartments	218.0	1.4	3.7	212.9	18.7%	173.1
Miscellaneous	216.2	86.4	3.3	126.5	30.6%	87.7

1. This is the 1995 and beyond baseline tertiary cooling load taking into account the increase in plug loads which is added to the 1988 baseline tertiary cooling load

2. Net Cooling Savings = (Reduction in Envelope Heat Gain) x (Envelope Cooling Fraction)
+ (Reduction in Ventilation Cooling) x (Ventilation Cooling Fraction)

where: Envelope Cooling Fraction = Cooling energy required to meet envelope gains, including solar gains.

Ventilation Cooling Fraction = Cooling energy required for ventilation air.

High Efficiency Air Conditioning Equipment

Existing direct expansion (DX) cooling equipment and centrifugal chillers are assumed to be replaced at the end of their life with high efficiency equipment. Table 9.9 provides a comparison of baseline and upgrade COP's.

Table 9.9
Technological Potential
Comparison of Baseline and Upgrade Cooling COP's

	Baseline	Upgrade
DX equipment reciprocating compressor	2.5	3.2
Centrifugal chillers	4.5	6.1

Table 9.10 shows the secondary loads for each building segment for baseline (Frozen Efficiency) and upgrade (Technological Potential).

9.1.4 HVAC Electricity

The technologies used to reduce building HVAC electricity use were as follows:

- VAV Ventilation Systems
- Air Balancing
- Energy Efficient Motors
- Displacement Ventilation
- Variable Flow Pumping
- BAS/DDC Control Systems

Descriptions of each of these technologies may be found in Section 7.5.

All the technologies with exception of energy efficient motors apply only to a limited number of segments. Table 9.11 shows the applicability of the technologies to the building segments under study.

TABLE 9.10
TECHNOLOGICAL POTENTIAL
COMPARISON OF BASELINE & UPGRADE SECONDARY COOLING ENERGY / INTENSITIES

EXISTING BUILDINGS	BASELINE Secondary Cooling Load (MJ/m².yr)	UPGRADE Secondary Cooling Load (MJ/m².yr)
Large Office (> 3,700 m ²)	91.4	37.5
Small Office (< 3,700 m ²)	150.2	56.0
Non-Food Retail	182.9	69.0
Food Retail	144.6	40.3
Restaurant/Tavern	154.8	60.5
Hotels/Motels	90.8	62.0
Warehouse/Wholesale	104.2	41.8
Hospitals	130.0	78.1
Nursing Homes	92.4	54.6
Universities/Colleges	59.1	28.8
Schools	88.1	58.0
High Rise Apartments	103.0	55.0
Miscellaneous	94.8	39.5
NEW BUILDINGS		
Large Office (> 3,700 m ²)	101.7	44.7
Small Office (< 3,700 m ²)	153.7	60.0
Non-Food Retail	182.9	71.9
Food Retail	42.5	21.6
Restaurant/Tavern	154.8	60.1
Hotels/Motels	90.8	48.4
Warehouse/Wholesale	104.2	44.7
Hospitals	140.8	83.2
Nursing Homes	92.4	47.1
Universities/Colleges	62.9	30.5
Schools	89.1	58.8
High Rise Apartments	98.9	63.8
Miscellaneous	94.8	31.3

TABLE 9.11
TECHNOLOGICAL POTENTIAL
APPLICABILITY OF TECHNOLOGIES TO BUILDING SEGMENTS

	Displacement Ventilation 85%	Air Balancing 27%	VAV 20%	E.E. Motors 5%	Variable Flow Pumping 30%	BMS 20%
NOMINAL SAVINGS						
EXISTING BUILDINGS						
Large Office (> 3,700 m ²)		X		X	X	
Small Office (< 3,700 m ²)		X	X (50%)	X	X (30%)	X
Non-Food Retail			X (50%)	X		X
Food Retail			X (25%)	X		
Restaurant/Tavern				X		
Hotels/Motels			X (25%)	X	X (15%)	X (50%)
Warehouse/Wholesale				X		
Hospitals		X	X (25%)	X	X	
Nursing Homes				X	X (30%)	
Universities/Colleges		X	X (50%)	X	X	
Schools		X (40%)	X (50%)	X	X (50%)	X (50%)
High Rise Apartments				X	X (50%)	
Miscellaneous			X	X		
NEW BUILDINGS						
Large Office (> 3,700 m ²)	X			X	X	
Small Office (< 3,700 m ²)	X		X (50%)	X	X (30%)	X
Non-Food Retail	X (45%)		X (50%)	X		X
Food Retail			X (25%)	X		
Restaurant/Tavern				X		
Hotels/Motels			X (25%)	X	X (15%)	X (50%)
Warehouse/Wholesale				X		
Hospitals			X	X	X	
Nursing Homes				X	X (30%)	
Universities/Colleges	X		X (50%)	X	X	
Schools			X (50%)	X	X (50%)	X (50%)
High Rise Apartments				X	X (50%)	
Miscellaneous			X	X		

VAV: Variable air volume
 EE Motors: Energy efficient motors
 BMS: Building management system

The "X" indicates that the technology is applicable to that building segment

The figures in brackets indicate the applicability as a percentage of the total building segment floor area. For example BMS would only apply to large schools which will tend to be high schools in most cases. This building group is assumed to represent 50% of the total schools floor area. As a result, the potential savings only applies to half of the available market.

Some of the technologies apply to a small portion of buildings within a building segment (i.e. savings from a building automated system/direct digital control (BAS/DDC) will only apply to larger high schools, or savings from variable flow pumping will only apply to larger small offices). In these cases the savings were derated to account for this applicability restriction.

Table 9.12 shows the overall energy savings attainable in HVAC electricity with the use of all the technologies listed above and the baseline (Frozen Efficiency) and upgrade (Technological Potential) end-use intensities.

9.1.5 Service Hot Water

It was assumed that 50% energy savings can be realized in Service Hot Water through the use of faucet aerators and low flow shower heads. These technologies only apply to the portion of Service Hot Water used for wetting and shower service. All other hot water uses, including dishwashing, cleaning, etc, were assumed to be reduced by 20 % through the use of more efficient water using devices. Wetting/Shower fractions (the portion of hot water used for handwashing and showering) for each building segment were derived in Section 6. Table 9.13 shows the baseline (Frozen Efficiency), the net savings in hot water use, and Technological Potential upgrade tertiary loads.

9.1.6 Cooking

It was assumed that all cooking intensities would be reduced by 25% to reflect the increased use of microwave cooking and high efficiency cooking equipment such as convection ovens. Table 9.14 shows baseline and Technological Potential upgrade cooking intensities.

9.1.7 Refrigeration Equipment

It was assumed that all existing equipment in Food Retail (grocery stores) and warehouses that are refrigerated, is replaced with state-of-the-art refrigeration plants with unequal capacity multiplexed compressors using hot gas defrost, refrigerant heat recovery and advanced display cases, which together would reduce refrigeration loads by 18%. Each of these technologies were described in Section 7.7.

It was assumed that in all other building segments, except high rise apartments, refrigeration loads would be due to the use a combination of stand alone commercial refrigerators and freezers, where savings of about 30% might be expected as a result of improved compressors and wall insulation. In high rise apartments, it was assumed that the 75% reduction in refrigerator and freezer intensities shown to be possible in the Residential Sector Conservation Potential Review, would apply.

TABLE 9.12
TECHNOLOGICAL POTENTIAL
COMPARISON OF BASELINE & UPGRADE HVAC ENERGY INTENSITIES

	SAVINGS	BASELINE	UPGRADE
EXISTING BUILDINGS	HVAC Elec. (MJ/m ² .yr)	HVAC Elec. (MJ/m ² .yr)	HVAC Elec. (MJ/m ² .yr)
Large Office (> 3,700 m ²)	42.6	135.4	92.8
Small Office (< 3,700 m ²)	55.6	112.8	57.1
Non-Food Retail	45.1	122.1	77.0
Food Retail	28.0	124.9	96.9
Restaurant/Tavern	19.3	394.0	374.7
Hotels/Motels	14.9	82.5	67.6
Warehouse/Wholesale	0.3	12.9	12.6
Hospitals	100.7	282.0	181.3
Nursing Homes	0.0	32.6	32.6
Universities/Colleges	64.5	165.7	101.2
Schools	4.5	15.1	10.7
High Rise Apartments	4.1	51.8	47.7
Miscellaneous	15.4	61.6	46.2
NEW BUILDINGS			
Large Office (> 3,700 m ²)	99.7	135.4	35.7
Small Office (< 3,700 m ²)	131.5	145.0	13.5
Non-Food Retail	78.2	122.1	44.0
Food Retail	7.0	34.4	27.4
Restaurant/Tavern	6.7	160.0	153.3
Hotels/Motels	14.9	82.5	67.6
Warehouse/Wholesale	0.3	12.9	12.6
Hospitals	38.6	282.0	243.3
Nursing Homes	0.0	32.6	32.6
Universities/Colleges	136.1	165.7	29.6
Schools	3.6	15.1	11.6
High Rise Apartments	4.1	51.8	47.7
Miscellaneous	15.4	61.6	46.2

HVAC Elec.: Heating, ventilation and air conditioning electricity

TABLE 9.13
TECHNOLOGICAL POTENTIAL
COMPARISON OF BASELINE & UPGRADE SERVICE HOT WATER USE TERTIARY LOAD

EXISTING BUILDINGS	BASELINE Service Hot Water (MJ/m ² .yr)	Net Reduction ¹ (%)	UPGRADE Service Hot Water (MJ/m ² .yr)
Large Office (> 3,700 m ²)	4.7	47%	2.5
Small Office (< 3,700 m ²)	4.7	47%	2.5
Non—Food Retail	1.6	47%	0.8
Food Retail	19.3	47%	10.2
Restaurant/Tavern	327.0	35%	212.6
Hotels/Motels	100.0	32%	68.0
Warehouse/Wholesale	1.8	47%	1.0
Hospitals	140.0	29%	99.4
Nursing Homes	140.0	41%	82.6
Universities/Colleges	53.8	32%	36.6
Schools	22.0	35%	14.3
High Rise Apartments	100.0	41%	59.0
Miscellaneous	4.0	47%	2.1
NEW BUILDINGS			
Large Office (> 3,700 m ²)	4.7	47%	2.5
Small Office (< 3,700 m ²)	4.7	47%	2.5
Non—Food Retail	1.6	47%	0.8
Food Retail	19.3	47%	10.2
Restaurant/Tavern	327.0	35%	212.6
Hotels/Motels	100.0	32%	68.0
Warehouse/Wholesale	1.8	47%	1.0
Hospitals	140.0	29%	99.4
Nursing Homes	140.0	41%	82.6
Universities/Colleges	53.8	32%	36.6
Schools	22.0	35%	14.3
High Rise Apartments	100.0	41%	59.0
Miscellaneous	4.0	47%	2.1

1. Net Reduction = $WSF \times 0.5 + OF \times 0.2$

where:

WSF is the Wetting and Shower Fraction. This represents the portion of total hot water use that is due to hand washing (wetting) and shower use.

The 0.5 represents the energy savings (50%) that can be achieved with low flow shower heads and faucet aerators.

OF is the other hot water use such as dishwashing, cooking, process use, cleaning etc.

The 0.2 represents the energy savings (20%) that can be achieved from the use of equipment that uses less hot water such as efficient dishwashers, efficient close washers etc.

TABLE 9.14
TECHNOLOGICAL POTENTIAL
COMPARISON OF BASELINE & UPGRADE COOKING INTENSITIES

EXISTING BUILDINGS	BASELINE Cooking Equipment (MJ/m².yr)	UPGRADE Cooking Equipment (MJ/m².yr)
Large Office (> 3,700 m ²)	4.0	3.0
Small Office (< 3,700 m ²)	4.0	3.0
Non-Food Retail	4.1	3.1
Food Retail	130.0	97.5
Restaurant/Tavern	419.0	314.3
Hotels/Motels	67.8	50.9
Warehouse/Wholesale	4.0	3.0
Hospitals	61.0	45.8
Nursing Homes	12.8	9.6
Universities/Colleges	22.0	16.5
Schools	4.8	3.6
High Rise Apartments	19.0	14.3
Miscellaneous	0.0	0.0
NEW BUILDINGS		
Large Office (> 3,700 m ²)	4.0	3.0
Small Office (< 3,700 m ²)	4.0	3.0
Non-Food Retail	4.1	3.1
Food Retail	269.0	201.8
Restaurant/Tavern	366.5	274.9
Hotels/Motels	67.8	50.9
Warehouse/Wholesale	4.0	3.0
Hospitals	68.0	51.0
Nursing Homes	68.0	51.0
Universities/Colleges	22.0	16.5
Schools	4.8	3.6
High Rise Apartments	19.0	14.3
Miscellaneous	0.0	0.0

Energy end-use intensities for the baseline (Frozen Efficiency) and upgrade technologies are compared in Table 9.15.

9.1.8 Plug Loads (Office Equipment and Appliances)

The technologies used to reduce the Office Equipment energy end-use were as follows.

- Computer energy use is expected to drop by up to 50% through increased use of laptop computers, power management software, and the introduction of low energy consumption, large LCD/electroluminescent screens on desktop computers (after 1995).
- Ink-jet printers used in place of laser printers for low volume printing will provide savings of 30%.
- Use of photocopiers with high "turn-down" power consumption ratios plus use of ion deposition photocopiers for very large scale printing, will reduce copying energy use by 30%.

The weighted average reduction for all of these technologies in a typical commercial building would be 36%. These technologies are applicable to all commercial buildings that have a sizable office equipment load: Offices, Schools, Universities, and Hospitals. In all other segments (except apartments) it was assumed that plug loads intensities would be reduced by 30%.

Plug loads in apartment buildings include small appliances and miscellaneous products such as TVs, radios, etc. (Refrigerators, freezers, clothes washers and dishwashers are included in Other end-uses). The Residential Sector Conservation Potential Review indicates that technical savings of up to 50% can be achieved in appliance energy use in low rise apartments. Since appliances account for most of the plug load in apartments, it was assumed that a 50% reduction could be achieved in existing high rise plug loads, and 30% reduction in new high rise plug loads where it is assumed that some efficient appliances are already in use.

Table 9.16 shows the energy savings for plug loads in each building segment under study. The baseline (Frozen Efficiency) and Technological Potential upgrade plug load energy use is also shown in Table 9.16.

TABLE 9.15
TECHNOLOGICAL POTENTIAL
COMPARISON OF BASELINE & UPGRADE REFRIGERATION INTENSITIES

EXISTING BUILDINGS	BASELINE Refrigeration Equipment (MJ/m².yr)	Refrigeration Equipment Savings	UPGRADE Refrigeration Equipment (MJ/m².yr)
Large Office (> 3,700 m ²)	12.4	30%	8.7
Small Office (< 3,700 m ²)	12.4	30%	8.7
Non-Food Retail	9.5	30%	6.7
Food Retail	1492.4	18%	1223.8
Restaurant/Tavern	220.0	30%	154.0
Hotels/Motels	12.6	30%	8.8
Warehouse/Wholesale	19.0	18%	15.6
Hospitals	25.0	30%	17.5
Nursing Homes	30.0	30%	21.0
Universities/Colleges	10.0	30%	7.0
Schools	10.0	30%	7.0
High Rise Apartments	36.0	75%	9.0
Miscellaneous	0.0	0%	0.0
NEW BUILDINGS			
Large Office (> 3,700 m ²)	12.4	30%	8.7
Small Office (< 3,700 m ²)	12.4	30%	8.7
Non-Food Retail	9.5	30%	6.7
Food Retail	1492.4	18%	1223.8
Restaurant/Tavern	220.0	30%	154.0
Hotels/Motels	12.6	30%	8.8
Warehouse/Wholesale	19.0	0%	19.0
Hospitals	25.0	30%	17.5
Nursing Homes	30.0	30%	21.0
Universities/Colleges	10.0	30%	7.0
Schools	10.0	30%	7.0
High Rise Apartments	36.0	75%	9.0
Miscellaneous	0.0	0%	0.0

TABLE 9.16
TECHNOLOGICAL POTENTIAL
COMPARISON OF BASELINE AND UPGRADE PLUG LOAD ENERGY USE

EXISTING BUILDINGS	BASELINE ¹	Plug Load	UPGRADE
	Plug Loads	Savings	Plug Loads
	(MJ/m².yr)		(MJ/m².yr)
Large Office (> 3,700 m ²)	170.1	36%	108.9
Small Office (< 3,700 m ²)	170.1	36%	108.9
Non-Food Retail	89.9	30%	62.9
Food Retail	115.9	30%	81.1
Restaurant/Tavern	63.2	30%	44.2
Hotels/Motels	129.6	30%	90.7
Warehouse/Wholesale	62.4	30%	43.7
Hospitals	245.7	36%	157.2
Nursing Homes	55.1	30%	38.6
Universities/Colleges	64.8	36%	41.5
Schools	13.5	36%	8.6
High Rise Apartments	81.0	50%	40.5
Miscellaneous	48.6	30%	34.0
NEW BUILDINGS			
Large Office (> 3,700 m ²)	283.5	36%	181.4
Small Office (< 3,700 m ²)	283.5	36%	181.4
Non-Food Retail	89.9	30%	62.9
Food Retail	115.9	30%	81.1
Restaurant/Tavern	63.2	30%	44.2
Hotels/Motels	129.6	30%	90.7
Warehouse/Wholesale	62.4	30%	43.7
Hospitals	378.0	36%	241.9
Nursing Homes	55.1	30%	38.6
Universities/Colleges	108.0	36%	69.1
Schools	20.3	36%	13.0
High Rise Apartments	54.0	30%	37.8
Miscellaneous	48.6	30%	34.0

1. This is the 1995 baseline and beyond plug load which assumes a 50% increase due to personal computer saturation in the office space.

9.2 Technological Potential in BC

A summary of all EUIs for the upgraded buildings used in the Technological Potential model estimate are shown for the two target years of 2000 and 2010 in Tables 9.17 and 9.18, respectively. The EUIs are for a building which uses electricity for all end-uses. As discussed in Section 9.1, it was assumed that all efficient technologies and measures, including those currently under development, would be in place in all buildings by 2010. By 2000, it was assumed that only those technologies currently available would be in place.

It should be noted that in some cases EUIs for new buildings exceed those for existing buildings. This is due to higher ventilation rates and lighting levels found in new baseline buildings. Class A buildings⁵² traditionally require higher levels of service.

Tables 9.19 and 9.20 show Technological Potential by building segment and end-use, respectively. These estimates were derived using the same spreadsheet model used to produce Frozen Efficiency. That is to say, energy electricity consumption is the product of the EUI (Tables 9.17/9.18) fuel share, equipment saturation, and floor area. Technological Potential is then equal to Frozen Efficiency minus electricity consumption. In this case, however, the EUIs from the Typical Building Profiles in Appendix 6 were replaced with those in Tables 9.17 and 9.18 above. Fuel shares were retained at the same levels as in Frozen Efficiency.

The largest savings were achieved in general and service area lighting and space heating, with over 88% reduction from Frozen Efficiency by 2010 in these end-uses. The highest savings on a building segment basis were in Schools, Small Offices and Non-food Retail (77%, 70% and 74%, respectively). The latter two also happen to be the largest energy consuming segments. The overall reduction in commercial electricity use over Frozen Efficiency was 65%. It should be noted, however, that small end-uses such as refrigeration, plug-loads, and miscellaneous represent much higher proportions of total sector use when high reductions are achieved in lighting and space heating.

⁵² A Class A building is a relatively new building situated in a prime location with high occupancy rates and high competitive rental rates (BOMA).



TABLE 9.17A

SUMMARY OF AVERAGE END-USE INTENSITIES FOR ALL ELECTRIC COMMERCIAL BUILDINGS - TECHNOLOGICAL POTENTIAL MODEL INPUTS YEAR 2000 (MJ/m²·yr)

EXISTING BUILDINGS	General Lighting (MJ/m ² ·yr)	Service Area Lighting (MJ/m ² ·yr)	Other Lighting (MJ/m ² ·yr)	Space Heating (MJ/m ² ·yr)	Space Cooling (MJ/m ² ·yr)	HVAC Electricity (MJ/m ² ·yr)	Service Hot water (MJ/m ² ·yr)	Cooking Equipment (MJ/m ² ·yr)	Refrig. Equipment (MJ/m ² ·yr)	Office Equipment (MJ/m ² ·yr)	Misc. Equipment (MJ/m ² ·yr)	Total (MJ/m ² ·yr)
Large Office (> 3,700 m ²)	52.2 (84%)	19.8 (77%)	8.8 (28%)	33.8 (79%)	37.5 (51%)	92.8 (31%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	108.9 (4%)	43.2 (0%)	411.2 (56%)
Small Office (< 3,700 m ²)	54.5 (84%)	20.8 (77%)	9.2 (28%)	36.8 (86%)	56.0 (55%)	57.1 (49%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	108.9 (4%)	12.8 (0%)	370.2 (68%)
Non-Food Retail	104.8 (68%)	82.2 (72%)	7.4 (28%)	28.8 (85%)	69.0 (59%)	77.0 (37%)	0.8 (47%)	3.1 (25%)	6.7 (30%)	82.9 (-5%)	6.5 (0%)	449.2 (63%)
Food Retail	54.9 (84%)	58.3 (71%)	6.5 (28%)	67.1 (85%)	40.3 (68%)	96.9 (22%)	10.2 (47%)	97.5 (25%)	1223.8 (18%)	81.1 (-5%)	97.0 (0%)	1833.5 (40%)
Restaurant/Tavern	86.2 (65%)	57.3 (75%)	0.0 (0%)	97.8 (90%)	60.5 (58%)	374.7 (5%)	212.8 (35%)	314.3 (25%)	154.0 (30%)	44.2 (-5%)	103.0 (0%)	1504.2 (51%)
Hotels/Motels	56.0 (63%)	19.8 (66%)	14.0 (41%)	25.9 (89%)	62.0 (17%)	67.8 (18%)	68.0 (32%)	50.9 (25%)	8.8 (30%)	90.7 (-5%)	14.2 (0%)	477.7 (48%)
Warehouse/Wholesale	103.0 (47%)	8.8 (65%)	0.0 (0%)	44.0 (89%)	41.8 (56%)	12.8 (3%)	1.0 (47%)	3.0 (25%)	15.8 (18%)	43.7 (-5%)	19.0 (0%)	292.1 (64%)
Hospitals	28.1 (69%)	45.1 (62%)	18.9 (28%)	74.2 (71%)	78.1 (29%)	181.3 (38%)	89.4 (29%)	45.8 (25%)	17.5 (30%)	157.2 (4%)	20.0 (0%)	765.5 (41%)
Nursing Homes	50.4 (56%)	50.3 (53%)	0.0 (0%)	67.8 (84%)	54.8 (36%)	32.8 (0%)	82.8 (41%)	9.8 (25%)	21.0 (30%)	38.6 (-5%)	12.8 (0%)	420.0 (58%)
Universities/Colleges	72.5 (67%)	25.2 (65%)	0.0 (0%)	84.8 (69%)	28.8 (46%)	101.2 (39%)	36.8 (32%)	16.5 (25%)	7.0 (30%)	41.5 (4%)	15.0 (0%)	408.8 (53%)
Schools	46.6 (64%)	23.6 (62%)	0.0 (0%)	22.7 (90%)	58.0 (33%)	10.7 (30%)	14.3 (35%)	3.6 (25%)	7.0 (30%)	8.6 (4%)	0.4 (0%)	195.5 (65%)
High Rise Apartments	24.0 (65%)	38.7 (65%)	0.0 (0%)	54.0 (88%)	55.0 (39%)	47.7 (8%)	59.0 (41%)	14.3 (25%)	9.0 (75%)	40.5 (28%)	12.8 (0%)	355.1 (64%)
Miscellaneous	81.2 (61%)	16.8 (56%)	4.7 (31%)	60.5 (86%)	55.0 (39%)	46.2 (25%)	2.1 (47%)	0.0 (0%)	0.0 (0%)	34.0 (-5%)	12.0 (0%)	312.7 (64%)
NEW BUILDINGS	General Lighting (MJ/m ² ·yr)	Service Area Lighting (MJ/m ² ·yr)	Other Lighting (MJ/m ² ·yr)	Space Heating (MJ/m ² ·yr)	Space Cooling (MJ/m ² ·yr)	HVAC Electricity (MJ/m ² ·yr)	Service Hot water (MJ/m ² ·yr)	Cooking Equipment (MJ/m ² ·yr)	Refrig. Equipment (MJ/m ² ·yr)	Office Equipment (MJ/m ² ·yr)	Misc. Equipment (MJ/m ² ·yr)	Total (MJ/m ² ·yr)
Large Office (> 3,700 m ²)	52.2 (84%)	18.8 (77%)	8.8 (27%)	19.8 (63%)	44.7 (41%)	35.7 (74%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	181.4 (4%)	43.2 (0%)	419.0 (55%)
Small Office (< 3,700 m ²)	54.5 (84%)	19.8 (77%)	9.2 (27%)	25.9 (74%)	60.0 (46%)	13.5 (91%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	181.4 (4%)	12.8 (0%)	391.2 (61%)
Non-Food Retail	104.8 (68%)	74.8 (71%)	8.8 (14%)	21.0 (70%)	71.9 (58%)	44.0 (64%)	0.8 (47%)	3.1 (25%)	6.7 (30%)	82.9 (-5%)	6.5 (0%)	405.0 (61%)
Food Retail	52.0 (86%)	58.3 (75%)	6.5 (28%)	23.8 (-1%)	21.8 (14%)	27.4 (20%)	10.2 (47%)	201.8 (25%)	1223.8 (18%)	81.1 (-5%)	97.0 (0%)	1803.3 (32%)
Restaurant/Tavern	83.5 (64%)	68.1 (72%)	0.0 (0%)	116.0 (83%)	60.1 (59%)	153.3 (4%)	212.8 (35%)	274.9 (25%)	154.0 (30%)	44.2 (-5%)	103.0 (0%)	1269.6 (50%)
Hotels/Motels	56.0 (71%)	19.8 (66%)	14.0 (41%)	55.9 (85%)	48.4 (35%)	67.8 (18%)	68.0 (32%)	50.9 (25%)	8.8 (30%)	90.7 (-5%)	14.2 (0%)	494.1 (55%)
Warehouse/Wholesale	106.0 (44%)	8.8 (65%)	0.0 (0%)	44.7 (82%)	44.7 (53%)	12.8 (3%)	1.0 (47%)	3.0 (25%)	19.0 (0%)	43.7 (-5%)	19.0 (0%)	278.5 (57%)
Hospitals	28.7 (67%)	47.7 (64%)	18.9 (32%)	93.1 (62%)	83.2 (24%)	243.3 (14%)	89.4 (29%)	51.0 (25%)	17.5 (30%)	241.9 (4%)	20.0 (0%)	944.5 (32%)
Nursing Homes	56.9 (63%)	39.0 (56%)	0.0 (0%)	55.3 (84%)	47.1 (44%)	32.8 (0%)	82.8 (41%)	51.0 (25%)	21.0 (30%)	38.8 (-5%)	12.8 (0%)	438.8 (56%)
Universities/Colleges	64.0 (73%)	25.2 (65%)	0.0 (0%)	80.9 (62%)	30.5 (43%)	29.8 (82%)	36.8 (32%)	16.5 (25%)	7.0 (30%)	69.1 (4%)	15.0 (0%)	438.8 (56%)
Schools	44.9 (68%)	20.2 (62%)	0.0 (0%)	25.3 (88%)	58.8 (32%)	11.8 (23%)	14.3 (35%)	3.6 (25%)	7.0 (30%)	13.0 (4%)	0.4 (0%)	199.2 (65%)
High Rise Apartments	15.5 (82%)	19.8 (58%)	0.0 (0%)	37.1 (83%)	63.8 (30%)	47.7 (8%)	59.0 (41%)	14.3 (25%)	9.0 (75%)	37.8 (-5%)	12.8 (0%)	316.8 (55%)
Miscellaneous	107.0 (67%)	17.8 (63%)	4.7 (31%)	34.9 (87%)	63.8 (30%)	46.2 (25%)	2.1 (47%)	0.0 (0%)	0.0 (0%)	34.0 (-5%)	12.0 (0%)	322.7 (62%)

Note:

The percent reduction over the frozen efficiency forecast is shown in brackets.

HVAC: Heating, ventilation and air conditioning

Refrig: Refrigeration

TABLE 9.17B

SUMMARY OF AVERAGE END-USE INTENSITIES FOR ALL ELECTRIC COMMERCIAL BUILDINGS - TECHNOLOGICAL POTENTIAL MODEL INPUTS YEAR 2000 (kWh/ft²·yr)

EXISTING BUILDINGS	General Lighting (kWh/ft ² ·yr)	Service Area Lighting (kWh/ft ² ·yr)	Other Lighting (kWh/ft ² ·yr)	Space Heating (kWh/ft ² ·yr)	Space Cooling (kWh/ft ² ·yr)	HVAC Electricity (kWh/ft ² ·yr)	Service Hot water (kWh/ft ² ·yr)	Cooking Equipment (kWh/ft ² ·yr)	Refrig. Equipment (kWh/ft ² ·yr)	Office Equipment (kWh/ft ² ·yr)	Misc. Equipment (kWh/ft ² ·yr)	Total (kWh/ft ² ·yr)
Large Office (> 3,700 m ²)	1.3 (84%)	0.5 (77%)	0.2 (28%)	0.9 (79%)	1.0 (51%)	2.4 (31%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	2.8 (4%)	1.1 (0%)	10.8 (58%)
Small Office (< 3,700 m ²)	1.4 (84%)	0.5 (77%)	0.2 (28%)	1.0 (86%)	1.4 (55%)	1.5 (49%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	2.8 (4%)	0.3 (0%)	9.6 (66%)
Non-Food Retail	2.7 (88%)	2.1 (72%)	0.2 (28%)	0.7 (85%)	1.8 (59%)	2.0 (37%)	0.0 (47%)	0.1 (25%)	0.2 (30%)	1.6 (-5%)	0.2 (0%)	11.6 (83%)
Food Retail	1.4 (84%)	1.5 (71%)	0.2 (28%)	1.7 (85%)	1.0 (68%)	2.5 (22%)	0.3 (47%)	2.5 (25%)	31.8 (18%)	2.1 (-5%)	2.5 (0%)	47.3 (40%)
Restaurant/Tavern	2.2 (65%)	1.5 (75%)	0.0 (0%)	2.5 (90%)	1.8 (58%)	9.7 (5%)	5.5 (35%)	8.1 (25%)	4.0 (30%)	1.1 (-5%)	2.7 (0%)	38.8 (51%)
Hotels/Motels	1.4 (63%)	0.5 (66%)	0.4 (41%)	0.7 (89%)	1.6 (17%)	1.7 (18%)	1.8 (32%)	1.3 (25%)	0.2 (30%)	2.3 (-5%)	0.4 (0%)	12.3 (48%)
Warehouse/Wholesale	2.7 (47%)	0.2 (65%)	0.0 (0%)	1.1 (89%)	1.1 (56%)	0.3 (3%)	0.0 (47%)	0.1 (25%)	0.4 (18%)	1.1 (-5%)	0.5 (0%)	7.5 (64%)
Hospitals	0.7 (69%)	1.2 (62%)	0.5 (28%)	1.9 (71%)	2.0 (29%)	4.7 (36%)	2.8 (29%)	1.2 (25%)	0.5 (30%)	4.1 (4%)	0.3 (0%)	19.8 (41%)
Nursing Homes	1.3 (56%)	1.3 (53%)	0.0 (0%)	1.7 (84%)	1.4 (36%)	0.8 (0%)	2.1 (41%)	0.2 (25%)	0.5 (30%)	1.0 (-5%)	0.3 (0%)	10.8 (58%)
Universities/Colleges	1.9 (67%)	0.7 (65%)	0.0 (0%)	1.7 (69%)	0.7 (46%)	2.6 (39%)	0.9 (32%)	0.4 (25%)	0.2 (30%)	1.1 (4%)	0.4 (0%)	10.6 (53%)
Schools	1.2 (64%)	0.8 (62%)	0.0 (0%)	0.6 (80%)	1.5 (33%)	0.3 (30%)	0.4 (35%)	0.1 (25%)	0.2 (30%)	0.2 (4%)	0.0 (0%)	5.0 (65%)
High Rise Apartments	0.6 (65%)	1.0 (65%)	0.0 (0%)	0.0 (0%)	1.4 (39%)	1.2 (8%)	1.5 (41%)	0.4 (25%)	0.2 (75%)	1.0 (26%)	0.3 (0%)	9.2 (64%)
Miscellaneous	2.1 (61%)	0.4 (58%)	0.1 (31%)	1.6 (86%)	1.4 (30%)	1.2 (25%)	0.1 (47%)	0.0 (0%)	0.0 (0%)	0.9 (-5%)	0.3 (0%)	8.1 (64%)

NEW BUILDINGS	General Lighting (kWh/ft ² ·yr)	Service Area Lighting (kWh/ft ² ·yr)	Other Lighting (kWh/ft ² ·yr)	Space Heating (kWh/ft ² ·yr)	Space Cooling (kWh/ft ² ·yr)	HVAC Electricity (kWh/ft ² ·yr)	Service Hot water (kWh/ft ² ·yr)	Cooking Equipment (kWh/ft ² ·yr)	Refrig. Equipment (kWh/ft ² ·yr)	Office Equipment (kWh/ft ² ·yr)	Misc. Equipment (kWh/ft ² ·yr)	Total (kWh/ft ² ·yr)
Large Office (> 3,700 m ²)	1.3 (84%)	0.5 (77%)	0.2 (27%)	0.5 (63%)	1.2 (41%)	0.9 (74%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	4.7 (4%)	1.1 (0%)	32.8 (55%)
Small Office (< 3,700 m ²)	1.4 (84%)	0.5 (77%)	0.2 (27%)	0.7 (74%)	1.5 (46%)	0.3 (91%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	4.7 (4%)	0.3 (0%)	10.1 (81%)
Non-Food Retail	2.7 (88%)	1.9 (71%)	0.2 (14%)	0.5 (70%)	1.9 (58%)	1.1 (64%)	0.0 (47%)	0.1 (25%)	0.2 (30%)	1.8 (-5%)	0.2 (0%)	10.5 (81%)
Food Retail	1.3 (86%)	1.5 (75%)	0.2 (28%)	0.8 (-1%)	0.8 (14%)	0.7 (20%)	0.3 (47%)	5.2 (25%)	31.8 (18%)	2.1 (-5%)	2.5 (0%)	48.8 (32%)
Restaurant/Tavern	2.2 (64%)	1.8 (72%)	0.0 (0%)	3.0 (83%)	1.6 (59%)	4.0 (4%)	5.5 (35%)	7.1 (25%)	4.0 (30%)	1.1 (-5%)	2.7 (0%)	32.8 (50%)
Hotels/Motels	1.4 (71%)	0.5 (66%)	0.4 (41%)	1.4 (85%)	1.2 (35%)	1.7 (18%)	1.8 (32%)	1.3 (25%)	0.2 (30%)	2.3 (-5%)	0.4 (0%)	12.8 (55%)
Warehouse/Wholesale	2.7 (44%)	0.2 (65%)	0.0 (0%)	0.5 (92%)	1.2 (53%)	0.3 (3%)	0.0 (47%)	0.1 (25%)	0.5 (0%)	1.1 (-5%)	0.5 (0%)	7.1 (57%)
Hospitals	0.7 (67%)	1.2 (64%)	0.5 (32%)	2.4 (82%)	2.1 (24%)	6.3 (14%)	2.8 (29%)	1.3 (25%)	0.5 (30%)	6.2 (4%)	0.5 (0%)	24.4 (32%)
Nursing Homes	1.5 (63%)	1.0 (56%)	0.0 (0%)	1.4 (84%)	1.2 (44%)	0.8 (0%)	2.1 (41%)	1.3 (25%)	0.5 (30%)	1.0 (-5%)	0.3 (0%)	11.3 (56%)
Universities/Colleges	1.7 (73%)	0.7 (65%)	0.0 (0%)	2.1 (82%)	0.8 (43%)	0.8 (82%)	0.9 (32%)	0.4 (25%)	0.2 (30%)	1.8 (4%)	0.4 (0%)	9.7 (59%)
Schools	1.2 (68%)	0.5 (62%)	0.0 (0%)	0.7 (86%)	1.5 (32%)	0.3 (23%)	0.4 (35%)	0.1 (25%)	0.2 (30%)	0.3 (4%)	0.0 (0%)	5.1 (65%)
High Rise Apartments	0.4 (82%)	0.5 (58%)	0.0 (0%)	1.0 (83%)	1.6 (30%)	1.2 (8%)	1.5 (41%)	0.4 (25%)	0.2 (75%)	1.0 (-5%)	0.3 (0%)	8.2 (55%)
Miscellaneous	2.8 (67%)	0.5 (63%)	0.1 (31%)	0.9 (87%)	1.8 (30%)	1.2 (25%)	0.1 (47%)	0.0 (0%)	0.0 (0%)	0.9 (-5%)	0.3 (0%)	8.3 (62%)

Note:
The percent reduction over the frozen efficiency forecast is shown in brackets.
HVAC: Heating, ventilation and air conditioning
Refrig: Refrigeration

TABLE 8.18A

SUMMARY OF AVERAGE END-USE INTENSITIES FOR ALL ELECTRIC COMMERCIAL BUILDINGS – TECHNOLOGICAL POTENTIAL MODEL INPUTS YEAR 2010 (MJ/m²·yr)

EXISTING BUILDINGS	General Lighting (MJ/m ² ·yr)	Service Area Lighting (MJ/m ² ·yr)	Other Lighting (MJ/m ² ·yr)	Space Heating (MJ/m ² ·yr)	Space Cooling (MJ/m ² ·yr)	HVAC Electricity (MJ/m ² ·yr)	Service Hot water (MJ/m ² ·yr)	Cooking Equipment (MJ/m ² ·yr)	Refrig. Equipment (MJ/m ² ·yr)	Office Equipment (MJ/m ² ·yr)	Misc. Equipment (MJ/m ² ·yr)	Total (MJ/m ² ·yr)
Large Office (> 3,700 m ²)	22.7 (93%)	6.7 (92%)	3.5 (72%)	33.8 (79%)	37.5 (51%)	92.8 (31%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	108.9 (4%)	43.2 (0%)	383.3 (63%)
Small Office (< 3,700 m ²)	23.7 (93%)	7.0 (92%)	3.6 (72%)	36.8 (86%)	56.0 (55%)	57.1 (49%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	108.9 (4%)	12.9 (0%)	320.2 (71%)
Non-Food Retail	34.0 (90%)	26.9 (91%)	2.9 (72%)	28.8 (85%)	69.0 (59%)	77.0 (37%)	4.8 (47%)	3.1 (25%)	6.7 (30%)	62.9 (-5%)	6.5 (0%)	318.6 (74%)
Food Retail	19.3 (94%)	20.7 (90%)	2.5 (72%)	67.1 (85%)	40.3 (69%)	96.9 (22%)	10.2 (47%)	97.5 (25%)	123.8 (18%)	81.1 (-5%)	87.0 (0%)	1756.5 (43%)
Restaurant/Tavern	20.6 (92%)	15.7 (93%)	0.0 (0%)	97.6 (90%)	60.5 (59%)	374.7 (5%)	212.8 (35%)	314.3 (25%)	154.0 (30%)	44.2 (-5%)	103.0 (0%)	1387.1 (55%)
Hotels/Hotels	13.6 (91%)	4.3 (93%)	5.2 (76%)	25.9 (89%)	62.0 (17%)	67.6 (18%)	68.0 (32%)	50.9 (25%)	8.8 (30%)	90.7 (-5%)	14.2 (0%)	411.1 (55%)
Warehouse/Wholesale	36.9 (81%)	3.7 (85%)	0.0 (0%)	44.0 (89%)	41.8 (56%)	12.6 (3%)	1.0 (47%)	3.0 (25%)	15.8 (18%)	43.7 (-5%)	19.0 (0%)	221.1 (72%)
Hospitals	10.0 (89%)	17.6 (85%)	7.4 (72%)	74.2 (71%)	78.1 (28%)	181.3 (36%)	89.4 (29%)	45.8 (25%)	17.5 (30%)	157.2 (4%)	20.0 (0%)	708.4 (45%)
Nursing Homes	17.9 (84%)	19.6 (81%)	0.0 (0%)	67.6 (84%)	54.6 (36%)	32.6 (0%)	82.6 (41%)	9.8 (25%)	21.0 (30%)	38.6 (-5%)	12.8 (0%)	356.8 (64%)
Universities/Colleges	26.4 (88%)	9.0 (87%)	0.0 (0%)	64.6 (69%)	28.8 (46%)	101.2 (39%)	36.8 (32%)	16.5 (25%)	7.0 (30%)	41.5 (4%)	15.0 (0%)	346.5 (60%)
Schools	17.2 (87%)	9.2 (85%)	0.0 (0%)	22.7 (80%)	58.0 (33%)	10.7 (30%)	14.3 (35%)	3.8 (25%)	7.0 (30%)	8.8 (4%)	0.4 (0%)	151.7 (73%)
High Rise Apartments	5.5 (92%)	9.2 (92%)	0.0 (0%)	54.0 (86%)	55.0 (39%)	47.7 (8%)	59.0 (41%)	14.3 (25%)	9.0 (75%)	40.5 (26%)	12.8 (0%)	307.1 (69%)
Miscellaneous	30.0 (86%)	6.0 (84%)	1.9 (73%)	60.5 (86%)	55.0 (39%)	46.2 (25%)	2.1 (47%)	0.0 (0%)	0.0 (0%)	34.0 (-5%)	12.0 (0%)	247.8 (72%)
NEW BUILDINGS	General Lighting (MJ/m ² ·yr)	Service Area Lighting (MJ/m ² ·yr)	Other Lighting (MJ/m ² ·yr)	Space Heating (MJ/m ² ·yr)	Space Cooling (MJ/m ² ·yr)	HVAC Electricity (MJ/m ² ·yr)	Service Hot water (MJ/m ² ·yr)	Cooking Equipment (MJ/m ² ·yr)	Refrig. Equipment (MJ/m ² ·yr)	Office Equipment (MJ/m ² ·yr)	Misc. Equipment (MJ/m ² ·yr)	Total (MJ/m ² ·yr)
Large Office (> 3,700 m ²)	22.7 (93%)	6.7 (92%)	3.5 (71%)	16.6 (69%)	44.7 (41%)	35.7 (74%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	181.4 (4%)	43.2 (0%)	388.7 (60%)
Small Office (< 3,700 m ²)	23.7 (93%)	7.0 (92%)	3.6 (71%)	21.8 (78%)	60.0 (46%)	13.5 (91%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	181.4 (4%)	12.9 (0%)	337.8 (66%)
Non-Food Retail	34.0 (90%)	26.5 (90%)	2.9 (72%)	17.5 (75%)	71.9 (59%)	44.0 (64%)	0.8 (47%)	3.1 (25%)	6.7 (30%)	62.9 (-5%)	6.5 (0%)	276.7 (73%)
Food Retail	19.2 (95%)	20.7 (91%)	2.5 (72%)	19.9 (16%)	21.6 (14%)	27.4 (20%)	10.2 (47%)	201.8 (25%)	123.8 (18%)	81.1 (-5%)	87.0 (0%)	1725.1 (35%)
Restaurant/Tavern	20.5 (91%)	16.3 (93%)	0.0 (0%)	96.7 (86%)	60.1 (59%)	153.3 (4%)	212.8 (35%)	274.9 (25%)	154.0 (30%)	44.2 (-5%)	103.0 (0%)	1135.4 (55%)
Hotels/Hotels	13.6 (93%)	4.3 (93%)	5.2 (76%)	46.6 (88%)	48.4 (35%)	67.8 (18%)	68.0 (32%)	50.9 (25%)	8.8 (30%)	90.7 (-5%)	14.2 (0%)	418.2 (62%)
Warehouse/Wholesale	37.2 (80%)	3.7 (85%)	0.0 (0%)	15.8 (93%)	44.7 (53%)	12.6 (3%)	1.0 (47%)	3.0 (25%)	19.0 (0%)	43.7 (-5%)	19.0 (0%)	199.7 (69%)
Hospitals	11.2 (87%)	17.7 (85%)	7.4 (74%)	77.5 (89%)	83.2 (24%)	243.3 (14%)	89.4 (29%)	51.0 (25%)	17.5 (30%)	241.9 (4%)	20.0 (0%)	870.2 (37%)
Nursing Homes	15.2 (80%)	13.9 (84%)	0.0 (0%)	46.1 (87%)	47.1 (44%)	32.6 (0%)	82.6 (41%)	51.0 (25%)	21.0 (30%)	38.6 (-5%)	12.8 (0%)	360.8 (64%)
Universities/Colleges	26.0 (89%)	9.0 (87%)	0.0 (0%)	67.4 (68%)	30.5 (43%)	29.6 (82%)	36.8 (32%)	16.5 (25%)	7.0 (30%)	68.1 (4%)	15.0 (0%)	306.7 (65%)
Schools	18.3 (87%)	7.9 (85%)	0.0 (0%)	21.1 (90%)	58.8 (32%)	11.8 (23%)	14.3 (35%)	3.8 (25%)	7.0 (30%)	13.0 (4%)	0.4 (0%)	155.9 (72%)
High Rise Apartments	3.8 (96%)	6.5 (86%)	0.0 (0%)	30.9 (86%)	63.8 (30%)	47.7 (8%)	59.0 (41%)	14.3 (25%)	9.0 (75%)	37.8 (-5%)	12.8 (0%)	285.4 (60%)
Miscellaneous	32.0 (90%)	4.8 (90%)	1.9 (73%)	29.1 (89%)	63.8 (30%)	46.2 (25%)	2.1 (47%)	0.0 (0%)	0.0 (0%)	34.0 (-5%)	12.0 (0%)	225.8 (73%)

Note: Reductions over Frozen Efficiency are shown in parenthesis.

HVAC: Heating, ventilation and air conditioning

Refrig.: Refrigeration

TABLE 9.18B SUMMARY OF AVERAGE END-USE INTENSITIES FOR ALL ELECTRIC COMMERCIAL BUILDINGS – TECHNOLOGICAL POTENTIAL MODEL INPUTS YEAR 2010 (kWh/ft²·yr)													
EXISTING BUILDINGS	General Lighting (kWh/ft²·yr)	Service Area Lighting (kWh/ft²·yr)	Other Lighting (kWh/ft²·yr)	Space Heating (kWh/ft²·yr)	Space Cooling (kWh/ft²·yr)	HVAC Electricity (kWh/ft²·yr)	Service Hot water (kWh/ft²·yr)	Cooking Equipment (kWh/ft²·yr)	Refrig. Equipment (kWh/ft²·yr)	Office Equipment (kWh/ft²·yr)	Misc. Equipment (kWh/ft²·yr)	Total (kWh/ft²·yr)	
Large Office (> 3,700 m²)	0.6 (93%)	0.2 (92%)	0.1 (72%)	0.9 (79%)	1.0 (51%)	2.4 (31%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	2.8 (4%)	1.1 (0%)	9.4 (63%)	
Small Office (< 3,700 m²)	0.6 (93%)	0.2 (92%)	0.1 (72%)	1.0 (86%)	1.4 (55%)	1.5 (49%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	2.8 (4%)	0.3 (0%)	8.3 (71%)	
Non-Food Retail	0.9 (90%)	0.7 (81%)	0.1 (72%)	0.7 (85%)	1.8 (59%)	2.0 (37%)	0.0 (47%)	0.1 (25%)	0.2 (30%)	1.6 (-5%)	0.2 (0%)	8.2 (74%)	
Food Retail	0.5 (94%)	0.5 (90%)	0.1 (72%)	1.7 (85%)	1.0 (68%)	2.5 (22%)	0.3 (47%)	2.5 (25%)	31.8 (18%)	2.1 (-5%)	2.5 (0%)	45.3 (43%)	
Restaurant/Tavern	0.5 (92%)	0.4 (93%)	0.0 (0%)	2.5 (90%)	1.6 (68%)	9.7 (5%)	5.5 (35%)	8.1 (25%)	4.0 (30%)	1.1 (-5%)	2.7 (0%)	36.1 (55%)	
Hotels/Motels	0.4 (91%)	0.1 (93%)	0.1 (78%)	0.7 (89%)	1.6 (17%)	1.7 (18%)	1.8 (32%)	1.3 (25%)	0.2 (18%)	2.3 (-5%)	0.4 (0%)	10.6 (72%)	
Warehouse/Wholesale	1.0 (81%)	0.1 (85%)	0.0 (0%)	1.1 (89%)	1.1 (58%)	0.3 (3%)	0.0 (47%)	0.1 (25%)	0.4 (30%)	1.1 (-5%)	0.5 (0%)	5.7 (55%)	
Hospitals	0.3 (89%)	0.5 (85%)	0.2 (72%)	1.9 (71%)	2.0 (28%)	4.7 (36%)	2.6 (28%)	1.2 (25%)	0.5 (30%)	4.1 (4%)	0.5 (0%)	18.3 (45%)	
Nursing Homes	0.5 (84%)	0.5 (81%)	0.0 (0%)	1.7 (84%)	1.4 (36%)	0.8 (0%)	2.1 (41%)	0.2 (25%)	0.5 (30%)	1.0 (-5%)	0.3 (0%)	9.2 (84%)	
Universities/Colleges	0.7 (88%)	0.2 (87%)	0.0 (0%)	1.7 (89%)	0.7 (46%)	2.8 (39%)	0.9 (32%)	0.4 (25%)	0.2 (30%)	1.1 (4%)	0.4 (0%)	8.9 (80%)	
Schools	0.4 (87%)	0.2 (85%)	0.0 (0%)	0.6 (90%)	1.5 (33%)	0.3 (30%)	0.4 (35%)	0.1 (25%)	0.2 (30%)	0.2 (4%)	0.0 (0%)	3.9 (73%)	
High Rise Apartments	0.1 (92%)	0.2 (92%)	0.0 (0%)	1.4 (88%)	1.4 (38%)	1.2 (8%)	1.5 (41%)	0.4 (25%)	0.2 (75%)	1.0 (26%)	0.3 (0%)	7.9 (69%)	
Miscellaneous	0.8 (86%)	0.2 (84%)	0.0 (73%)	1.6 (86%)	1.4 (38%)	1.2 (25%)	0.1 (47%)	0.0 (0%)	0.0 (0%)	0.9 (-5%)	0.3 (0%)	6.4 (72%)	
NEW BUILDINGS	General Lighting (kWh/ft²·yr)	Service Area Lighting (kWh/ft²·yr)	Other Lighting (kWh/ft²·yr)	Space Heating (kWh/ft²·yr)	Space Cooling (kWh/ft²·yr)	HVAC Electricity (kWh/ft²·yr)	Service Hot water (kWh/ft²·yr)	Cooking Equipment (kWh/ft²·yr)	Refrig. Equipment (kWh/ft²·yr)	Office Equipment (kWh/ft²·yr)	Misc. Equipment (kWh/ft²·yr)	Total (kWh/ft²·yr)	
Large Office (> 3,700 m²)	0.6 (93%)	0.2 (92%)	0.1 (71%)	0.4 (69%)	1.2 (41%)	0.9 (74%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	4.7 (4%)	1.1 (0%)	9.5 (60%)	
Small Office (< 3,700 m²)	0.6 (93%)	0.2 (92%)	0.1 (71%)	0.6 (78%)	1.5 (46%)	0.3 (91%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	4.7 (4%)	0.3 (0%)	8.7 (66%)	
Non-Food Retail	0.9 (90%)	0.7 (80%)	0.1 (72%)	0.5 (75%)	1.9 (58%)	1.1 (64%)	0.0 (47%)	0.1 (25%)	0.2 (30%)	1.6 (-5%)	0.2 (0%)	7.1 (73%)	
Food Retail	0.5 (95%)	0.5 (91%)	0.1 (72%)	0.5 (16%)	0.8 (14%)	0.7 (20%)	0.3 (47%)	5.2 (25%)	31.8 (18%)	2.1 (-5%)	2.5 (0%)	44.5 (35%)	
Restaurant/Tavern	0.5 (91%)	0.4 (93%)	0.0 (0%)	2.5 (86%)	1.8 (56%)	4.0 (4%)	5.5 (35%)	7.1 (25%)	4.0 (30%)	1.1 (-5%)	2.7 (0%)	29.3 (55%)	
Hotels/Motels	0.4 (93%)	0.1 (93%)	0.1 (78%)	1.2 (88%)	1.2 (35%)	1.7 (18%)	1.8 (32%)	1.3 (25%)	0.2 (30%)	2.3 (-5%)	0.4 (0%)	10.8 (82%)	
Warehouse/Wholesale	1.0 (80%)	0.1 (85%)	0.0 (0%)	0.4 (93%)	1.2 (53%)	0.3 (3%)	0.0 (47%)	0.1 (25%)	0.5 (0%)	1.1 (-5%)	0.5 (0%)	5.2 (69%)	
Hospitals	0.3 (87%)	0.5 (86%)	0.2 (74%)	2.0 (68%)	2.1 (24%)	6.3 (14%)	2.8 (29%)	1.3 (25%)	0.5 (30%)	6.2 (4%)	0.5 (0%)	22.5 (37%)	
Nursing Homes	0.4 (90%)	0.4 (84%)	0.0 (0%)	1.2 (87%)	1.2 (44%)	0.8 (0%)	2.1 (41%)	1.3 (25%)	0.5 (30%)	1.8 (-5%)	0.3 (0%)	9.3 (64%)	
Universities/Colleges	0.7 (89%)	0.2 (87%)	0.0 (0%)	1.7 (88%)	0.8 (43%)	0.8 (82%)	0.9 (32%)	0.4 (25%)	0.2 (30%)	1.0 (4%)	0.4 (0%)	7.9 (86%)	
Schools	0.5 (87%)	0.2 (85%)	0.0 (0%)	0.5 (90%)	1.5 (32%)	0.3 (30%)	0.4 (35%)	0.1 (25%)	0.2 (75%)	0.3 (4%)	0.0 (0%)	4.0 (72%)	
High Rise Apartments	0.1 (96%)	0.2 (96%)	0.0 (0%)	0.8 (86%)	1.6 (30%)	1.2 (8%)	1.5 (41%)	0.4 (25%)	0.2 (75%)	1.0 (41%)	0.3 (0%)	7.4 (60%)	
Miscellaneous	0.8 (90%)	0.1 (90%)	0.0 (73%)	0.8 (89%)	1.6 (30%)	1.2 (25%)	0.1 (47%)	0.0 (0%)	0.0 (0%)	0.8 (-5%)	0.3 (0%)	5.8 (73%)	

Note: Reductions over Frozen Efficiency are shown in parenthesis.
HVAC: Heating, ventilation and air conditioning
Refrig.: Refrigeration

TABLE 9.19
TECHNOLOGICAL POTENTIAL MODEL ESTIMATE BY BUILDING SEGMENT

BUILDING SEGMENT	YEAR 2000				YEAR 2010			
	LOW GROWTH		HIGH GROWTH		LOW GROWTH		HIGH GROWTH	
	ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹	
	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)
Large Office (> 3,700 m ²)	192.6	58%	202.5	58%	248.7	63%	272.3	64%
Small Office (< 3,700 m ²)	1,728.8	66%	1,813.0	65%	2,191.4	71%	2,391.0	70%
Non-Food Retail	1,335.1	61%	1,638.4	61%	1,701.2	73%	2,368.1	74%
Food Retail	287.9	35%	349.8	35%	328.0	38%	450.9	37%
Restaurant/Tavern	271.7	45%	296.9	45%	336.3	51%	389.4	51%
Hotels/Motels	329.3	50%	374.2	51%	450.9	60%	544.5	60%
Warehouse/Wholesale	380.0	46%	492.9	44%	574.0	63%	857.5	62%
Hospitals	162.5	40%	174.4	39%	208.5	45%	239.7	44%
Nursing Homes	93.4	51%	100.7	51%	129.0	62%	149.4	62%
Universities/Colleges	210.6	54%	229.5	54%	285.8	65%	334.8	65%
Schools	360.9	63%	388.7	63%	498.1	77%	574.3	77%
High Rise Apartments	585.0	62%	618.8	62%	707.4	69%	791.4	69%
Miscellaneous	333.2	53%	361.8	53%	481.4	66%	565.1	67%
Total Savings	6,271.2	56%	7,041.3	55%	8,140.7	65%	9,928.4	65%

Notes:

¹ Electricity savings (GWh and %) represent savings over corresponding year's Frozen Efficiency consumption.

TABLE 9.20
TECHNOLOGICAL POTENTIAL MODEL ESTIMATE BY END-USE

END-USE	YEAR 2000				YEAR 2010			
	LOW GROWTH		HIGH GROWTH		LOW GROWTH		HIGH GROWTH	
	ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹	
	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)
General Lighting	2,346.1	70%	2,656.8	69%	3,376.4	90%	4,184.9	89%
Service Area Lighting	1,089.9	70%	1,240.1	70%	1,530.3	90%	1,893.3	90%
Other Lighting	30.9	30%	33.6	30%	84.2	73%	100.2	73%
Space Heating	1,072.2	87%	1,148.3	87%	1,155.6	87%	1,309.3	87%
Space Cooling	442.9	50%	502.6	50%	483.7	50%	596.0	50%
HVAC Electricity	481.8	37%	551.7	39%	586.6	41%	725.5	42%
Service Hot Water	59.9	38%	65.2	38%	66.9	38%	77.7	38%
Cooking Equipment	43.4	25%	50.0	25%	49.0	25%	61.2	25%
Refrigeration Equipment	187.0	25%	215.6	24%	203.6	25%	257.7	24%
Office Equipment	517.0	35%	577.5	34%	604.3	35%	722.5	34%
Misc. Equipment	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Total Savings	6,271.2	56%	7,041.3	55%	8,140.7	65%	9,928.4	65%

Notes:

¹ Electricity savings (GWh and %) represent savings over corresponding year's Frozen Efficiency consumption.

HVAC: Heating, ventilation and air conditioning



10. SOCIAL POTENTIAL**10.1 Summary of Social Potential**

Operational practices which currently affect electricity use in commercial buildings are concerned with the scheduling of lighting, and the scheduling and maintenance of HVAC equipment. The estimated penalties associated with these practices, expressed in percent increase in energy use, were given in Tables 5.1 and 5.2. Improved practices that would effectively remove these penalties and other actions by building occupants and owners that would improve energy efficiency were described in Section 7.1.

The savings that could be achieved through operational (social) improvements in the commercial sector may be summarized as follows:

Lighting: Improved scheduling of overall lighting system and manual switching of individual lights where rooms are not occupied.

HVAC: Improved scheduling and maintenance of HVAC equipment.

Office Equipment: Turning off office equipment when not in use.

The percentage reduction in end-use intensities that could be achieved through implementation of these practices were shown in Table 7.4 and are repeated in Table 10.1.

Table 10.1
Potential Savings Achievable
Through Operational (Social) Improvements

	Lighting*	HVAC	Office Equipment
Large Offices	32%	14%	50%
Small Offices	36%	16%	50%
Non-food Retail	20%	16%	n/a
Food Retail	65%	18%	n/a
Restaurants	5%	12%	n/a
Hotel/Motel	30%	12%	n/a
Warehouse	5%	18%	n/a
Hospital/Nursing Home	25%	10%	n/a
Universities/Colleges	32%	12%	50%
Schools	36%	12%	50%
Apartments	5%	18%	n/a

- * When electronic dimmable ballasts are used in lighting, regular cleaning of the fixtures will result in additional savings in lighting electricity. The coefficient of utilization (CU), and therefore connected loads, can be reduced by a further 10% to 15%.

10.2 Social plus Technological Potential in BC

When operational improvements are carried out in conjunction with technological improvements, increased savings over Technological Potential alone can be achieved.

Tables 10.2 and 10.3 show the EUIs used in the model estimate of Social plus Technological Potential for 2000 and 2010, respectively. Tables 10.4 and 10.5 show Social plus Technological Potential by building segment and end-use, respectively. The estimates of conservation potential were derived using the calibrated spreadsheet model used to determine Technological Potential. New EUIs for lighting, heating, cooling and HVAC electricity were calculated by setting all scheduling and maintenance factors for these end-uses on the Typical Building Profiles to 1.0. Coefficients of utilization (CUs) were increased to take account of future cleaning. Hours of operation for lighting were also reduced by 20% (except where occupancy sensors were already in use), and hours of operation for plug-loads were reduced by 50% in Offices, Schools and Universities, to allow for optimum behaviour of building occupants.

The savings of between 20% and 25% in operational practice through improvements in lighting scheduling and HVAC system maintenance and scheduling have the overall effect of adding 3% to Technological Potential - i.e., 68% over Frozen Efficiency. While not as large as the savings associated with technical improvements only, these operational savings are significant because they can usually be obtained by refocussing training on energy efficiency and do not involve high costs.

TABLE 10.2A

SUMMARY OF AVERAGE END-USE INTENSITIES FOR ALL ELECTRIC BUILDINGS IN B.C. - SOCIAL PLUS TECHNOLOGICAL POTENTIAL MODEL INPUTS YEAR 2000 (MJ/m²·yr)

EXISTING BUILDINGS	General Lighting (MJ/m ² ·yr)	Service Area Lighting (MJ/m ² ·yr)	Other Lighting (MJ/m ² ·yr)	Space Heating (MJ/m ² ·yr)	Space Cooling (MJ/m ² ·yr)	HVAC Electricity (MJ/m ² ·yr)	Service Hot water (MJ/m ² ·yr)	Cooking Equipment (MJ/m ² ·yr)	Refrig. Equipment (MJ/m ² ·yr)	Office Equipment (MJ/m ² ·yr)	Misc. Equipment (MJ/m ² ·yr)	Total (MJ/m ² ·yr)
Large Office (> 3,700 m ²)	46.4 (86%)	18.5 (79%)	6.1 (50%)	29.7 (81%)	32.9 (57%)	92.8 (31%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	54.4 (52%)	43.2 (0%)	338.3 (66%)
Small Office (< 3,700 m ²)	48.4 (86%)	19.3 (79%)	6.1 (52%)	31.7 (88%)	48.3 (61%)	57.1 (49%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	54.4 (52%)	12.9 (0%)	292.5 (73%)
Non-Food Retail	83.3 (75%)	64.7 (76%)	6.1 (40%)	24.8 (87%)	59.5 (65%)	77.0 (37%)	0.8 (47%)	3.1 (25%)	6.7 (30%)	82.9 (-5%)	6.5 (0%)	395.5 (67%)
Food Retail	48.8 (86%)	51.6 (74%)	6.1 (31%)	56.9 (87%)	34.2 (73%)	96.9 (22%)	10.2 (47%)	97.5 (25%)	1223.8 (18%)	81.1 (-5%)	97.0 (0%)	1804.0 (41%)
Restaurant/Tavern	81.2 (87%)	53.0 (77%)	0.0 (0%)	82.7 (91%)	51.3 (65%)	374.7 (5%)	212.6 (35%)	314.3 (25%)	154.0 (30%)	44.2 (-5%)	103.0 (0%)	1470.8 (52%)
Hotels/Motels	52.8 (65%)	18.7 (67%)	13.1 (45%)	23.1 (90%)	55.3 (29%)	67.8 (18%)	68.0 (32%)	50.9 (25%)	8.8 (30%)	90.7 (-5%)	14.2 (0%)	483.2 (49%)
Warehouse/Wholesale	91.8 (53%)	7.3 (70%)	0.0 (0%)	37.3 (90%)	35.4 (63%)	12.8 (3%)	1.0 (47%)	3.0 (25%)	15.8 (18%)	43.7 (-5%)	19.0 (0%)	266.3 (67%)
Hospitals	24.9 (73%)	39.1 (67%)	18.0 (31%)	67.4 (73%)	71.0 (35%)	181.3 (36%)	99.4 (28%)	45.8 (25%)	17.5 (30%)	157.2 (4%)	20.0 (0%)	741.6 (43%)
Nursing Homes	44.6 (61%)	43.6 (59%)	0.0 (0%)	61.4 (86%)	49.6 (41%)	32.8 (0%)	82.6 (41%)	9.6 (25%)	21.0 (30%)	36.6 (-5%)	12.8 (0%)	396.4 (60%)
Universities/Colleges	67.2 (70%)	23.4 (67%)	0.0 (0%)	57.7 (73%)	25.7 (52%)	101.2 (39%)	36.6 (32%)	16.5 (25%)	7.0 (30%)	20.7 (52%)	15.0 (0%)	371.0 (57%)
Schools	43.2 (67%)	21.5 (65%)	0.0 (0%)	20.3 (91%)	51.8 (40%)	10.7 (30%)	14.3 (35%)	3.6 (25%)	7.0 (30%)	4.3 (52%)	0.4 (0%)	177.1 (68%)
High Rise Apartments	22.7 (67%)	36.5 (67%)	0.0 (0%)	45.8 (90%)	46.6 (49%)	47.7 (8%)	59.0 (41%)	14.3 (25%)	9.0 (75%)	40.5 (26%)	12.8 (0%)	334.9 (66%)
Miscellaneous	69.2 (67%)	14.3 (63%)	4.2 (39%)	53.0 (87%)	46.8 (49%)	46.2 (25%)	2.1 (47%)	0.0 (0%)	0.0 (0%)	34.0 (-5%)	12.0 (0%)	281.7 (68%)
NEW BUILDINGS	General Lighting (MJ/m ² ·yr)	Service Area Lighting (MJ/m ² ·yr)	Other Lighting (MJ/m ² ·yr)	Space Heating (MJ/m ² ·yr)	Space Cooling (MJ/m ² ·yr)	HVAC Electricity (MJ/m ² ·yr)	Service Hot water (MJ/m ² ·yr)	Cooking Equipment (MJ/m ² ·yr)	Refrig. Equipment (MJ/m ² ·yr)	Office Equipment (MJ/m ² ·yr)	Misc. Equipment (MJ/m ² ·yr)	Total (MJ/m ² ·yr)
Large Office (> 3,700 m ²)	46.4 (85%)	17.5 (78%)	6.1 (49%)	17.5 (69%)	39.2 (48%)	35.7 (74%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	90.7 (52%)	43.2 (0%)	310.5 (67%)
Small Office (< 3,700 m ²)	48.4 (85%)	18.2 (78%)	6.1 (51%)	25.9 (74%)	51.7 (54%)	13.5 (91%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	90.7 (52%)	12.9 (0%)	281.7 (72%)
Non-Food Retail	83.3 (75%)	57.8 (77%)	7.3 (28%)	21.0 (70%)	62.0 (63%)	44.0 (64%)	0.8 (47%)	3.1 (25%)	6.7 (30%)	82.9 (-5%)	6.5 (0%)	355.3 (66%)
Food Retail	45.9 (87%)	51.6 (73%)	6.1 (31%)	23.8 (-1%)	18.3 (27%)	27.4 (20%)	10.2 (47%)	201.8 (25%)	1223.8 (18%)	81.1 (-5%)	97.0 (0%)	1787.0 (32%)
Restaurant/Tavern	78.4 (86%)	64.1 (73%)	0.0 (0%)	116.0 (83%)	51.0 (65%)	153.3 (4%)	212.6 (35%)	274.9 (25%)	154.0 (30%)	44.2 (-5%)	103.0 (0%)	1251.4 (50%)
Hotels/Motels	52.8 (73%)	18.7 (67%)	13.1 (45%)	55.9 (85%)	43.2 (42%)	67.8 (18%)	68.0 (32%)	50.9 (25%)	8.8 (30%)	90.7 (-5%)	14.2 (0%)	483.9 (56%)
Warehouse/Wholesale	95.1 (49%)	7.3 (70%)	0.0 (0%)	19.0 (92%)	37.9 (60%)	12.6 (3%)	1.0 (47%)	3.0 (25%)	19.0 (0%)	43.7 (-5%)	19.0 (0%)	257.5 (60%)
Hospitals	24.9 (71%)	41.8 (68%)	18.0 (36%)	93.1 (62%)	75.6 (31%)	243.3 (14%)	99.4 (29%)	51.0 (25%)	17.5 (30%)	241.9 (4%)	20.0 (0%)	926.4 (33%)
Nursing Homes	52.8 (65%)	34.5 (61%)	0.0 (0%)	55.3 (84%)	42.8 (49%)	32.8 (0%)	82.6 (41%)	16.5 (25%)	21.0 (30%)	36.6 (-5%)	12.8 (0%)	424.0 (57%)
Universities/Colleges	58.2 (76%)	23.4 (67%)	0.0 (0%)	60.9 (62%)	27.2 (29%)	29.8 (82%)	36.6 (32%)	16.5 (25%)	7.0 (30%)	34.8 (52%)	15.0 (0%)	328.0 (64%)
Schools	40.9 (71%)	18.4 (65%)	0.0 (0%)	25.3 (88%)	52.5 (39%)	11.6 (23%)	14.3 (35%)	3.6 (25%)	7.0 (30%)	6.5 (52%)	0.4 (0%)	180.5 (68%)
High Rise Apartments	14.6 (83%)	17.8 (63%)	0.0 (0%)	37.1 (83%)	54.1 (40%)	47.7 (8%)	59.0 (41%)	14.3 (25%)	9.0 (75%)	37.8 (-5%)	12.8 (0%)	304.2 (57%)
Miscellaneous	94.1 (71%)	15.9 (67%)	4.2 (39%)	30.8 (88%)	54.1 (40%)	46.2 (25%)	2.1 (47%)	0.0 (0%)	0.0 (0%)	34.0 (-5%)	12.0 (0%)	293.2 (65%)

Note: Reduction over Frozen Efficiency is shown in brackets.
 HVAC: Heating, ventilation and air conditioning
 Refrig: Refrigeration

TABLE 10.2B

SUMMARY OF AVERAGE END-USE INTENSITIES FOR ALL ELECTRIC BUILDINGS IN B.C. - SOCIAL PLUS TECHNOLOGICAL POTENTIAL MODEL INPUTS YEAR 2000 (kWh/ft²-yr)

EXISTING BUILDINGS	General Lighting (kWh/ft ² -yr)	Service Area Lighting (kWh/ft ² -yr)	Other Lighting (kWh/ft ² -yr)	Space Heating (kWh/ft ² -yr)	Space Cooling (kWh/ft ² -yr)	HVAC Electricity (kWh/ft ² -yr)	Service Hot water (kWh/ft ² -yr)	Cooking Equipment (kWh/ft ² -yr)	Refrig. Equipment (kWh/ft ² -yr)	Office Equipment (kWh/ft ² -yr)	Misc. Equipment (kWh/ft ² -yr)	Total (kWh/ft ² -yr)
Large Office (> 3,700 m ²)	1.2 (86%)	0.5 (79%)	0.2 (50%)	0.8 (81%)	0.9 (57%)	2.4 (31%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	1.4 (52%)	1.1 (0%)	8.7 (66%)
Small Office (< 3,700 m ²)	1.3 (86%)	0.5 (79%)	0.2 (52%)	0.8 (89%)	1.2 (61%)	1.5 (49%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	1.4 (52%)	0.3 (0%)	7.6 (73%)
Non-Food Retail	2.2 (75%)	1.7 (78%)	0.2 (40%)	0.8 (87%)	1.5 (65%)	2.0 (37%)	0.0 (47%)	0.1 (25%)	0.2 (30%)	1.8 (-5%)	0.2 (0%)	10.2 (67%)
Food Retail	1.3 (86%)	1.3 (74%)	0.2 (31%)	0.5 (87%)	0.9 (73%)	2.5 (22%)	0.3 (47%)	2.5 (25%)	31.6 (18%)	2.1 (-5%)	2.5 (0%)	46.6 (41%)
Restaurant/Tavern	2.1 (87%)	1.4 (77%)	0.0 (0%)	2.1 (91%)	1.3 (65%)	9.7 (5%)	5.5 (35%)	8.1 (25%)	4.0 (30%)	1.1 (-5%)	2.7 (0%)	38.0 (52%)
Hotels/Motels	1.4 (85%)	0.5 (67%)	0.3 (45%)	0.6 (90%)	1.4 (26%)	1.7 (18%)	1.8 (32%)	1.3 (25%)	0.2 (30%)	2.3 (-5%)	0.4 (0%)	12.0 (49%)
Warehouse/Wholesale	2.4 (53%)	0.2 (70%)	0.0 (0%)	1.0 (90%)	0.9 (63%)	0.3 (3%)	0.0 (47%)	0.1 (25%)	0.4 (18%)	1.1 (-5%)	0.5 (0%)	6.9 (67%)
Hospitals	0.6 (73%)	1.0 (67%)	0.5 (31%)	1.7 (73%)	1.8 (35%)	4.7 (36%)	2.8 (29%)	1.2 (25%)	0.5 (30%)	4.1 (4%)	0.5 (0%)	18.1 (43%)
Nursing Homes	1.2 (61%)	1.1 (59%)	0.0 (0%)	1.6 (86%)	1.3 (41%)	0.8 (0%)	2.1 (41%)	0.2 (25%)	0.5 (30%)	1.0 (-5%)	0.3 (0%)	10.2 (60%)
Universities/Colleges	1.7 (70%)	0.6 (67%)	0.0 (0%)	1.5 (73%)	0.7 (52%)	2.6 (39%)	0.9 (32%)	0.4 (25%)	0.2 (30%)	0.5 (52%)	0.4 (0%)	9.6 (57%)
Schools	1.1 (67%)	0.6 (65%)	0.0 (0%)	0.5 (91%)	1.3 (40%)	0.3 (30%)	0.4 (35%)	0.1 (25%)	0.2 (30%)	0.1 (52%)	0.0 (0%)	4.6 (68%)
High Rise Apartments	0.6 (67%)	0.9 (67%)	0.0 (0%)	1.2 (90%)	1.2 (49%)	1.2 (8%)	1.5 (41%)	0.4 (25%)	0.2 (75%)	1.0 (25%)	0.3 (0%)	8.6 (66%)
Miscellaneous	1.8 (67%)	0.4 (63%)	0.1 (39%)	1.4 (87%)	1.2 (49%)	1.2 (25%)	0.1 (47%)	0.0 (0%)	0.0 (0%)	0.9 (-5%)	0.3 (0%)	7.3 (68%)
NEW BUILDINGS	General Lighting (kWh/ft ² -yr)	Service Area Lighting (kWh/ft ² -yr)	Other Lighting (kWh/ft ² -yr)	Space Heating (kWh/ft ² -yr)	Space Cooling (kWh/ft ² -yr)	HVAC Electricity (kWh/ft ² -yr)	Service Hot water (kWh/ft ² -yr)	Cooking Equipment (kWh/ft ² -yr)	Refrig. Equipment (kWh/ft ² -yr)	Office Equipment (kWh/ft ² -yr)	Misc. Equipment (kWh/ft ² -yr)	Total (kWh/ft ² -yr)
Large Office (> 3,700 m ²)	1.2 (85%)	0.5 (78%)	0.2 (49%)	0.5 (88%)	1.0 (48%)	0.9 (74%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	2.3 (52%)	1.1 (0%)	8.0 (67%)
Small Office (< 3,700 m ²)	1.3 (85%)	0.5 (78%)	0.2 (51%)	0.7 (74%)	1.3 (54%)	0.3 (91%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	2.3 (52%)	0.3 (0%)	7.3 (72%)
Non-Food Retail	2.2 (75%)	1.5 (77%)	0.2 (29%)	0.5 (70%)	1.6 (63%)	1.1 (64%)	0.0 (47%)	0.1 (25%)	0.2 (30%)	1.8 (-5%)	0.2 (0%)	9.2 (66%)
Food Retail	1.2 (87%)	1.3 (78%)	0.2 (31%)	0.6 (-1%)	0.5 (27%)	0.7 (20%)	0.3 (47%)	5.2 (25%)	31.8 (18%)	2.1 (-5%)	2.5 (0%)	46.1 (32%)
Restaurant/Tavern	2.0 (86%)	1.7 (73%)	0.0 (0%)	3.0 (83%)	1.3 (65%)	4.0 (4%)	5.5 (35%)	7.1 (25%)	4.0 (30%)	1.1 (-5%)	2.7 (0%)	32.3 (50%)
Hotels/Motels	1.4 (73%)	0.5 (67%)	0.3 (45%)	1.4 (85%)	1.1 (42%)	1.7 (18%)	1.8 (32%)	1.3 (25%)	0.2 (30%)	2.3 (-5%)	0.4 (0%)	12.5 (56%)
Warehouse/Wholesale	2.5 (49%)	0.2 (70%)	0.0 (0%)	0.5 (92%)	1.0 (60%)	0.3 (3%)	0.0 (47%)	0.1 (25%)	0.5 (0%)	1.1 (-5%)	0.5 (0%)	6.8 (60%)
Hospitals	0.6 (71%)	1.1 (68%)	0.5 (35%)	2.4 (62%)	2.0 (31%)	6.3 (14%)	2.6 (29%)	1.3 (25%)	0.5 (30%)	6.2 (4%)	0.5 (0%)	23.9 (33%)
Nursing Homes	1.4 (65%)	0.9 (61%)	0.0 (0%)	1.4 (84%)	1.1 (49%)	0.8 (0%)	2.1 (41%)	1.3 (25%)	0.5 (30%)	1.0 (-5%)	0.3 (0%)	10.9 (57%)
Universities/Colleges	1.5 (76%)	0.6 (67%)	0.0 (0%)	2.1 (82%)	0.7 (49%)	0.8 (82%)	0.9 (32%)	0.4 (25%)	0.2 (30%)	0.9 (52%)	0.4 (0%)	8.5 (64%)
Schools	1.1 (71%)	0.5 (65%)	0.0 (0%)	0.7 (88%)	1.4 (39%)	0.3 (23%)	0.4 (35%)	0.1 (25%)	0.2 (30%)	0.2 (52%)	0.0 (0%)	4.7 (68%)
High Rise Apartments	0.4 (83%)	0.5 (63%)	0.0 (0%)	1.0 (83%)	1.4 (40%)	1.2 (8%)	1.5 (41%)	0.4 (25%)	0.2 (75%)	1.0 (-5%)	0.3 (0%)	7.9 (57%)
Miscellaneous	2.4 (71%)	0.4 (67%)	0.1 (39%)	0.8 (88%)	1.4 (40%)	1.2 (25%)	0.1 (47%)	0.0 (0%)	0.0 (0%)	0.9 (-5%)	0.3 (0%)	7.6 (65%)

Note: Reduction over Frozen Efficiency is shown in brackets.

HVAC: Heating, ventilation and air conditioning

Refrig: Refrigeration

TABLE 10.3A

SUMMARY OF AVERAGE END-USE INTENSITIES FOR ALL ELECTRIC COMMERCIAL BUILDINGS IN B.C. – SOCIAL PLUS TECHNOLOGICAL POTENTIAL MODEL INPUTS YEAR 2010 (M.J/m².yr)

EXISTING BUILDINGS	General Lighting (M.J/m ² .yr)	Service Area Lighting (M.J/m ² .yr)	Other Lighting (M.J/m ² .yr)	Space Heating (M.J/m ² .yr)	Space Cooling (M.J/m ² .yr)	HVAC Electricity (M.J/m ² .yr)	Service Hot water (M.J/m ² .yr)	Cooking Equipment (M.J/m ² .yr)	Refrig. Equipment (M.J/m ² .yr)	Office Equipment (M.J/m ² .yr)	Misc. Equipment (M.J/m ² .yr)	Total (M.J/m ² .yr)
Large Office (> 3,700 m ²)	20.2 (94%)	6.2 (93%)	2.4 (80%)	29.7 (81%)	32.9 (57%)	92.8 (31%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	54.4 (52%)	43.2 (0%)	286.0 (70%)
Small Office (< 3,700 m ²)	21.1 (94%)	6.5 (93%)	2.4 (81%)	31.7 (88%)	48.3 (61%)	57.1 (49%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	54.4 (52%)	12.9 (0%)	248.5 (77%)
Non-Food Retail	26.8 (92%)	20.8 (93%)	2.4 (76%)	24.8 (87%)	59.5 (65%)	77.0 (37%)	0.8 (47%)	3.1 (25%)	6.7 (30%)	82.9 (-5%)	6.5 (0%)	291.1 (76%)
Food Retail	16.9 (95%)	18.0 (91%)	2.4 (73%)	56.9 (87%)	34.2 (73%)	98.9 (22%)	10.2 (47%)	97.5 (25%)	1223.8 (19%)	81.1 (-5%)	97.0 (0%)	1,734.9 (44%)
Restaurant/Tavern	19.2 (92%)	14.3 (94%)	0.0 (0%)	82.7 (91%)	51.3 (65%)	374.7 (5%)	212.6 (35%)	314.3 (25%)	154.0 (30%)	44.2 (-5%)	103.0 (0%)	1,370.2 (55%)
Hotels/Motels	12.7 (92%)	4.1 (93%)	4.8 (80%)	23.1 (90%)	55.3 (26%)	67.8 (18%)	69.0 (32%)	50.9 (25%)	8.8 (30%)	90.7 (-5%)	14.2 (0%)	400.3 (56%)
Warehouse/Wholesale	32.6 (83%)	3.2 (87%)	0.0 (0%)	37.3 (90%)	35.4 (63%)	12.6 (3%)	1.0 (47%)	3.0 (25%)	15.6 (19%)	43.7 (-5%)	19.0 (0%)	203.2 (75%)
Hospitals	8.7 (90%)	15.1 (87%)	7.0 (73%)	67.4 (73%)	71.0 (35%)	181.3 (36%)	99.4 (29%)	45.8 (25%)	17.5 (30%)	157.2 (4%)	20.0 (0%)	690.5 (46%)
Nursing Homes	15.6 (86%)	16.9 (84%)	0.0 (0%)	61.4 (86%)	49.6 (41%)	32.6 (0%)	82.6 (41%)	9.8 (25%)	21.0 (30%)	38.8 (-5%)	12.8 (0%)	340.8 (68%)
Universities/Colleges	24.1 (89%)	8.2 (89%)	0.0 (0%)	57.7 (73%)	25.7 (52%)	101.2 (39%)	36.6 (32%)	16.5 (25%)	7.0 (30%)	20.7 (52%)	15.0 (0%)	312.7 (84%)
Schools	15.7 (88%)	8.3 (87%)	0.0 (0%)	20.3 (91%)	51.8 (40%)	10.7 (30%)	14.3 (35%)	3.6 (25%)	7.0 (30%)	4.3 (52%)	0.4 (0%)	136.4 (76%)
High Rise Apartments	5.1 (93%)	8.6 (92%)	0.0 (0%)	45.8 (90%)	46.8 (49%)	47.7 (8%)	59.0 (41%)	14.3 (25%)	9.0 (75%)	40.5 (26%)	12.8 (0%)	289.5 (71%)
Miscellaneous	25.3 (88%)	5.0 (87%)	1.7 (76%)	53.0 (87%)	46.6 (49%)	46.2 (25%)	2.1 (47%)	0.0 (0%)	0.0 (0%)	34.0 (-5%)	12.0 (0%)	226.0 (74%)
NEW BUILDINGS	General Lighting (M.J/m ² .yr)	Service Area Lighting (M.J/m ² .yr)	Other Lighting (M.J/m ² .yr)	Space Heating (M.J/m ² .yr)	Space Cooling (M.J/m ² .yr)	HVAC Electricity (M.J/m ² .yr)	Service Hot water (M.J/m ² .yr)	Cooking Equipment (M.J/m ² .yr)	Refrig. Equipment (M.J/m ² .yr)	Office Equipment (M.J/m ² .yr)	Misc. Equipment (M.J/m ² .yr)	Total (M.J/m ² .yr)
Large Office (> 3,700 m ²)	20.2 (94%)	6.1 (92%)	2.4 (80%)	14.5 (73%)	39.2 (48%)	35.7 (74%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	90.7 (52%)	43.2 (0%)	266.3 (71%)
Small Office (< 3,700 m ²)	21.1 (94%)	6.4 (92%)	2.4 (81%)	18.6 (81%)	51.7 (54%)	13.5 (91%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	90.7 (52%)	12.9 (0%)	231.4 (77%)
Non-Food Retail	26.6 (92%)	20.2 (92%)	2.4 (76%)	15.1 (79%)	62.0 (63%)	44.0 (57%)	0.8 (47%)	3.1 (25%)	6.7 (30%)	82.9 (-5%)	6.5 (0%)	250.2 (75%)
Food Retail	16.7 (95%)	18.0 (92%)	2.4 (73%)	16.8 (29%)	18.3 (27%)	27.4 (20%)	10.2 (47%)	201.8 (25%)	1223.8 (18%)	81.1 (-5%)	87.0 (0%)	1,713.5 (55%)
Restaurant/Tavern	19.0 (92%)	15.2 (94%)	0.0 (0%)	81.9 (88%)	51.0 (65%)	153.3 (4%)	212.6 (35%)	274.9 (25%)	154.0 (30%)	44.2 (-5%)	103.0 (0%)	1,109.0 (56%)
Hotels/Motels	12.7 (94%)	4.1 (93%)	4.8 (80%)	41.6 (89%)	43.2 (42%)	67.6 (-56%)	68.0 (32%)	50.9 (25%)	8.8 (30%)	90.7 (-5%)	14.2 (0%)	406.6 (81%)
Warehouse/Wholesale	32.9 (82%)	3.2 (87%)	0.0 (0%)	13.4 (94%)	37.9 (60%)	12.8 (3%)	1.0 (47%)	3.0 (25%)	19.0 (0%)	43.7 (-5%)	19.0 (0%)	185.6 (71%)
Hospitals	9.8 (89%)	15.3 (86%)	7.0 (75%)	70.5 (72%)	75.8 (31%)	243.3 (14%)	99.4 (29%)	51.0 (25%)	17.5 (30%)	241.9 (4%)	20.0 (0%)	851.2 (38%)
Nursing Homes	13.8 (91%)	12.1 (86%)	0.0 (0%)	41.9 (88%)	42.8 (49%)	32.6 (0%)	82.6 (21%)	51.0 (25%)	21.0 (30%)	38.8 (-5%)	12.8 (0%)	349.2 (63%)
Universities/Colleges	23.5 (90%)	8.2 (89%)	0.0 (0%)	60.2 (71%)	27.2 (49%)	29.6 (82%)	36.6 (32%)	16.5 (25%)	7.0 (30%)	34.8 (52%)	15.0 (0%)	258.4 (72%)
Schools	16.5 (88%)	7.1 (87%)	0.0 (0%)	18.9 (91%)	52.5 (39%)	11.6 (23%)	14.3 (35%)	3.6 (25%)	7.0 (30%)	6.5 (52%)	0.4 (0%)	138.3 (75%)
High Rise Apartments	3.4 (96%)	5.7 (86%)	0.0 (0%)	26.2 (88%)	54.1 (40%)	47.7 (8%)	59.0 (41%)	14.3 (25%)	9.0 (75%)	37.8 (-5%)	12.8 (0%)	270.0 (82%)
Miscellaneous	27.7 (92%)	4.2 (91%)	1.7 (76%)	25.5 (90%)	54.1 (40%)	46.2 (25%)	2.1 (47%)	0.0 (0%)	0.0 (0%)	34.0 (-5%)	12.0 (0%)	207.4 (75%)

Note: Reduction over Frozen Efficiency is shown in brackets.

HVAC: Heating, ventilation and air conditioning

Refig.: Refrigeration

TABLE 10.3B

SUMMARY OF AVERAGE END-USE INTENSITIES FOR ALL ELECTRIC COMMERCIAL BUILDINGS IN B.C. - SOCIAL PLUS TECHNOLOGICAL POTENTIAL MODEL INPUTS YEAR 2010 (kWh/m²-yr)

EXISTING BUILDINGS	General Lighting (kWh/m ² -yr)	Service Area Lighting (kWh/m ² -yr)	Other Lighting (kWh/m ² -yr)	Space Heating (kWh/m ² -yr)	Space Cooling (kWh/m ² -yr)	HVAC Electricity (kWh/m ² -yr)	Service Hot water (kWh/m ² -yr)	Cooking Equipment (kWh/m ² -yr)	Refrig. Equipment (kWh/m ² -yr)	Office Equipment (kWh/m ² -yr)	Misc. Equipment (kWh/m ² -yr)	Total (kWh/m ² -yr)
Large Office (> 3,700 m ²)	0.5 (94%)	0.2 (93%)	0.1 (80%)	0.8 (81%)	0.9 (57%)	2.4 (31%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	1.4 (52%)	1.1 (0%)	7.8 (70%)
Small Office (< 3,700 m ²)	0.5 (94%)	0.2 (93%)	0.1 (81%)	0.8 (88%)	1.2 (81%)	1.5 (49%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	1.4 (52%)	0.3 (0%)	8.4 (77%)
Non-Food Retail	0.7 (92%)	0.5 (93%)	0.1 (79%)	0.6 (87%)	1.5 (65%)	2.0 (37%)	0.0 (47%)	0.1 (25%)	0.2 (30%)	1.8 (-5%)	0.2 (0%)	7.5 (76%)
Food Retail	0.4 (95%)	0.5 (91%)	0.1 (73%)	0.5 (87%)	0.9 (73%)	2.5 (22%)	0.3 (47%)	2.5 (25%)	31.8 (18%)	2.1 (-5%)	2.5 (0%)	44.8 (44%)
Restaurant/Tavern	0.5 (92%)	0.4 (94%)	0.0 (0%)	2.1 (91%)	1.3 (65%)	9.7 (5%)	5.5 (35%)	8.1 (25%)	4.0 (30%)	1.1 (-5%)	2.7 (0%)	35.4 (55%)
Hotels/Motels	0.3 (92%)	0.1 (83%)	0.1 (80%)	0.6 (90%)	1.4 (28%)	1.7 (18%)	1.8 (32%)	1.3 (25%)	0.2 (30%)	2.3 (-5%)	0.4 (0%)	10.3 (56%)
Warehouse/Wholesale	0.8 (93%)	0.1 (87%)	0.0 (0%)	1.0 (90%)	0.9 (63%)	0.3 (3%)	0.0 (47%)	0.1 (25%)	0.4 (18%)	1.1 (-5%)	0.5 (0%)	5.2 (75%)
Hospitals	0.2 (90%)	0.4 (87%)	0.2 (73%)	1.7 (73%)	1.8 (35%)	4.7 (36%)	2.8 (29%)	1.2 (25%)	0.5 (30%)	4.1 (4%)	0.5 (0%)	17.8 (46%)
Nursing Homes	0.4 (86%)	0.4 (84%)	0.0 (0%)	1.6 (86%)	1.3 (41%)	0.8 (0%)	2.1 (41%)	0.2 (25%)	0.5 (30%)	1.0 (-5%)	0.3 (0%)	8.8 (66%)
Universities/Colleges	0.6 (89%)	0.2 (89%)	0.0 (0%)	1.5 (73%)	0.7 (52%)	2.8 (39%)	0.9 (32%)	0.4 (25%)	0.2 (30%)	0.5 (52%)	0.4 (0%)	8.1 (64%)
Schools	0.4 (88%)	0.2 (87%)	0.0 (0%)	0.5 (91%)	1.3 (40%)	0.3 (30%)	0.4 (35%)	0.1 (25%)	0.2 (30%)	0.1 (52%)	0.0 (0%)	3.5 (76%)
High Rise Apartments	0.1 (93%)	0.2 (92%)	0.0 (0%)	1.2 (90%)	1.2 (49%)	1.2 (8%)	1.5 (41%)	0.4 (25%)	0.2 (75%)	1.0 (25%)	0.3 (0%)	7.5 (71%)
Miscellaneous	0.7 (88%)	0.1 (87%)	0.0 (76%)	1.4 (87%)	1.2 (49%)	1.2 (25%)	0.1 (47%)	0.0 (0%)	0.0 (0%)	0.9 (-5%)	0.3 (0%)	5.8 (74%)
NEW BUILDINGS	General Lighting (kWh/m ² -yr)	Service Area Lighting (kWh/m ² -yr)	Other Lighting (kWh/m ² -yr)	Space Heating (kWh/m ² -yr)	Space Cooling (kWh/m ² -yr)	HVAC Electricity (kWh/m ² -yr)	Service Hot water (kWh/m ² -yr)	Cooking Equipment (kWh/m ² -yr)	Refrig. Equipment (kWh/m ² -yr)	Office Equipment (kWh/m ² -yr)	Misc. Equipment (kWh/m ² -yr)	Total (kWh/m ² -yr)
Large Office (> 3,700 m ²)	0.5 (94%)	0.2 (92%)	0.1 (80%)	0.4 (73%)	1.0 (48%)	0.9 (74%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	2.3 (52%)	1.1 (0%)	6.9 (71%)
Small Office (< 3,700 m ²)	0.5 (94%)	0.2 (92%)	0.1 (81%)	0.5 (81%)	1.3 (54%)	0.3 (91%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	2.3 (52%)	0.3 (0%)	8.0 (77%)
Non-Food Retail	0.7 (92%)	0.5 (92%)	0.1 (79%)	0.4 (79%)	1.6 (63%)	1.1 (57%)	0.0 (47%)	0.1 (25%)	0.2 (30%)	1.8 (-5%)	0.2 (0%)	6.5 (75%)
Food Retail	0.4 (95%)	0.5 (92%)	0.1 (73%)	0.4 (29%)	0.5 (27%)	0.7 (20%)	0.3 (47%)	5.2 (25%)	31.8 (18%)	2.1 (-5%)	2.5 (0%)	44.2 (35%)
Restaurant/Tavern	0.5 (92%)	0.4 (94%)	0.0 (0%)	2.1 (88%)	1.3 (65%)	4.0 (4%)	5.5 (35%)	7.1 (25%)	4.0 (30%)	1.1 (-5%)	2.7 (0%)	28.6 (56%)
Hotels/Motels	0.3 (94%)	0.1 (83%)	0.1 (80%)	1.1 (89%)	1.1 (42%)	1.7 (-56%)	1.8 (32%)	1.3 (25%)	0.2 (30%)	2.3 (-5%)	0.4 (0%)	10.5 (61%)
Warehouse/Wholesale	0.9 (92%)	0.1 (87%)	0.0 (0%)	0.3 (94%)	1.0 (60%)	0.3 (3%)	0.0 (47%)	0.1 (25%)	0.5 (0%)	1.1 (-5%)	0.5 (0%)	4.8 (71%)
Hospitals	0.2 (89%)	0.4 (88%)	0.2 (75%)	1.8 (72%)	2.0 (31%)	6.3 (14%)	2.6 (29%)	1.3 (25%)	0.5 (30%)	8.2 (4%)	0.5 (0%)	22.0 (39%)
Nursing Homes	0.4 (91%)	0.3 (86%)	0.0 (0%)	1.1 (86%)	1.1 (48%)	0.8 (0%)	2.1 (21%)	1.3 (25%)	0.5 (30%)	1.0 (-5%)	0.3 (0%)	9.0 (63%)
Universities/Colleges	0.6 (90%)	0.2 (89%)	0.0 (0%)	1.8 (71%)	0.7 (49%)	0.8 (82%)	0.9 (32%)	0.4 (25%)	0.2 (30%)	0.9 (52%)	0.4 (0%)	6.7 (72%)
Schools	0.4 (88%)	0.2 (87%)	0.0 (0%)	0.5 (91%)	1.4 (39%)	0.3 (35%)	0.4 (39%)	0.1 (25%)	0.2 (75%)	0.2 (52%)	0.0 (0%)	3.8 (75%)
High Rise Apartments	0.1 (96%)	0.1 (88%)	0.0 (0%)	0.7 (88%)	1.4 (40%)	1.2 (8%)	1.5 (41%)	0.4 (25%)	0.2 (75%)	1.0 (-5%)	0.3 (0%)	7.0 (62%)
Miscellaneous	0.7 (92%)	0.1 (91%)	0.0 (76%)	0.7 (90%)	1.4 (40%)	1.2 (25%)	0.1 (47%)	0.0 (0%)	0.0 (0%)	0.9 (-5%)	0.3 (0%)	5.4 (75%)

Note: Reduction over Frozen Efficiency is shown in brackets.
 HVAC: Heating, ventilation and air conditioning
 Refrig.: Refrigeration

TABLE 10.4
SOCIAL PLUS TECHNOLOGICAL POTENTIAL MODEL ESTIMATE BY BUILDING SEGMENT

BUILDING SEGMENT	YEAR 2000				YEAR 2010			
	LOW GROWTH		HIGH GROWTH		LOW GROWTH		HIGH GROWTH	
	ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹	
	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)
Large Office (> 3,700 m ²)	221.2	67%	233.0	67%	282.0	72%	309.3	72%
Small Office (< 3,700 m ²)	1,950.5	74%	2,048.4	74%	2,447.7	79%	2,676.4	79%
Non-Food Retail	1,438.5	66%	1,765.8	66%	1,752.7	76%	2,440.7	76%
Food Retail	294.1	36%	357.1	35%	331.8	38%	455.9	38%
Restaurant/Tavern	278.2	46%	303.9	46%	341.7	52%	395.7	52%
Hotels/Motels	339.1	52%	384.9	52%	459.3	61%	554.4	61%
Warehouse/Wholesale	409.7	49%	532.6	48%	588.6	65%	879.6	64%
Hospitals	169.1	41%	181.5	41%	213.3	46%	245.4	45%
Nursing Homes	98.7	54%	106.2	54%	132.3	64%	153.1	64%
Universities/Colleges	231.7	59%	252.6	60%	308.0	70%	361.4	70%
Schools	382.7	66%	412.2	67%	515.9	80%	595.2	80%
High Rise Apartments	597.0	63%	631.2	63%	716.4	70%	801.3	70%
Miscellaneous	360.5	57%	391.2	57%	499.3	69%	585.8	69%
Total Savings	6,770.9	60%	7,600.7	60%	8,588.9	69%	10,454.1	68%

Notes:

¹ Electricity savings (GWh and %) represent savings over corresponding year's Frozen Efficiency consumption.

TABLE 10.5
SOCIAL PLUS TECHNOLOGICAL POTENTIAL MODEL ESTIMATE BY END-USE

END-USE	YEAR 2000				YEAR 2010			
	LOW GROWTH		HIGH GROWTH		LOW GROWTH		HIGH GROWTH	
	ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹	
	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)
General Lighting	2,469.6	74%	2,803.5	73%	3,427.4	91%	4,251.6	91%
Service Area Lighting	1,153.7	74%	1,315.3	74%	1,555.9	91%	1,927.0	91%
Other Lighting	44.6	44%	48.7	43%	90.3	78%	107.3	78%
Space Heating	1,090.8	88%	1,167.1	88%	1,178.7	89%	1,335.2	89%
Space Cooling	501.1	57%	568.5	57%	549.1	56%	676.2	56%
HVAC Electricity	481.8	37%	551.7	39%	586.6	41%	725.5	42%
Service Hot Water	59.9	38%	65.2	38%	66.9	38%	77.7	38%
Cooking Equipment	43.4	25%	50.0	25%	49.0	25%	61.2	25%
Refrigeration Equipment	187.0	25%	215.6	24%	203.6	25%	257.7	24%
Office Equipment	738.9	50%	815.2	49%	881.3	51%	1,034.5	49%
Misc. Equipment	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Total Savings	6,770.9	60%	7,600.7	60%	8,588.9	69%	10,454.1	68%

Notes:

¹ Electricity savings (GWh and %) represent savings over corresponding year's Frozen Efficiency consumption.

HVAC: Heating, ventilation and air conditioning



11. ECONOMIC POTENTIAL

11.1 Description of Economic Potential

Economic Potential is the savings that can be achieved when all equipment and building envelopes are upgraded only to a level which is cost effective against the long run marginal cost of electricity in the BC Hydro service area.

Cost effective means that the technology upgrade passes the total resource cost test, i.e. the cost of the measure per unit electricity saved (cost of conserved energy) minus any environmental credits, is less than or equal to the long run marginal cost of electricity.

The long run marginal cost of electricity supplied by BC Hydro for the study is the cost of electricity supply delivered to the Lower Mainland during the study period, assuming no Power Smart programs. This cost is shown in Table 11.1.

Table 11.1
BC Hydro Cost of New Supply of Electricity

Year	Electricity Cost (1990 cents/kWh)
1992	2.4
1993	2.6
1994	2.8
1995	3.1
1996	3.6
1997	4.3
1998	4.9
1999	5.7
2000 +	6.3

Environmental credits are a measure of the benefit of efficiency technologies in reducing the external (environmental) costs associated with new electricity supply or transmission. They are normally expressed as a percentage of the cost of new supply. In the estimation of Economic Potential, environmental credits were assumed to be between 0% and 100% of the cost of supply. Table 11.2 shows the environmental credits for each year between 1992 and 2000 assuming that they represent 15%, 30%, 60% and 100% of the cost of new supply.

Table 11.2
Environmental Credits at Various Percentages of Supply Cost (1990 cents/kWh)

Year	15%	30%	60%	100%
1992	0.4	0.7	1.4	2.4
1993	0.4	0.8	1.6	2.6
1994	0.4	0.8	1.6	2.8
1995	0.5	0.9	1.9	3.1
1996	0.5	1.1	2.2	3.6
1997	0.6	1.3	2.6	4.3
1998	0.7	1.5	2.9	4.9
1999	0.9	1.7	3.4	5.7
2000 +	0.9	1.9	3.8	6.3

11.2 Definition of Total Resource Cost

The total resource cost (TRC) of an efficiency measure is defined as the annualized incremental cost of the measure divided by the annual savings achieved, excluding any administrative costs associated with the use of the measure. The units of TRC are constant (1991) cents or dollars per kWh.

The annualized cost is a function of the life of the measure and the assumed discount rate as follows:

$$\text{Annualized Cost} = \text{Annual Operating Cost} + \text{Capital Cost} \times \text{Present Worth Factor}$$

$$\text{Present Worth Factor} = d / (1 - 1 / (1 + d)^n)$$

$$\text{Discount Rate} = d$$

$$\text{Life of measure} = n$$

The annualized incremental cost of a measure is the annualized cost of the measure minus the annualized cost of the equivalent baseline measure. The annualized cost of the baseline measure is zero if the efficiency measure is an add-on feature.

The annual savings associated with the efficiency measure is the difference in annual electricity consumption with and without the measure. In the derivation of total resource cost, the annual

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electricity consumption is assumed to include current operational practice as reflected in the scheduling and maintenance factors given in the Typical Building Profiles in Appendix 6.

The total resource cost test therefore is applied as follows. A measure or technology is economic if its TRC minus environmental credit is less than or equal to the cost of new supply:

$$\text{TRC} - \text{Env. Credit} < \text{Cost of New Supply}$$

11.3 Sensitivity to Discount Rate

The total resource cost is sensitive to the chosen discount rate. In the analysis that follows, three discount rates were used: a base rate of 8%, plus rates of 4% and 12%.

11.4 Total Resource Cost of Efficient Technologies

This section derives the TRC for each efficiency measure included in the study, and compares this TRC with the BC Hydro Cost of New Supply at the three discount rates and five levels of environmental credit. For each individual technology or electrical end-use, a table is presented showing the calculated total resource cost (TRC) for that technology at annual discount rates of 8%, 4% and 12%, respectively. These TRCs are then compared with BC Hydro's marginal electricity costs (as presented in Table 11.1), and a rationale is presented for the selection of the most economic technology at the various levels of environmental credit shown in Table 11.2.

For some end-uses such as lighting, TRCs are derived for "packages" of efficiency measures which reflect increasing efficiency and cost. For others, including heating and cooling equipment, TRCs are derived for a single high efficiency version of the currently used equipment.

An estimate of the TRC for HVAC scheduling and maintenance has also been included. As discussed in Section 5, it is only possible to cost operational improvements when a building operator or outside firm can be hired to carry out the additional work.

11.4.1 *Fluorescent Lighting*

TRCs for fluorescent lighting were estimated for three fixtures with increasing efficiencies and costs. The base fixture is a two lamp unit with F40 lamps, core/coil ballast, and white reflector. The five upgrades are as follows:

1. 1 F32 lamp with core/coil ballast and specular reflector
2. 1 small diameter (T8) lamp with an energy efficient core/coil ballast and reflector

3. 1 T8 lamp with a dimmable electronic ballast and photosensor, and a specular reflector
4. The T8/dimmable ballast/reflector fixture with daylight enhancement (new buildings only)
5. The T8/dimmable ballast/reflector fixture with improved lighting design and task tuning.

Table 11.3 shows the comparative performance and cost of these five lighting systems compared to the base unit, and the TRCs for two duty levels which span the range of hours of operation in all building segments (3000 to 5000 hours per year), and three discount rates.

Table 11.3 illustrates how the use of efficient lighting design can greatly improve the cost effectiveness of the most advanced fixtures. On its own, the T8/dimmable ballast/reflector fixture is cost effective with environmental credits between 0% and 60%, the size of the credit required depending on the hours of operation and discount rate. However, if the dimming capability is used to task tune lighting levels and take advantage of light shelves, atria, etc., to increase daylighting, then the TRC for this fixture drops to below 6.4 cents per kWh under all conditions without environmental credits. Savings of up to 77% in light energy use are therefore economic without environmental credits.

11.4.2 Incandescent Lighting

Two types of incandescent lamps are now in use for small lighting loads: the conventional 60W argon filled globe lamp and the 75 W PAR (parabolic aluminized reflector) lamp. For higher lighting loads, 150 W PAR lamps are used. Table 11.4 compares the performance and costs of these lamps to 18 W compact fluorescent lamps (for small loads) and to 90W Tungsten Halogen lamps (for large loads). TRCs are estimated for two lighting duty levels (3000 and 5000 hours per year), and three discount rates.

Table 11.4 shows that all upgrades are cost effective today at all discount rates and duty levels, without environmental credits.

11.4.3 HID Lighting

Two types of HID lamps can be used to replace standard mercury vapour lamps. Table 11.5 provides TRCs for metal halide and high pressure sodium lamps at two duty levels and three discount rates.

Table 11.5 shows that high pressure sodium lamps are cost effective today at all discount rates and duty levels, without environmental credits. Metal halide lamps would be cost effective today with a 60% environmental credit, but will be economic by 1996 without environmental credits. The TRCs are relatively independent of lighting duty level and discount rate.

TABLE 11.3
TOTAL RESOURCE COST (TRC) – FLUORESCENT LIGHTING LUMINAIRE

Annual Hours of Operation	Technology Generation	Technology Description	Energy Consumption Watts	Energy Savings		Actual Costs		Total Resource Cost (cents/kWh)		
				%	Annual kWh	Bulb \$	Ballast/ Reflector (\$)	Discount Rate		
								4%	8%	12%
3,000	0	2 x 40W/White Reflector	92	--	--	1.75	32	--	--	--
	1	ES F32/Reflector	38	59%	163	2.5	65	1.6	2.2	2.8
	2	T8/EE Ballast/Reflector	36	61%	168	6	102	3.5	4.7	6.1
	3	T8/Dimm. Ballast/ Photosensor/Reflector	30	67%	185	6	215	7.7	10.5	13.8
	4*	Gen 3 + Daylight Enhancement	23	75%	207	6	215	6.9	9.4	12.3
	5	Gen 3 + Optimum Light Levels	21	77%	213	6	215	6.7	9.2	12.0
5,000	0	2 x 40W/White Reflector	92	--	--	1.75	32	--	--	--
	1	ES F32/Reflector	38	59%	271	2.5	65	1.0	1.3	1.7
	2	T8/EE Ballast/Reflector	36	61%	281	6	102	2.3	3.0	3.8
	3	T8/Dimm. Ballast/ Photosensor/Reflector	30	67%	308	6	215	4.7	6.5	8.4
	4*	Gen 3 + Daylight Enhancement	23	75%	345	6	215	4.2	5.8	7.5
	5	Gen 3 + Optimum Light Levels	21	77%	354	6	215	4.1	5.6	7.3

Assumed lifetimes:

- Bulbs
- Luminaire

20,000 hours
20 years

* New buildings only for Daylight Enhancement

TABLE 11.4
TOTAL RESOURCE COST (TRC) – INCANDESCENT & PAR LAMP UPGRADE

Annual Hours of Operation	Technology Generation	Technology Description	Energy Consumption Watts	Energy Savings		Actual Costs Bulb \$	Bulb Life hrs	Total Resource Cost (cents/kWh)		
				%	Annual kWh			Discount Rate		
								4%	8%	12%
3,000	0 A	Incandescent	75	--	--	0.60	2,000	--	--	--
	1 A	CF Lamp (18W & 2W ballast)	19	75%	169	20.00	10000	3.3	3.6	3.9
	0 B	75W PAR Lamp	75	--	--	2.00	2,000	--	--	--
	1 B	CF Lamp (18W & 2W ballast)	19	75%	169	20.00	10,000	2.0	2.3	2.6
5,000	0 A	Incandescent	75	--	--	0.60	2,000	--	--	--
	1 A	CF Lamp (18W & 2W ballast)	19	75%	281	20.00	10000	3.2	3.4	3.6
	0 B	75W PAR Lamp	75	--	--	2.00	2,000	--	--	--
	1 B	CF Lamp (18W & 2W ballast)	19	75%	281	20.00	10,000	1.9	2.1	2.3
3,000	0 C	150W PAR Lamp	150	--	--	2.00	2000	--	--	--
	2	90W Tungsten-halogen	90	40%	180	4.50	3000	0.9	0.9	1.0
5,000	0 C	150W PAR Lamp	150	--	--	2.00	2000	--	--	--
	2	90W Tungsten-halogen	90	40%	300	4.50	3000	0.9	0.9	0.9

CF: Compact fluorescent
PAR: Parabolic aluminized reflector

TABLE 11.5
TOTAL RESOURCE COST (TRC) – HIGH INTENSITY DISCHARGE LIGHTING

Annual Hours of Operation	Technology Generation	Technology Description	Energy Consumption Watts	Energy Savings		Actual Costs		Bulb Life hrs	Total Resource Cost (cents/kWh)		
				%	Annual kWh	Bulb \$	Fixture \$		Discount Rate		
3,000	0	Mercury Vapour	400	--	--	25	425	24,000	--	--	--
	1	Metal Halide	300	25%	300	40	440	10,000	3.6	3.8	4.1
	2	High Pressure Sodium	200	50%	600	30	440	24,000	0.3	0.4	0.5
5,000	0	Mercury Vapour	400	--	--	25	425	24,000	--	--	--
	1	Metal Halide	300	25%	500	40	440	10,000	3.3	3.5	3.7
	2	High Pressure Sodium	200	50%	1000	30	440	24,000	0.3	0.3	0.4

Assumed lifetime:

– Fixture

15 years

11.4.4 *Lighting Controls*

Automatic lighting controls (ALCs) allow the building operator to program lighting in the building on a zone basis. Individual occupancy sensors automatically turn on individual lights within a zone when the area is occupied. Table 11.6 provides TRCs for ALC alone and for ALC combined with occupancy sensors, at two duty levels and three discount rates.

Table 11.6 shows that ALCs will be economic at all discount rates within a few years without environmental credits, particularly at high duty levels. They are already cost effective at 5000 hours per year and 4% and 8% discount rates. The addition of occupancy sensors greatly reduces the TRC of ALCs, making the combination cost effective today under all conditions without environmental credits.

11.4.5 *Building Insulation*

The economics of retrofitting an existing building depends on the starting level. The greater the existing insulation level in the wall or roof, the less economic it is to add more. In new buildings on the other hand, where there is a choice of using any level of insulation, the economics are related only to the amount of insulation used. An uninsulated building has an overall effective⁵³ R value of about R5.7 (RSI 1.0). The highest effective R level found in existing buildings is about R12.5 (RSI 2.2). Table 11.7 shows the TRCs for insulating existing buildings to R11 and R14 (RSIs of 2.0 and 2.5), starting at R6 and R12 (RSI 1.0 and 2.2), for the three discount rates of 4%, 8% and 12%. An R11 to R14 (RSI 2.5 to 2.8) is the maximum practical level for insulation in an existing building, making maximum use of the cavity and adding additional insulation on the inside or outside of the wall or flat roof. Table 11.7 also shows TRCs for a new building insulated to an effective R31 (RSI 5.5), the maximum practical level achievable using a curtain wall system, or a filled masonry wall or roof cavity with outside insulated sheathing.

Table 11.7 shows that it is not cost effective to upgrade the insulation in any already well insulated buildings in BC, even in areas with degree day values well above the base value of 2900 used in the analysis. It is economic to upgrade poorly insulated or uninsulated buildings where the degree day value is 2900 or less, to R11 (RSI 2.0), filling the cavity only. With a 100% environmental credit at an 8% discount rate, or a 15% credit and a 4% rate, it is economic to retrofit to R14 (RSI 2.5). Lower credits would be required in areas with higher degree days. High insulation levels in new buildings, however, are economic today without environmental credits. By 2000, R31 (RSI of 5.5) are economic under all conditions.

⁵³ The effective thermal resistance is the insulating value of the wall taking into account the additional insulating value of the wall sheathing and air spaces, the airtightness of the structure, and the thermal bridging that takes place through floor slabs, etc.

TABLE 11.6
TOTAL RESOURCE COST (TRC) – AUTOMATED LIGHTING CONTROLS & OCCUPANCY DETECTORS

Annual Hours of Operation	Technology Generation	Technology Description	Energy Consumption Watts/m²	Energy Savings		System Costs \$/m²	Total Resource Cost (cents/kWh)			
				%	Annual kWh/m²		Discount Rate			
							4%	8%	12%	
3,000	1	<u>Existing Buildings</u>								
		Auto Lighting Controls	23	15%	12	5.00	3.0	4.1	5.4	
	2	Auto Lighting/ Occupancy Sensors	10	65%	54	10.00	1.4	1.9	2.5	
5,000	1	Auto Lighting Controls	23	15%	21	5.00	1.8	2.5	3.2	
	2	Auto Lighting/ Occupancy Sensors	10	65%	90	10.00	0.8	1.1	1.5	
3,000	1	<u>New Construction</u>								
		Auto Lighting Controls	23	15%	12	4.25	2.5	3.5	4.6	
	2	Auto Lighting/ Occupancy Sensors	10	65%	54	8.50	1.2	1.6	2.1	
	5,000	1	Auto Lighting Controls	23	15%	21	4.25	1.5	2.1	2.7
		2	Auto Lighting/ Occupancy Sensors	10	65%	90	8.50	0.7	1.0	1.3

Baseline Power Consumption: 27.6 Watts/m²

Assumed lifetime:

– System 20 years

TABLE 11.7
TOTAL RESOURCE COST (TRC) – BUILDING INSULATION

Technology Generation	Technology Description	RSI Value	Energy Savings kWh/m ²	Insulation Cost \$m ²	Total Resource Cost (cents/kWh)		
					Discount Rate		
					4%	8%	12%
0 A	Existing Buildings Baseline A	1.0	n/a	n/a	--	--	--
1 A	Improved Existing from A	2.0	34.7	8.00	1.2	1.9	2.8
1 B	Improved Existing from A	2.5	41.6	55.50	6.7	11.2	16.2
0 B	Existing Buildings Baseline B	2.2	n/a	n/a	--	--	--
1 B	Improved Existing from B	2.5	3.5	46.94	68.4	113.5	164.2
0 C	New Buildings Baseline	1.0	n/a	n/a	--	--	--
2	Improved New Buildings	5.6	56.9	27.33	2.4	4.0	5.8

Note: Cost and performance are per m² of wall or roof.

n/a: not available

Envelope lifetime 40 years

Degree Days 2890

Costs

- New 6 \$/m².RSI
- Existing > RSI 2.0 7 \$/m².RSI plus base of \$45.00/m² (additional structure)
- ≤ RSI 2.0 8 \$/m².RSI (cavity only)

Commercial buildings have a long life. Also, once a low or average amount of insulation is added to an existing building or used in a new one, the economics of adding more is very poor. It is very important, therefore, that all retrofits and new buildings be insulated to maximum practical levels, even in the 1990s when doing so may not appear cost effective.

11.4.6 *Windows*

Table 11.8 provides TRCs for the addition of window film to existing single glazed windows, and for three high efficiency window systems of increasing cost, each at three discount rates. At the base degree days of 2900, window film is cost effective at 4% and 8% discount rates without environmental credits. The three high efficiency window systems all have similar TRCs, and are cost effective without environmental credits at a 4% discount rate beyond 1999. At a small environmental credit these windows are economic at all discount rates. Since the TRC is directly proportional to the inverse of the degree days, these high efficiency windows will be cost effective much sooner in colder parts of the province.

The similarity of the TRCs for the three window systems means that it will always be preferable to install the system with the maximum RSI, i.e. the HIT window. Given the long life of windows and the infrequency of full building retrofits, it will be very important that all new and replacement windows installed in the 1990s are high efficiency units (i.e., at least insulated super double) even if they are not cost effective until the end of the decade.

11.4.7 *Heat Pump Upgrade*

The calculation of TRCs for more efficient heat pumps was determined on a per ton basis (1 ton = 3.5 kW). Table 11.9 shows TRCs for efficient air source, water source, and heat recovery heat pumps compared with the least efficient heat pump, at a full load hour level of 1600 hours per year and three discount rates.

Table 11.9 shows that at 4% and 8% discount rates, all heat pump upgrades are cost effective today without environmental credits. At a 12% discount rate, some credits are needed during the 1990s, but all upgrades are cost effective without credits by 2000.

11.4.8 *Electric Resistance/Heat Pump Conversion*

The cost of using heat pumps instead of electric resistance heating will be different for existing and new buildings. In existing buildings, some additional work will be required when installing the heating system, e.g. wall panels for air source units, and hot water lines for water source and heat recovery chillers. In new buildings the differences between the various types of heat distribution systems will not be significant. Table 11.10 provides TRCs for replacement of electric resistance heating with heat pumps in existing buildings and the use of heat pumps instead of electric resistance heating in new buildings, at three discount rates.

TABLE 11.8
TOTAL RESOURCE COST (TRC) – WINDOWS

Technology Generation	Technology Description	RSI Value	Energy Savings kWh/m ² .yr	Window Cost \$m ²	Total Resource Cost (cents/kWh) Discount Rate		
					4%	8%	12%
0	Single	0.18	n/a	150	n/a	n/a	n/a
1	Low e Film*	0.24	96.33	32	2.4	3.4	4.4
2	Super Double	0.42	220.19	310	5.3	7.4	9.7
3	Upgrade Super Double	0.77	295.26	360	5.2	7.2	9.5
4	HIT (High Insulation Technology)	1.15	325.02	400	5.7	7.8	10.3

Window lifetime 20 years

Degree Days 2890

* Low e film added to existing buildings with single pane windows only.

Note cost and performance are per m² of window.

TABLE 11.9
TOTAL RESOURCE COST (TRC) – HEAT PUMP UPGRADE AT CONSTANT
TERTIARY LOAD (CONSTANT DEGREE DAYS)

Technology Generation	Technology Description	Performance Seasonal COP	Energy Savings * kWh/ton.yr	Cost \$/ton	Option Life yrs	Total Resource Cost (cents/kWh)		
						Discount Rate		
						4%	8%	12%
0 A	Baseline Air Source HP	2.2		300	10	n/a	n/a	n/a
0 B	Baseline Water Source HP	2.5		300	25	n/a	n/a	n/a
0 C	Baseline Heat Recovery HP	4.5		250	25	n/a	n/a	n/a
1 A	Upgrade Air Source HP	2.7	354	375	10	2.6	3.2	3.8
1 B	Upgrade Water Source HP	3	280	375	25	1.7	2.5	3.4
1 C	Upgrade Heat Recovery HP	5.4	156	325	25	3.1	4.5	6.1

Tertiary Load:
= 300 MJ/m².yr
= 300/3.6 kWh/m².yr
= 83 * 50 kWh/ton.yr
= 4200 kWh/ton.yr

* Energy savings = Tertiary load * (1/COP_{base} – 1/COP_{upgr})

HP: Heat Pump

TABLE 11.10

**TOTAL RESOURCE COST (TRC) – ELECTRIC RESISTANCE CONVERSION TO HEAT PUMP
AT CONSTANT TERTIARY LOAD (CONSTANT DEGREE DAYS)**

Technology Generation	Technology Description	Performance Seasonal COP	Energy Savings * kWh/ton.yr	Annual Cost \$/ton	Option Life yrs	Total Resource Cost (cents/kWh)		
						Discount Rate		
						4%	8%	12%
	<u>Existing Buildings</u>							
0	Electric Resistance Baseboards	1.0		450	40	--	--	--
1 A	Upgrade Air Source HP	2.7	2,644	2,000	10	8.5	9.8	11.3
1 B	Upgrade Water Source HP	3.0	2,800	3,500	25	7.2	10.4	14.0
1 C	Upgrade Heat Recovery HP	5.4	3,422	3,500	25	5.9	8.5	11.4
	<u>New Buildings</u>							
0	Electric Resistance Baseboards	1.0		900	40	--	--	--
1 A	Upgrade Air Source HP	2.7	2,644	1,200	10	3.9	3.9	3.9
1 B	Upgrade Water Source HP	3.0	2,800	2,500	25	4.1	5.7	7.5
1 C	Upgrade Heat Recovery HP	5.4	3,422	2,500	25	3.3	4.6	6.1

Tertiary Load: = 300 MJ/m².yr
 = 300/3.6 kWh/m².yr
 = 83 * 50 kWh/ton.yr
 = 4200 kWh/ton.yr

* Energy savings = Tertiary load * (1/COP_{base} – 1/COP_{upgr})

HP: Heat Pump

Table 11.10 shows that at 4% and 8% discount rates all types of heat pumps are cost effective against electric resistance heat in new buildings by 2000 without environmental credits. In existing buildings, heat pumps are economic at a 4% discount without environmental credits, and at an 8% discount rate with only a 30% environmental credit.

11.4.9 *Efficient Cooling Equipment*

TRCs for efficient chillers were, like heat pumps, estimated on a per ton basis. Table 11.11 provides TRCs for efficient centrifugal and reciprocal chillers at three discount rates. The table shows that efficient chillers are economic today under all conditions.

11.4.10 *Ventilation System Options*

Three more efficient ventilation systems were analyzed: variable air volume (VAV), compartmental ventilation, and low temperature distribution/cold storage. Each system reduces HVAC electricity, heating and cooling loads. Table 11.12 provides savings and cost estimates and TRCs for each system compared to a conventional continuous air volume (CAV) ventilation system, for three discount rates. Differences between existing and new buildings are also shown. Annual maintenance costs are also included in the TRC.

In new buildings, the low temperature distribution system has a TRC of zero (no incremental cost), and also provides the highest savings. It is therefore the system of choice in all new buildings in which it can be used. VAV and low temperature distribution have similar TRCs in existing buildings, and both are economic at a 4% discount rate without environmental credits. Only a small credit is required at an 8% discount rate. Compartmental ventilation is not cost effective for existing or new buildings.

11.4.11 *HVAC System Improvements*

HVAC air and water pumping electrical use can be reduced through the use of energy efficient (EE) motors, variable frequency speed drives (VFDs), direct digital control (DDC), and through air and water balancing. Table 11.13 provides TRCs for EE Motors, VFDs and DDC for three discount rates. Table 11.14 provides TRCs for air and water balancing.

Tables 11.13 and 11.14 show that EE motors, VFDs, and air and water balancing are cost effective under all conditions without environmental credits. DDC is cost effective at a 60% or 100% environmental credit, depending on the discount rate.

11.4.12 *Service Water Heating Improvements*

Table 11.15 provides TRCs for faucet aerators and low flow shower heads. Both are cost effective today under all conditions. The cost of efficiency measures applicable to other water

TABLE 11.11
TOTAL RESOURCE COST (TRC) – COOLING

Technology Generation	Technology Description	Performance Seasonal COP	Energy Savings kWh/ton.yr	Annual Cost \$/ton	Option Life yrs	Total Resource Cost (cents/kWh)		
						Discount Rate		
						4%	8%	12%
0 A	Baseline DX equip. reciprocating comp.	2.5		300	15	--	--	--
0 B	Baseline Centrifugal chillers	4.5		250	25	--	--	--
1 A	Baseline DX equip. reciprocating comp.	3.2	306	375	15	2.2	2.9	3.6
1 B	Baseline Centrifugal chillers	6.1	204	325	25	2.4	3.4	4.7
2	Air Side Economizer Existing Buildings	3.6	420	200	15	4.3	5.6	7.0
	Air Side Economizer New Buildings	3.6	420	100	15	2.1	2.8	3.5

Full load hours: 1,000

DX equip. reciprocating comp.: Direct expansion equipment reciprocating compressor

TABLE 11.12
TOTAL RESOURCE COST (TRC) – VENTILATION AIR DISTRIBUTION OPTIONS

Technology Generation	Technology Description	Energy Savings (%)				Option Life years	Upgrade Costs \$/m ²	Annual Maintenance Costs \$/m ² .yr	Total Resource Cost (cents/kWh)		
		HVAC Electricity	Ventilation Heating	Ventilation Cooling	Annual kWh/m ²				Discount Rate		
									4%	8%	12%
1	VAV										
	– existing buildings	20%	20%	10%	28.0	35	20	0.225	4.6	6.9	9.5
	– new buildings	20%	20%	10%	28.0	35	8	0.225	2.3	3.3	4.3
2	Compartmental VAV										
	– existing buildings	40%	20%	10%	37.7	35	90	0.35	13.7	21.4	30.2
	– new buildings	40%	20%	10%	37.7	35	45	0.35	7.3	11.2	15.5
3	Low Temp Dist. (& TES)										
	– new buildings	25%	n/a	25%	16.4	40	0	n/a	0.0	0.0	0.0

Note: hospitals not included.

HVAC: Heating, ventilation and air–conditioning

VAV: Variable air volume

Low Temp Dist: Low temperature distribution

TES: Thermal energy storage

n/a: not applicable

Baseline Power Consumption (Typical for commercial buildings – see Appendix 6)

Fans	48 kWh/m ² .yr
Heating	83 kWh/m ² .yr
Cooling	17 kWh/m ² .yr

Yearly Operating Hours: 4500

TABLE 11.13
TOTAL RESOURCE COST (TRC) – VENTILATION/DISTRIBUTION DRIVE AND CONTROL OPTIONS

Technology Generation	Technology Description	Energy Savings (%)				Option Life years	Upgrade Costs \$/m²	Annual Maintenance Costs \$/m².yr	Total Resource Cost (cents/kWh)		
		HVAC Electricity	Ventilation Heating	Ventilation Cooling	Annual kWh/m²				Discount Rate		
									4%	8%	12%
1 A	E.E. Motors Retail & Warehouses	5%			3.0	25	0.144	n/a	0.3	0.4	0.6
1 B	E.E. Motors Large Comm./Apts.	5%			3.0	25	0.361	n/a	0.8	1.1	1.5
2	VFD in pumps	30%	8%	8%	11.6	20	4	0.07	3.1	4.1	5.2
3	DDC	20%	5%	5%	9.8	15	6	0.225	7.8	9.4	11.2

E.E. Motors: Energy efficient motors

Comm: Commercial

VFD: Variable frequency drive

DDC: Direct digital control

Baseline Power Consumption (Typical for commercial buildings -- see Appendix 6)

Fans	48 kWh/m ² .yr
Pumps	12 kWh/m ² .yr
Heating	83 kWh/m ² .yr
Cooling	17 kWh/m ² .yr

Yearly Operating Hours: 4500

TABLE 11.14
TOTAL RESOURCE COST (TRC) – VENTILATION/DISTRIBUTION AIR AND WATER BALANCING

Technology Generation	Technology Description	Energy Savings (%)			Option Life years	Upgrade Costs \$/m²	Total Resource Cost (cents/kWh)		
		HVAC Electricity	Ventilation Cooling	Annual kWh/m²			Discount Rate		
							4%	8%	12%
1	Air & Water Balancing	27%	10%	18.0	20	2.5	1.0	1.4	1.9

HVAC: Heating, ventilation and air-conditioning

Baseline Power Consumption:

Fans	48 kWh/m ² .yr
Pumps	12 kWh/m ² .yr
Cooling	17 kWh/m ² .yr

Yearly Operating Hours: 4500

TABLE 11.15
TOTAL RESOURCE COST (TRC) – SERVICE WATER HEATING

Technology Generation	Technology Description	Annual Consumption kWh.yr	Energy Savings		Upgrade Cost \$	Upgrade Life yrs	Total Resource Cost (cents/kWh)		
			%	Annual kWh			Discount Rate		
							4%	8%	12%
1	Faucet Aerator	850	50%	425	5.00	10	0.1	0.2	0.2
2	Low flow showerhead	1140	50%	570	10.00	10	0.2	0.3	0.3

using equipment (dishwashers, etc.) will be similar to those found in the Residential Sector Conservation Potential Review. They may all be assumed to be cost effective.

11.4.13 *Refrigeration System Improvements*

Table 11.16 provides TRCs for upgrades to commercial refrigeration systems found in the Food-Retail and Warehouse segments. All upgrades are cost effective today under all conditions.

Refrigeration equipment found in other segments are mostly conventional refrigerators and freezers. The Residential Sector study showed that all but the most advanced technology is cost effective.

11.4.14 *Other End-Uses*

No TRCs could be estimated for upgrades to cooking equipment, plug load appliances and equipment, or miscellaneous equipment, due to the lack of cost and performance data.

11.4.15 *HVAC System Maintenance and Scheduling*

The average cost of maintaining and operating an HVAC system was estimated in Section 5 as being between 20 to 40 cents per square foot per year (\$2 to \$4 /m².yr). It was also estimated that proper maintenance would save between 10% and 20 % of the heating, cooling and HVAC electricity. From Section 6, the combined heating and cooling and HVAC loads in BC buildings vary between about 350 and 500 MJ/m².yr (100 and 140 kWh/yr).

If it is assumed that proper maintenance and operation (making a system operate efficiently instead of just functioning) adds a 25% premium to current costs, the TRC, defined as additional annual cost per unit area divided by annual savings per unit area, therefore varies between 2 and 10 cents/kWh.

11.5 *Summary of Economic Analysis*

Table 11.17 summarizes the results of the economic analysis, showing which measures are economic in 2000 at each level of environmental credit, at an 8% discount rate. Table 11.17 shows the ratio of TRC to the cost of new electricity supply. This ratio was calculated by subtracting the respective environmental credit (Table 11.2) from the TRC at an 8% discount rate (Tables 11.3 to 11.16), and dividing by BC Hydro's long run marginal cost of electricity (Table 11.1).

For example, the ratio of TRC to new electricity cost for a fluorescent light (F32) with a reflector, operating 3000 hrs per year, at a 15% environmental credit and an 8% discount rate,

TABLE 11.16
TOTAL RESOURCE COST (TRC) – REFRIGERATION

Technology Generation	Technology Description	Annual Consumption kWh.yr	Energy Savings		Cost \$/m ²	Life yrs	Total Resource Cost (cents/kWh) Discount Rate		
			%	Annual kWh			4%	8%	12%
1	Unequal Capacity Multiplexed Compressors	414	20%	83	12.00	20	1.1	1.5	1.9
2	Door/Cover Upgrade	414	12%	50	12.00	15	2.2	2.8	3.5

Table 11.17

Ratio of Total Resource Cost to Cost of New Electricity Supply¹
Commercial Sector Technologies between 2000 and 2010 at an 8% Discount Rate

Technology	Hours of Operation	Environmental Credit				
		0%	15%	30%	60%	100%
Fluorescent Lighting						
F32 + Reflector	3000	0.35	0.21	0.05	-0.25	-0.65
T8 lamp + Energy Efficient Ballast + Reflector	3000	0.75	0.60	0.44	0.14	-0.25
T8 + Dimmable electronic ballast (EB _D) + Reflector	3000	1.67	1.52	1.37	1.06	0.67
T8 lamp + EB _D + Reflector + Daylighting	3000	1.49	1.35	1.19	0.89	0.49
T8 lamp + EB _D + Reflector + Efficient Design	3000	1.46	1.32	1.16	0.86	0.46
F32 + Reflector	5000	0.21	0.06	-0.10	-0.40	-0.79
T8 lamp + Energy Efficient Ballast + Reflector	5000	0.48	0.33	0.17	-0.13	-0.52
T8 lamp + EB _D + Reflector	5000	1.03	0.89	0.73	0.43	0.03
T8 lamp + EB _D + Reflector + Daylighting	5000	0.92	0.78	0.62	0.32	-0.08
T8 lamp + EB _D + Reflector + Efficient Design	5000	0.89	0.75	0.59	0.29	-0.11
Incandescent Lighting						
Compact Fluorescent	3000	0.57	0.43	0.27	-0.03	-0.43
Tungsten Halogen	3000	0.14	0.00	-0.16	-0.46	-0.86
Compact Fluorescent	5000	0.54	0.40	0.24	-0.06	-0.46
Tungsten Halogen	5000	0.14	0.00	-0.16	-0.46	-0.86
High Intensity Discharge Lighting						
Metal Halide	3000	0.60	0.46	0.30	0.00	-0.40
Low Pressure Sodium	3000	0.06	-0.08	-0.24	-0.54	-0.94
Metal Halide	5000	0.56	0.41	0.25	-0.05	-0.44
Low Pressure Sodium	5000	0.05	-0.10	-0.25	-0.56	-0.95
Lighting Controls						
Automatic Lighting Controls (ALC)	3000	0.65	0.51	0.35	0.05	-0.35
ALC + Occupancy Sensors	3000	0.30	0.16	0.00	-0.30	-0.70
Automatic Lighting Controls (ALC)	5000	0.40	0.25	0.10	-0.21	-0.60
ALC + Occupancy Sensors	5000	0.17	0.03	-0.13	-0.43	-0.83
Building Insulation						
Retrofit of Low/Uninsulated Bldg to R11		0.30	0.16	0.00	-0.30	-0.70
Retrofit of Low/Uninsulated Bldg to R14		1.78	1.63	1.48	1.17	0.78
Retrofit of Average Insulated Building to R14		18.02	17.87	17.71	17.41	17.02
New Building Insulation to R31		0.63	0.49	0.33	0.03	-0.37
Window Film on Single Pane		0.54	0.40	0.24	-0.06	-0.46
Window Replacement ²						
Super Double Window		1.17	1.03	0.87	0.57	0.17
Insulated Super Double Window		1.14	1.00	0.84	0.54	0.14
High Insulation Technology Window		1.24	1.10	0.94	0.63	0.24

¹ A negative ratio indicates a negative Total Resource Cost, i.e., the efficient technologies (less environmental credit) costs less than conventional technology.

² Replacement at end of economic life.

Table 11.17 (continued)

Ratio of Total Resource Cost to Cost of New Electricity Supply¹

Commercial Sector Technologies between 2000 and 2010 at an 8% Discount Rate

Technology	Hours of Operation	Environmental Credit				
		0%	15%	30%	60%	100%
Heat Pump Upgrade						
High Efficiency (HE) Air Source	1600	0.51	0.37	0.21	-0.10	-0.49
HE Water Source	1600	0.40	0.25	0.10	-0.21	-0.60
HE Recovery Chiller	1600	0.71	0.57	0.41	0.11	-0.29
Electric Resistance Conversion						
HE Air Source - Existing Building	1600	1.56	1.41	1.25	0.95	0.56
HE Water Source - Existing Building	1600	1.65	1.51	1.35	1.05	0.65
HE Recovery Chiller - Existing Building	1600	1.35	1.21	1.05	0.75	0.35
HE Air Source - New Building	1600	0.62	0.48	0.32	0.02	-0.38
HE Water Source - New Building	1600	0.90	0.76	0.60	0.30	-0.10
HE Recovery Chiller - New Building	1600	0.73	0.59	0.43	0.13	-0.27
Efficient Cooling Equipment						
HE Reciprocating	1000	0.46	0.32	0.16	-0.14	-0.54
HE Centrifugal	1000	0.54	0.40	0.24	-0.06	-0.46
Economizers - Existing Building	1000	0.89	0.75	0.59	0.29	-0.11
Economizers - New Building	1000	0.44	0.30	0.14	-0.16	-0.56
Ventilation Options						
Variable Air Volume (VAV) - Existing Building	4500	1.10	0.95	0.79	0.49	0.10
Compartmental VAV - Existing Building	4500	3.40	3.25	3.10	2.79	2.40
VAV - New Building	4500	0.52	0.38	0.22	-0.08	-0.48
Compartmental VAV - Existing Building	4500	1.78	1.63	1.48	1.17	0.78
Low Temp. Distribution and Thermal Energy System - New Building	4500	0.00	-0.14	-0.30	-0.60	-1.00
HVAC Electricity						
Energy Efficient Motors	4500	0.17	0.03	-0.13	-0.43	-0.83
Variable Frequency Drives	4500	0.65	0.51	0.35	0.05	-0.35
Direct Digital Control/Building Automated System	4500	1.49	1.35	1.19	0.89	0.49
Air and Water Balancing	4500	0.22	0.08	-0.08	-0.38	-0.78
Service Hot Water						
Faucet Aerators/Low Flow Showerheads		0.03	-0.11	-0.27	-0.57	-0.97
High Efficiency Washing Equipment		0.05	-0.10	-0.25	-0.56	-0.95
Refrigeration						
Multiplexed Compressors		0.24	0.10	-0.06	-0.37	-0.76
Door/Cover Upgrades		0.54	0.40	0.24	-0.06	-0.46

¹ A negative ratio indicates a negative Total Resource Cost, i.e., the efficient technologies (less environmental credit) costs less than conventional technology.

would equal: $(2.2-0.9)/6.3 = 0.21$. Cost ratios less than 1.0 are "shaded" and identify the economic measures. Negative cost ratios mean that the cost of the efficient technology minus the environmental credit, is less than the cost of the conventional technology.

11.6 Economic Potential in BC

Based on the economic analysis described in Section 11.4 above, "packages" of efficiency measures which were cost effective at an 8% discount rate and no environmental credit were selected to estimate Economic Potential. Different packages were selected for each of the target years. If a measure became cost effective before 1999, it was included in the 2000 package. If it was not cost effective until 2000 it was included only in the 2010 package.

It was assumed that all operational upgrades included in the estimation of Social plus Technological Potential were economic. It was also assumed that all local lighting and office equipment would be switched on only when the area was occupied, either by the occupant or through use of an occupancy sensor (since occupancy sensors and auto lighting controls are cost effective.)

A summary of the economic measures is given in Table 11.18. Tables 11.19 and 11.20 give the EUIs used as model inputs for each building segment and end-use in 2000 and 2010, respectively. The EUIs were estimated in the same way as for Technological Potential as described in Section 9.1.

Tables 11.21 and 11.22 show Economic Potential for 2000 and 2010, respectively. The spreadsheet model was used again to estimate Economic Potential, using the new EUIs from Tables 11.19 and 11.20.

The results show that many technologies considered under Technological Potential are economic with no environmental credit. Economic Potential, therefore, comes close to Technological Potential and results in a 57% reduction over Frozen Efficiency in 2010. Economic savings for General and Service Area Lighting and Space Heating, is over 70%. Most advanced lighting systems and lighting designs, building upgrades, and heat pump technologies are economic. In some end-uses, the Economic Potential approaches the Social plus Technological Potential (i.e. is greater than the Technological Potential), because all technologies and operational improvements are economic.

Table 11.17 shows that at a 30% environmental credit, virtually all efficient technologies are economic at an 8% discount rate by 2000. At any environmental credit greater than 30%, therefore, Economic Potential approaches Social plus Technological Potential, i.e. a 68% reduction over Frozen Efficiency. The only measures that are not economic under any circumstances are: retrofit of already insulated existing buildings, and compartmental VAV, both

Table 11.18
Technology Assumptions for Economic Potential

End-Use	2000	2010
Lighting Design Existing Buildings New Buildings	No Change Task Tuning + Daylighting	Task Tuning Task Tuning + Daylighting
Fluorescent Lighting Existing Buildings New Buildings	T8 + Energy Efficient (EE) Ballast + Reflector T8 + DEtr. Ballast + Reflector + Daylighting	T8 + Dimm Etr Ballast + Reflector T8 + DEtr. Ballast + Reflector + Daylighting
Incandescent Low Wattage High Wattage	Compact Fluorescent Tungsten Halogen	Compact Fluorescent Tungsten Halogen
HID Retail All Other Segments	Metal Halide Low Pressure Sodium	Metal Halide Low Pressure Sodium
Lighting Controls	Automatic Lighting Control (ALC) + Occupancy Sensors	Automatic Lighting Control (ALC) + Occupancy Sensors
Building Insulation Existing Buildings less than R3 Existing Buildings more than R3 New Buildings	Retrofit to R11 No retrofit Build to R31	Retrofit to R11 No retrofit Build to R31
Windows Exist. Buildings Before Replacement Exist. Buildings On Replacement New Buildings	Window Film on Single Pane Insulated Super Double Insulated Super Double	Window Film on Single Pane Insulated Super Double Insulated Super Double
Heat Pumps	Replace with high efficiency units	Replace with high efficiency units
Electric Resistance Existing Buildings New Buildings	No Replacement High Efficiency Heat Pumps	No Replacement High Efficiency Heat Pumps
Cooling Equipment Existing Buildings New Buildings	High Efficiency (HE) Chillers HE Chillers + Economizers	High Efficiency (HE) Chillers + Economisers HE Chillers + Economizers
Ventilation System Existing Buildings New Buildings	Variable Air Volume (VAV) Low Temp. Dist + TES	Variable Air Volume (VAV) Low Temp. Dist + TES

Table 11.18 (continued)
Technology Assumptions for Economic Potential

End-Use	2000	2010
HVAC Pumps and Fans	Energy Efficient (EE) Motors + Variable Frequency Drives (VFD)	EE Motors + VFDs
Air and Water Balancing	Yes	Yes
Service Water Heating		
Sinks/Showerheads	Aerators/Low Flow Showerheads	Aerators/Low Flow Showerheads
Other	High Efficiency Units	High Efficiency Units
Refrigeration		
Food Retail/Warehouse	Multiplex + Door Upgrade	Multiplex + Door Upgrade
All other segments	High Efficiency Units	High Efficiency Units
All Other End-Uses	As per Technological Potential	As per Technological Potential
Operational Measures	As per Social plus Technological Potential	As per Social plus Technological Potential

TABLE 11.18A

SUMMARY OF AVERAGE END-USE INTENSITIES FOR ALL ELECTRIC COMMERCIAL BUILDINGS IN B.C. – ECONOMIC POTENTIAL MODEL INPUTS YEAR 2000 (MJ/m².yr)

EXISTING BUILDINGS	General Lighting (MJ/m ² .yr)	Service Area Lighting (MJ/m ² .yr)	Other Lighting (MJ/m ² .yr)	Space Heating (MJ/m ² .yr)	Space Cooling (MJ/m ² .yr)	HVAC Electricity (MJ/m ² .yr)	Service Hot water (MJ/m ² .yr)	Cooking Equipment (MJ/m ² .yr)	Refrig. Equipment (MJ/m ² .yr)	Office Equipment (MJ/m ² .yr)	Misc. Equipment (MJ/m ² .yr)	Total (MJ/m ² .yr)
Large Office (> 3,700 m ²)	61.4 (82%)	21.7 (75%)	7.7 (37%)	67.6 (58%)	35.6 (53%)	92.8 (31%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	54.4 (52%)	43.2 (0%)	388.6 (59%)
Small Office (< 3,700 m ²)	64.1 (82%)	22.7 (75%)	7.7 (40%)	125.5 (51%)	52.2 (56%)	71.4 (37%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	54.4 (52%)	12.9 (0%)	425.1 (81%)
Non-Food Retail	93.6 (72%)	74.6 (75%)	6.1 (40%)	124.3 (37%)	60.6 (64%)	96.3 (21%)	0.8 (47%)	3.1 (25%)	8.7 (30%)	82.9 (-5%)	6.5 (0%)	535.6 (56%)
Food Retail	56.9 (84%)	61.7 (69%)	8.1 (31%)	252.1 (44%)	39.2 (69%)	98.9 (22%)	10.2 (47%)	97.5 (25%)	1223.8 (18%)	81.1 (-5%)	97.0 (0%)	2022.8 (34%)
Restaurant/Tavern	83.5 (66%)	57.1 (75%)	0.0 (0%)	430.4 (55%)	51.3 (65%)	374.7 (5%)	212.6 (35%)	314.3 (25%)	154.0 (30%)	44.2 (-5%)	103.0 (0%)	1825.0 (41%)
Hotels/Motels	54.3 (64%)	18.7 (67%)	13.6 (42%)	125.6 (46%)	55.4 (26%)	75.1 (9%)	68.0 (32%)	50.9 (25%)	8.8 (30%)	90.7 (-5%)	14.2 (0%)	575.3 (37%)
Warehouse/Wholesale	100.7 (49%)	9.6 (61%)	0.0 (0%)	161.8 (58%)	32.7 (65%)	12.6 (3%)	1.0 (47%)	3.0 (25%)	15.6 (18%)	43.7 (-5%)	19.0 (0%)	369.8 (50%)
Hospitals	29.8 (67%)	49.0 (59%)	18.0 (31%)	94.9 (62%)	71.8 (35%)	181.3 (36%)	96.4 (29%)	45.8 (25%)	17.5 (30%)	157.2 (4%)	20.0 (0%)	784.8 (39%)
Nursing Homes	53.4 (53%)	54.6 (49%)	0.0 (0%)	281.5 (35%)	48.7 (42%)	32.6 (0%)	82.6 (41%)	9.6 (25%)	21.0 (30%)	38.8 (-5%)	12.8 (0%)	635.4 (37%)
Universities/Colleges	79.6 (64%)	28.0 (61%)	0.0 (0%)	78.4 (63%)	25.7 (52%)	101.2 (39%)	36.6 (32%)	16.5 (25%)	7.0 (30%)	20.7 (52%)	15.0 (0%)	408.7 (53%)
Schools	51.9 (60%)	26.9 (57%)	0.0 (0%)	110.3 (50%)	51.2 (41%)	11.8 (22%)	14.3 (35%)	3.8 (25%)	7.0 (30%)	4.3 (52%)	0.4 (0%)	281.8 (50%)
High Rise Apartments	23.0 (67%)	37.5 (66%)	0.0 (0%)	259.9 (43%)	46.6 (49%)	47.7 (8%)	59.0 (41%)	14.3 (25%)	9.0 (75%)	40.5 (26%)	12.8 (0%)	550.4 (45%)
Miscellaneous	80.0 (61%)	17.1 (56%)	4.4 (36%)	234.7 (44%)	46.6 (49%)	46.2 (25%)	2.1 (47%)	0.0 (0%)	0.0 (0%)	34.0 (-5%)	12.0 (0%)	477.2 (45%)

NEW BUILDINGS	General Lighting (MJ/m ² .yr)	Service Area Lighting (MJ/m ² .yr)	Other Lighting (MJ/m ² .yr)	Space Heating (MJ/m ² .yr)	Space Cooling (MJ/m ² .yr)	HVAC Electricity (MJ/m ² .yr)	Service Hot water (MJ/m ² .yr)	Cooking Equipment (MJ/m ² .yr)	Refrig. Equipment (MJ/m ² .yr)	Office Equipment (MJ/m ² .yr)	Misc. Equipment (MJ/m ² .yr)	Total (MJ/m ² .yr)
Large Office (> 3,700 m ²)	46.4 (85%)	17.5 (78%)	8.8 (27%)	22.6 (58%)	39.2 (48%)	35.7 (74%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	90.7 (52%)	43.2 (0%)	318.3 (68%)
Small Office (< 3,700 m ²)	48.4 (85%)	18.2 (78%)	9.2 (27%)	28.6 (71%)	51.7 (54%)	16.9 (86%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	90.7 (52%)	12.9 (0%)	290.9 (71%)
Non-Food Retail	100.0 (70%)	69.3 (73%)	8.8 (14%)	22.8 (68%)	62.0 (63%)	55.0 (55%)	0.8 (47%)	3.1 (25%)	8.7 (30%)	82.9 (-5%)	6.5 (0%)	397.7 (82%)
Food Retail	48.2 (87%)	54.1 (77%)	6.5 (28%)	23.2 (1%)	18.3 (27%)	27.4 (20%)	10.2 (47%)	201.8 (25%)	1223.8 (18%)	81.1 (-5%)	97.0 (0%)	1791.6 (32%)
Restaurant/Tavern	82.3 (65%)	67.3 (72%)	0.0 (0%)	119.7 (82%)	51.0 (65%)	153.3 (4%)	212.6 (35%)	274.9 (25%)	154.0 (30%)	44.2 (-5%)	103.0 (0%)	1282.2 (50%)
Hotels/Motels	55.4 (72%)	19.6 (66%)	13.8 (42%)	64.4 (83%)	43.2 (42%)	75.1 (9%)	68.0 (32%)	50.9 (25%)	8.8 (30%)	90.7 (-5%)	14.2 (0%)	504.1 (54%)
Warehouse/Wholesale	99.9 (47%)	7.6 (69%)	0.0 (0%)	17.6 (93%)	37.9 (60%)	12.6 (3%)	1.0 (47%)	3.0 (25%)	18.0 (0%)	43.7 (-5%)	19.0 (0%)	261.2 (58%)
Hospitals	26.1 (70%)	43.9 (66%)	18.9 (32%)	94.3 (62%)	75.6 (31%)	243.3 (14%)	98.4 (29%)	51.0 (25%)	17.5 (30%)	241.9 (4%)	20.0 (0%)	932.0 (33%)
Nursing Homes	55.4 (64%)	36.2 (59%)	0.0 (0%)	61.3 (82%)	42.8 (49%)	32.6 (0%)	82.6 (41%)	16.5 (25%)	21.0 (30%)	38.8 (-5%)	12.8 (0%)	434.4 (56%)
Universities/Colleges	58.2 (76%)	23.4 (67%)	0.0 (0%)	81.4 (61%)	27.2 (39%)	28.6 (82%)	36.6 (32%)	16.5 (25%)	7.0 (30%)	34.8 (52%)	15.0 (0%)	328.5 (64%)
Schools	40.9 (71%)	18.4 (65%)	0.0 (0%)	27.0 (88%)	52.5 (39%)	12.9 (15%)	14.3 (35%)	3.6 (25%)	7.0 (30%)	8.5 (52%)	0.4 (0%)	183.5 (67%)
High Rise Apartments	15.4 (83%)	18.7 (61%)	0.0 (0%)	40.9 (82%)	54.1 (40%)	47.7 (8%)	59.0 (41%)	14.3 (25%)	9.0 (75%)	37.8 (-5%)	12.8 (0%)	308.7 (56%)
Miscellaneous	103.5 (68%)	17.4 (64%)	4.7 (33%)	38.1 (85%)	54.1 (40%)	46.2 (25%)	2.1 (47%)	0.0 (0%)	0.0 (0%)	34.0 (-5%)	12.0 (0%)	313.1 (63%)

Notes:

1. Weighted average of electric resistance + heat pumps

Percent reduction over frozen efficiency scenario is shown in parentheses.

HVAC: Heating, ventilation and air conditioning Refrig.: Refrigeration

Notes:

1. Weighted average of electric resistance + heat pumps

Percent reduction over frozen efficiency scenario is shown in parentheses.

HVAC: Heating, ventilation and air conditioning Refrig.: Refrigeration

TABLE 11.18B

SUMMARY OF AVERAGE END-USE INTENSITIES FOR ALL ELECTRIC COMMERCIAL BUILDINGS IN B.C. - ECONOMIC POTENTIAL MODEL INPUTS YEAR 2000 (kWh/m².yr)

EXISTING BUILDINGS	General Lighting (kWh/m ² .yr)	Service Area Lighting (kWh/m ² .yr)	Other Lighting (kWh/m ² .yr)	Space Heating (kWh/m ² .yr)	Space Cooling (kWh/m ² .yr)	HVAC Electricity (kWh/m ² .yr)	Service Hot water (kWh/m ² .yr)	Cooking Equipment (kWh/m ² .yr)	Refrig. Equipment (kWh/m ² .yr)	Office Equipment (kWh/m ² .yr)	Misc. Equipment (kWh/m ² .yr)	Total (kWh/m ² .yr)
Large Office (> 3,700 m ²)	1.6 (82%)	0.6 (75%)	0.2 (37%)	1.7 (56%)	0.9 (53%)	2.4 (31%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	1.4 (52%)	1.1 (0%)	10.3 (59%)
Small Office (< 3,700 m ²)	1.7 (82%)	0.6 (75%)	0.2 (40%)	3.2 (37%)	1.3 (58%)	1.8 (37%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	1.4 (52%)	0.3 (0%)	11.0 (61%)
Non-Food Retail	2.4 (72%)	1.9 (75%)	0.2 (40%)	3.2 (37%)	1.6 (64%)	2.5 (21%)	0.0 (47%)	0.1 (25%)	0.2 (30%)	1.8 (-5%)	0.2 (0%)	13.8 (56%)
Food Retail	1.5 (84%)	1.6 (69%)	0.2 (31%)	6.5 (44%)	1.0 (69%)	2.5 (22%)	0.3 (47%)	2.5 (25%)	31.8 (18%)	2.1 (-5%)	2.5 (0%)	52.2 (34%)
Restaurant/Tavern	2.2 (66%)	1.5 (75%)	0.0 (0%)	11.1 (55%)	1.3 (65%)	9.7 (5%)	5.5 (35%)	8.1 (25%)	4.0 (30%)	1.1 (-5%)	2.7 (0%)	47.1 (41%)
Hotels/Motels	1.4 (64%)	0.5 (67%)	0.4 (42%)	3.2 (48%)	1.4 (26%)	1.9 (9%)	1.8 (32%)	1.3 (25%)	0.2 (30%)	2.3 (-5%)	0.4 (0%)	14.9 (37%)
Warehouse/Wholesale	2.6 (49%)	0.2 (61%)	0.0 (0%)	4.2 (58%)	0.8 (65%)	0.3 (3%)	0.0 (47%)	1.2 (25%)	0.4 (18%)	1.1 (-5%)	0.5 (0%)	10.3 (30%)
Hospitals	0.8 (67%)	1.3 (59%)	0.5 (31%)	2.4 (62%)	1.9 (35%)	4.7 (36%)	2.6 (29%)	1.2 (25%)	0.5 (30%)	1.0 (-5%)	0.3 (0%)	20.3 (37%)
Nursing Homes	1.4 (53%)	1.4 (49%)	0.0 (0%)	7.3 (35%)	1.3 (42%)	0.8 (0%)	2.1 (41%)	0.4 (25%)	0.2 (30%)	0.5 (52%)	0.4 (0%)	10.6 (53%)
Universities/Colleges	2.1 (64%)	0.7 (61%)	0.0 (0%)	2.0 (60%)	0.7 (52%)	2.6 (39%)	0.9 (32%)	0.1 (25%)	0.2 (30%)	0.1 (52%)	0.0 (0%)	7.3 (50%)
Schools	1.3 (60%)	0.7 (57%)	0.0 (0%)	2.8 (50%)	1.3 (41%)	0.3 (22%)	0.4 (35%)	0.1 (25%)	0.2 (30%)	0.1 (52%)	0.0 (0%)	7.3 (50%)
High Rise Apartments	0.6 (67%)	1.0 (66%)	0.0 (0%)	6.7 (43%)	1.2 (49%)	1.2 (8%)	1.5 (41%)	0.4 (25%)	0.2 (75%)	1.0 (26%)	0.3 (0%)	14.2 (45%)
Miscellaneous	2.1 (61%)	0.4 (56%)	0.1 (36%)	6.1 (44%)	1.2 (49%)	1.2 (25%)	0.1 (47%)	0.0 (0%)	0.0 (0%)	0.8 (-5%)	0.3 (0%)	12.3 (45%)

NEW BUILDINGS	General Lighting (kWh/m ² .yr)	Service Area Lighting (kWh/m ² .yr)	Other Lighting (kWh/m ² .yr)	Space Heating (kWh/m ² .yr)	Space Cooling (kWh/m ² .yr)	HVAC Electricity (kWh/m ² .yr)	Service Hot water (kWh/m ² .yr)	Cooking Equipment (kWh/m ² .yr)	Refrig. Equipment (kWh/m ² .yr)	Office Equipment (kWh/m ² .yr)	Misc. Equipment (kWh/m ² .yr)	Total (kWh/m ² .yr)
Large Office (> 3,700 m ²)	1.2 (85%)	0.5 (76%)	0.2 (27%)	0.6 (56%)	1.0 (46%)	0.9 (74%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	2.3 (52%)	1.1 (0%)	8.2 (66%)
Small Office (< 3,700 m ²)	1.3 (85%)	0.5 (76%)	0.2 (27%)	0.7 (71%)	1.3 (54%)	0.4 (68%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	2.3 (52%)	0.3 (0%)	7.5 (71%)
Non-Food Retail	2.6 (70%)	1.8 (73%)	0.2 (14%)	0.6 (68%)	1.6 (63%)	1.4 (55%)	0.0 (47%)	0.1 (25%)	0.2 (30%)	1.6 (-5%)	0.2 (0%)	10.3 (62%)
Food Retail	1.2 (67%)	1.4 (77%)	0.2 (28%)	0.6 (11%)	0.5 (27%)	0.7 (20%)	0.3 (47%)	5.2 (25%)	31.8 (18%)	2.1 (-5%)	2.5 (0%)	48.3 (32%)
Restaurant/Tavern	2.1 (65%)	1.7 (72%)	0.0 (0%)	3.1 (82%)	1.3 (65%)	4.0 (4%)	5.5 (35%)	7.1 (25%)	4.0 (30%)	1.1 (-5%)	2.7 (0%)	32.8 (50%)
Hotels/Motels	1.4 (72%)	0.5 (66%)	0.4 (42%)	1.7 (83%)	1.1 (42%)	1.9 (9%)	1.8 (32%)	1.3 (25%)	0.2 (30%)	2.3 (-5%)	0.4 (0%)	13.0 (54%)
Warehouse/Wholesale	2.6 (47%)	0.2 (65%)	0.0 (0%)	0.5 (63%)	1.0 (60%)	0.3 (3%)	0.0 (47%)	1.3 (25%)	0.5 (0%)	1.1 (-5%)	0.5 (0%)	8.7 (59%)
Hospitals	0.7 (70%)	1.1 (66%)	0.5 (32%)	2.4 (62%)	2.0 (31%)	6.3 (14%)	2.6 (29%)	1.3 (25%)	0.5 (30%)	1.0 (-5%)	0.3 (0%)	24.1 (33%)
Nursing Homes	1.4 (64%)	0.9 (59%)	0.0 (0%)	1.6 (82%)	1.1 (49%)	0.8 (0%)	2.1 (41%)	0.4 (25%)	0.2 (30%)	0.9 (52%)	0.4 (0%)	11.2 (56%)
Universities/Colleges	1.5 (76%)	0.6 (67%)	0.0 (0%)	2.1 (61%)	0.7 (49%)	0.8 (82%)	0.9 (32%)	0.1 (25%)	0.2 (30%)	0.2 (52%)	0.0 (0%)	8.5 (64%)
Schools	1.1 (71%)	0.5 (65%)	0.0 (0%)	0.7 (88%)	1.4 (39%)	0.3 (15%)	0.4 (35%)	0.1 (25%)	0.2 (30%)	0.2 (52%)	0.0 (0%)	4.7 (67%)
High Rise Apartments	0.4 (83%)	0.5 (61%)	0.0 (0%)	1.1 (82%)	1.4 (40%)	1.2 (8%)	1.5 (41%)	0.4 (25%)	0.2 (75%)	1.0 (-5%)	0.3 (0%)	8.0 (56%)
Miscellaneous	2.7 (69%)	0.5 (64%)	0.1 (33%)	1.0 (65%)	1.4 (40%)	1.2 (25%)	0.1 (47%)	0.0 (0%)	0.0 (0%)	0.8 (-5%)	0.3 (0%)	8.1 (63%)

Notes:

1. Weighted average of electric resistance + heat pumps

Percent reduction over frozen efficiency scenario is shown in parentheses.

HVAC: Heating, ventilation and air conditioning Refrig.: Refrigeration

Notes:

1. Weighted average of electric resistance + heat pumps

Percent reduction over frozen efficiency scenario is shown in parentheses.

HVAC: Heating, ventilation and air conditioning

Refrig.: Refrigeration

TABLE 11.20A SUMMARY OF AVERAGE END-USE INTENSITIES FOR ALL ELECTRIC COMMERCIAL BUILDINGS IN B.C. – ECONOMIC POTENTIAL MODEL INPUTS YEAR 2010 (MJ/m ² .yr)												
EXISTING BUILDINGS	General Lighting (MJ/m ² .yr)	Service Area Lighting (MJ/m ² .yr)	Other Lighting (MJ/m ² .yr)	Space Heating (MJ/m ² .yr)	Space Cooling (MJ/m ² .yr)	HVAC Electricity (MJ/m ² .yr)	Service Hot water (MJ/m ² .yr)	Cooling Equipment (MJ/m ² .yr)	Refrig. Equipment (MJ/m ² .yr)	Office Equipment (MJ/m ² .yr)	Misc. Equipment (MJ/m ² .yr)	Total (MJ/m ² .yr)
Large Office (> 3,700 m ²)	48.4 (85%)	18.5 (79%)	7.7 (37%)	45.3 (72%)	0.0 (100%)	82.8 (31%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	54.4 (52%)	43.2 (0%)	322.5 (87%)
Small Office (< 3,700 m ²)	48.4 (85%)	19.3 (79%)	7.7 (40%)	63.3 (67%)	82.2 (38%)	71.4 (37%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	54.4 (52%)	12.9 (0%)	363.8 (87%)
Non-Food Retail	83.3 (75%)	64.7 (78%)	6.1 (40%)	86.3 (55%)	60.6 (64%)	96.3 (21%)	0.8 (47%)	3.1 (25%)	6.7 (30%)	82.9 (-5%)	6.5 (0%)	479.4 (80%)
Food Retail	48.8 (85%)	51.6 (74%)	6.1 (31%)	204.9 (84%)	39.2 (69%)	98.9 (22%)	10.2 (47%)	97.5 (25%)	123.8 (18%)	81.1 (-5%)	97.0 (0%)	1857.1 (36%)
Restaurant/Tavern	81.2 (67%)	53.0 (77%)	0.0 (0%)	306.0 (88%)	51.3 (65%)	374.7 (5%)	212.6 (35%)	314.3 (25%)	154.0 (30%)	44.2 (-5%)	103.0 (0%)	1886.2 (45%)
Hotels/Motels	52.8 (65%)	18.7 (67%)	13.1 (45%)	80.8 (67%)	55.4 (26%)	75.1 (9%)	68.0 (32%)	50.9 (25%)	8.8 (30%)	90.7 (-5%)	14.2 (0%)	528.5 (42%)
Warehouse/Wholesale	91.6 (63%)	7.3 (70%)	0.0 (0%)	143.3 (63%)	32.7 (35%)	12.6 (3%)	1.0 (47%)	3.0 (25%)	15.6 (18%)	43.7 (-5%)	19.0 (0%)	369.6 (54%)
Hospitals	24.9 (73%)	39.1 (67%)	18.0 (31%)	73.8 (71%)	71.8 (35%)	181.3 (36%)	99.4 (29%)	45.8 (25%)	17.5 (30%)	157.2 (4%)	20.0 (0%)	748.8 (42%)
Nursing Homes	44.6 (61%)	43.6 (59%)	0.0 (0%)	211.4 (51%)	48.7 (42%)	32.8 (0%)	82.6 (41%)	9.6 (25%)	21.0 (30%)	38.6 (-5%)	12.8 (0%)	545.5 (46%)
Universities/Colleges	67.2 (70%)	23.4 (67%)	0.0 (0%)	63.4 (70%)	25.7 (52%)	101.2 (39%)	36.6 (32%)	18.5 (25%)	7.0 (30%)	20.7 (52%)	15.0 (0%)	378.7 (57%)
Schools	43.2 (67%)	21.5 (65%)	0.0 (0%)	72.0 (67%)	51.2 (41%)	11.8 (22%)	14.3 (35%)	3.6 (25%)	7.0 (30%)	4.3 (52%)	0.4 (0%)	229.4 (59%)
High Rise Apartments	22.7 (67%)	36.5 (67%)	0.0 (0%)	168.3 (63%)	46.6 (49%)	47.7 (8%)	59.0 (41%)	14.3 (25%)	9.0 (75%)	40.5 (26%)	12.8 (0%)	457.4 (54%)
Miscellaneous	69.2 (67%)	14.3 (63%)	4.2 (35%)	157.6 (63%)	46.6 (49%)	46.2 (25%)	2.1 (47%)	0.0 (0%)	0.0 (0%)	34.0 (-5%)	12.0 (0%)	386.3 (56%)
Notes: 1. Weighted average of electric resistance + heat pumps Percent reduction over frozen efficiency scenario is shown in parentheses. HVAC: Heating, ventilation and air conditioning Refrig.: Refrigeration												
NEW BUILDINGS	General Lighting (MJ/m ² .yr)	Service Area Lighting (MJ/m ² .yr)	Other Lighting (MJ/m ² .yr)	Space Heating (MJ/m ² .yr)	Space Cooling (MJ/m ² .yr)	HVAC Electricity (MJ/m ² .yr)	Service Hot water (MJ/m ² .yr)	Cooling Equipment (MJ/m ² .yr)	Refrig. Equipment (MJ/m ² .yr)	Office Equipment (MJ/m ² .yr)	Misc. Equipment (MJ/m ² .yr)	Total (MJ/m ² .yr)
Large Office (> 3,700 m ²)	48.4 (85%)	17.5 (78%)	8.8 (27%)	18.8 (65%)	39.2 (48%)	35.7 (74%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	90.7 (52%)	43.2 (0%)	314.5 (86%)
Small Office (< 3,700 m ²)	48.4 (85%)	18.2 (78%)	9.2 (27%)	23.8 (76%)	51.7 (54%)	18.9 (88%)	2.5 (47%)	3.0 (25%)	8.7 (30%)	90.7 (52%)	12.9 (0%)	286.1 (72%)
Non-Food Retail	100.0 (70%)	68.3 (73%)	8.8 (14%)	16.8 (73%)	62.0 (63%)	55.0 (35%)	0.8 (47%)	3.1 (25%)	6.7 (30%)	82.9 (-5%)	6.5 (0%)	383.9 (62%)
Food Retail	48.2 (87%)	54.1 (77%)	6.5 (28%)	19.4 (18%)	18.3 (27%)	27.4 (20%)	10.2 (47%)	201.8 (25%)	123.8 (18%)	81.1 (-5%)	97.0 (0%)	1767.7 (32%)
Restaurant/Tavern	82.3 (65%)	67.3 (72%)	0.0 (0%)	99.8 (85%)	51.0 (65%)	153.3 (4%)	212.6 (35%)	274.9 (25%)	154.0 (30%)	44.2 (-5%)	103.0 (0%)	1242.3 (51%)
Hotels/Motels	55.4 (72%)	19.6 (66%)	13.8 (42%)	53.6 (66%)	43.2 (42%)	75.1 (9%)	68.0 (32%)	50.9 (25%)	8.8 (30%)	90.7 (-5%)	14.2 (0%)	483.3 (55%)
Warehouse/Wholesale	98.9 (47%)	7.6 (69%)	0.0 (0%)	14.7 (64%)	37.9 (80%)	12.6 (3%)	1.0 (47%)	3.0 (25%)	19.0 (0%)	43.7 (-5%)	18.0 (0%)	258.3 (60%)
Hospitals	26.1 (70%)	43.9 (66%)	18.9 (32%)	76.6 (68%)	75.6 (31%)	243.3 (14%)	99.4 (29%)	51.0 (25%)	17.5 (30%)	241.9 (4%)	20.0 (0%)	916.2 (34%)
Nursing Homes	55.4 (64%)	36.2 (59%)	0.0 (0%)	51.1 (85%)	42.8 (49%)	32.6 (0%)	82.6 (41%)	16.5 (25%)	21.0 (30%)	38.6 (-5%)	12.8 (0%)	424.2 (57%)
Universities/Colleges	58.2 (76%)	23.4 (67%)	0.0 (0%)	67.8 (68%)	27.2 (46%)	29.6 (82%)	36.6 (32%)	15.5 (25%)	7.0 (30%)	34.6 (52%)	15.0 (0%)	315.9 (65%)
Schools	40.9 (71%)	18.4 (65%)	0.0 (0%)	22.5 (60%)	52.5 (38%)	12.9 (15%)	14.3 (35%)	3.6 (25%)	7.0 (30%)	6.5 (52%)	0.4 (0%)	179.0 (68%)
High Rise Apartments	15.4 (83%)	16.7 (61%)	0.0 (0%)	34.1 (85%)	54.1 (40%)	47.7 (8%)	59.0 (41%)	14.3 (25%)	9.0 (75%)	37.8 (-5%)	12.8 (0%)	302.8 (57%)
Miscellaneous	103.5 (65%)	17.4 (64%)	4.7 (33%)	32.6 (88%)	54.1 (40%)	46.2 (25%)	2.1 (47%)	0.0 (0%)	0.0 (0%)	34.0 (-5%)	12.0 (0%)	306.6 (64%)
Notes: 1. Weighted average of electric resistance + heat pumps Percent reduction over frozen efficiency scenario is shown in parentheses. HVAC: Heating, ventilation and air conditioning Refrig.: Refrigeration												

TABLE 11.208

SUMMARY OF AVERAGE END-USE INTENSITIES FOR ALL ELECTRIC COMMERCIAL BUILDINGS IN B.C. – ECONOMIC POTENTIAL MODEL INPUTS YEAR 2010 (kWh/m²-yr)

EXISTING BUILDINGS	General Lighting (kWh/m ² -yr)	Service Area Lighting (kWh/m ² -yr)	Other Lighting (kWh/m ² -yr)	Space Heating (kWh/m ² -yr)	Space Cooling (kWh/m ² -yr)	HVAC Electricity (kWh/m ² -yr)	Service Hot water (kWh/m ² -yr)	Cooking Equipment (kWh/m ² -yr)	Refrig. Equipment (kWh/m ² -yr)	Office Equipment (kWh/m ² -yr)	Misc. Equipment (kWh/m ² -yr)	Total (kWh/m ² -yr)
Large Office (> 3,700 m ²)	1.2 (86%)	0.5 (79%)	0.2 (37%)	1.2 (72%)	0.0 (100%)	2.4 (31%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	1.4 (52%)	1.1 (7%)	8.3 (87%)
Small Office (< 3,700 m ²)	1.3 (85%)	0.5 (79%)	0.2 (40%)	2.2 (67%)	1.3 (58%)	1.8 (37%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	1.4 (52%)	0.3 (7%)	9.4 (87%)
Non-Food Retail	2.2 (75%)	1.7 (78%)	0.2 (40%)	2.3 (55%)	1.6 (64%)	2.5 (21%)	0.0 (47%)	0.1 (25%)	0.2 (30%)	1.6 (-5%)	0.2 (7%)	12.4 (80%)
Food Retail	1.3 (85%)	1.3 (74%)	0.2 (31%)	5.3 (54%)	1.0 (69%)	2.5 (22%)	0.3 (47%)	2.5 (25%)	31.6 (18%)	2.1 (-5%)	2.5 (7%)	50.5 (36%)
Restaurant/Tavern	2.1 (87%)	1.4 (77%)	0.0 (7%)	8.0 (68%)	1.3 (85%)	9.7 (5%)	5.5 (35%)	8.1 (25%)	4.0 (30%)	1.1 (-5%)	2.7 (7%)	43.8 (45%)
Hotels/Motels	1.4 (65%)	0.5 (67%)	0.3 (45%)	2.1 (67%)	1.4 (25%)	1.9 (9%)	1.8 (32%)	1.3 (25%)	0.2 (30%)	2.3 (-5%)	0.4 (7%)	13.6 (42%)
Warehouse/Wholesale	2.4 (53%)	0.2 (70%)	0.0 (7%)	3.7 (63%)	0.8 (65%)	0.3 (3%)	2.6 (28%)	0.1 (25%)	0.4 (16%)	1.1 (-5%)	0.5 (7%)	9.5 (54%)
Hospitals	0.8 (73%)	1.0 (67%)	0.5 (31%)	1.9 (71%)	1.9 (35%)	4.7 (36%)	2.1 (41%)	1.2 (25%)	0.5 (30%)	1.0 (-5%)	0.3 (7%)	14.1 (46%)
Nursing Homes	1.2 (61%)	1.1 (59%)	0.0 (7%)	5.5 (51%)	1.3 (42%)	0.8 (7%)	2.1 (41%)	0.4 (25%)	0.2 (30%)	0.5 (52%)	0.4 (7%)	9.7 (57%)
Universities/Colleges	1.7 (70%)	0.6 (67%)	0.0 (7%)	1.6 (70%)	0.7 (52%)	2.6 (36%)	0.9 (32%)	0.4 (25%)	0.2 (30%)	0.1 (52%)	0.0 (7%)	5.9 (59%)
Schools	1.1 (67%)	0.6 (65%)	0.0 (7%)	1.9 (67%)	1.3 (41%)	0.3 (22%)	0.4 (35%)	0.1 (25%)	0.2 (30%)	0.1 (52%)	0.0 (7%)	5.9 (59%)
High Rise Apartments	0.6 (67%)	0.9 (67%)	0.0 (7%)	4.3 (63%)	1.2 (49%)	1.2 (8%)	1.5 (41%)	0.4 (25%)	0.2 (75%)	1.0 (35%)	0.3 (7%)	11.8 (54%)
Miscellaneous	1.8 (67%)	0.4 (63%)	0.1 (39%)	4.1 (63%)	1.2 (49%)	1.2 (25%)	0.1 (47%)	0.0 (7%)	0.0 (7%)	0.9 (-5%)	0.3 (7%)	10.0 (55%)

Notes:
1. Weighted average of electric resistance + heat pumps
Percent reduction over frozen efficiency scenario is shown in parentheses
HVAC: Heating, ventilation and air conditioning Refrig.: Refrigeration

NEW BUILDINGS	General Lighting (kWh/m ² -yr)	Service Area Lighting (kWh/m ² -yr)	Other Lighting (kWh/m ² -yr)	Space Heating (kWh/m ² -yr)	Space Cooling (kWh/m ² -yr)	HVAC Electricity (kWh/m ² -yr)	Service Hot water (kWh/m ² -yr)	Cooking Equipment (kWh/m ² -yr)	Refrig. Equipment (kWh/m ² -yr)	Office Equipment (kWh/m ² -yr)	Misc. Equipment (kWh/m ² -yr)	Total (kWh/m ² -yr)
Large Office (> 3,700 m ²)	1.2 (85%)	0.5 (76%)	0.2 (27%)	0.5 (65%)	1.0 (48%)	0.9 (74%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	2.3 (52%)	1.1 (7%)	8.1 (85%)
Small Office (< 3,700 m ²)	1.3 (85%)	0.5 (76%)	0.2 (27%)	0.6 (76%)	1.3 (54%)	0.4 (88%)	0.1 (47%)	0.1 (25%)	0.2 (30%)	2.3 (52%)	0.3 (7%)	7.4 (72%)
Non-Food Retail	2.6 (70%)	1.8 (73%)	0.2 (14%)	0.5 (73%)	1.6 (63%)	1.4 (55%)	0.0 (47%)	0.1 (25%)	0.2 (30%)	1.8 (-5%)	0.2 (7%)	10.2 (62%)
Food Retail	2.1 (85%)	1.4 (77%)	0.2 (26%)	0.5 (16%)	0.5 (27%)	0.7 (20%)	0.3 (47%)	5.2 (25%)	31.6 (18%)	2.1 (-5%)	2.5 (7%)	46.2 (32%)
Restaurant/Tavern	1.4 (72%)	1.7 (72%)	0.0 (7%)	2.6 (85%)	1.3 (82%)	4.0 (4%)	5.5 (35%)	7.1 (25%)	4.0 (30%)	1.1 (-5%)	2.7 (7%)	32.1 (51%)
Hotels/Motels	2.6 (47%)	0.5 (66%)	0.4 (42%)	1.4 (84%)	1.1 (60%)	0.3 (3%)	0.0 (47%)	0.1 (25%)	0.5 (7%)	2.3 (-5%)	0.4 (7%)	12.7 (55%)
Warehouse/Wholesale	0.7 (70%)	1.1 (66%)	0.5 (32%)	2.0 (66%)	2.0 (31%)	6.3 (14%)	2.6 (28%)	1.3 (25%)	0.5 (30%)	1.0 (-5%)	0.3 (7%)	23.7 (34%)
Hospitals	1.4 (64%)	0.9 (59%)	0.0 (7%)	1.3 (85%)	1.1 (49%)	0.8 (7%)	2.1 (41%)	0.4 (25%)	0.5 (30%)	0.9 (52%)	0.4 (7%)	10.9 (57%)
Nursing Homes	1.5 (76%)	0.8 (67%)	0.0 (7%)	1.8 (69%)	0.7 (49%)	0.8 (62%)	0.9 (32%)	0.1 (25%)	0.2 (30%)	0.2 (52%)	0.0 (7%)	8.2 (85%)
Universities/Colleges	1.1 (71%)	0.5 (68%)	0.0 (7%)	0.6 (80%)	1.4 (39%)	0.3 (15%)	0.4 (35%)	0.4 (25%)	0.2 (75%)	1.0 (-5%)	0.3 (7%)	4.8 (65%)
Schools	0.4 (63%)	0.5 (61%)	0.0 (7%)	0.9 (69%)	1.4 (40%)	1.2 (8%)	1.5 (41%)	0.4 (25%)	0.2 (75%)	1.0 (-5%)	0.3 (7%)	7.8 (57%)
High Rise Apartments	2.7 (69%)	0.5 (64%)	0.1 (30%)	0.8 (80%)	1.4 (40%)	1.2 (25%)	0.1 (47%)	0.0 (7%)	0.0 (7%)	0.9 (-5%)	0.3 (7%)	7.9 (64%)

Notes:
1. Weighted average of electric resistance + heat pumps
Percent reduction over frozen efficiency scenario is shown in parentheses
HVAC: Heating, ventilation and air conditioning Refrig.: Refrigeration

TABLE 11.21
ECONOMIC POTENTIAL MODEL ESTIMATE BY BUILDING SEGMENT
 (at No Environmental Credit and an 8% Discount Rate)

BUILDING SEGMENT	YEAR 2000				YEAR 2010			
	LOW GROWTH		HIGH GROWTH		LOW GROWTH		HIGH GROWTH	
	ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹	
	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)
Large Office (> 3,700 m ²)	213.4	65%	225.1	65%	262.0	67%	287.7	67%
Small Office (< 3,700 m ²)	1,789.4	68%	1,886.4	68%	2,220.3	71%	2,434.3	72%
Non-Food Retail	1,318.0	60%	1,624.8	60%	1,442.8	62%	2,002.7	62%
Food Retail	277.8	34%	340.4	34%	300.3	35%	414.6	34%
Restaurant/Tavern	244.0	41%	269.5	41%	284.5	43%	331.0	44%
Hotels/Motels	290.9	44%	335.1	45%	367.9	49%	449.1	50%
Warehouse/Wholesale	356.3	43%	475.4	43%	410.9	45%	608.9	44%
Hospitals	162.8	40%	175.1	39%	187.9	40%	216.1	39%
Nursing Homes	76.3	41%	83.7	42%	99.4	48%	116.4	49%
Universities/Colleges	223.4	57%	244.3	58%	268.9	61%	316.9	62%
Schools	328.8	57%	358.2	58%	411.7	64%	478.8	64%
High Rise Apartments	474.0	50%	507.9	51%	580.0	57%	657.8	57%
Miscellaneous	316.2	50%	345.6	50%	392.4	54%	460.2	54%
Total Savings	6,071.3	54%	6,871.4	54%	7,228.9	58%	8,774.5	57%

Notes:

¹ Electricity savings (GWh and %) represent savings over corresponding year's Frozen Efficiency consumption.

TABLE 11.22
ECONOMICAL POTENTIAL MODEL ESTIMATE BY END-USE
 (at No Environmental Credit and an 8% Discount Rate)

END-USE	YEAR 2000				YEAR 2010			
	LOW GROWTH		HIGH GROWTH		LOW GROWTH		HIGH GROWTH	
	ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹		ELECTRICITY SAVINGS ¹	
	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)
General Lighting	2,352.7	70%	2,673.1	70%	2,772.5	74%	3,385.5	72%
Service Area Lighting	1,095.0	70%	1,249.8	70%	1,244.8	73%	1,536.3	73%
Other Lighting	37.3	36%	40.0	35%	41.1	36%	46.6	34%
Space Heating	659.2	53%	734.3	55%	921.2	69%	1,073.1	71%
Space Cooling	492.8	56%	560.2	56%	541.1	55%	668.2	56%
HVAC Electricity	405.1	32%	468.1	33%	507.4	35%	633.5	37%
Service Hot Water	59.9	38%	65.2	38%	66.9	38%	77.7	38%
Cooking Equipment	43.4	25%	50.0	25%	49.0	25%	61.2	25%
Refrigeration Equipment	187.0	25%	215.6	24%	203.6	25%	257.7	24%
Office Equipment	738.9	50%	815.2	49%	881.3	51%	1,034.5	49%
Misc. Equipment	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Total Savings	6,071.3	54%	6,871.4	54%	7,228.9	58%	8,774.5	57%

Notes:

¹ Electricity savings (GWh and %) represent savings over corresponding year's Frozen Efficiency consumption.

HVAC: Heating, ventilation and air conditioning

of which would have a minor effect on electricity consumption. Advanced technologies such as "two-photon" lamps are also assumed not to be economic, but since lighting savings of between 60% and 80% (depending on the building segment) are already economic, this does not have a significant effect on Economic Potential.

The effect of the discount rate is also significant. At a 4% discount rate, all technologies are economic with no environmental credit. At a 12% discount rate, however, several technologies are not economic without a more significant environmental credit. It is estimated that savings of between 40% and 45% over Frozen Efficiency could be achieved at a 12% discount and no environmental credit, but closer to the full 68% Social plus Technological Potential if a 60% to 100% environmental credit is applied.

12. FORECASTS OF BC ELECTRICITY USE IN COMMERCIAL BUILDINGS

To present the study results in a way that would provide both a comparison of electricity conservation potential and forecasts of electricity consumption in 2000 and 2010 under each set of assumptions, a set of eight electricity forecasts for 2000 and 2010 were produced, each based on 1988 BC Hydro electricity sales to the commercial sector buildings (i.e. without high rise apartment suite electricity).

- High and low Frozen Efficiency forecasts were produced, with the percentage increases in electricity consumption estimated in Section 8, using the computer spreadsheet model, and were applied to all BC Hydro 1988 commercial sector building sales (7,935 GWh - see Table 2.2).
- High and low forecasts corresponding to Technological Potential, Social plus Technological Potential, and Economic Potential were produced by applying the percentage reductions estimated using the model in Sections 9, 10 and 11, respectively, to the Frozen Efficiency forecasts (i.e., assuming that the exclusion of high rise suite electricity does not affect percentage savings).

Table 12.1 shows forecasts for BC Hydro sales to Commercial Sector Buildings for each set of assumptions (ie assuming that only sales to common areas of apartments are included). Figures 12.1 and 12.2 show the change in electricity use between 1988, 2000 and 2010 for each forecast.

The forecasts show significant conservation potential that is available in BC commercial buildings through the unconstrained use of technological and operational social measures. Most of this potential is also economic, and electricity demand well below current (1988) sales to commercial buildings would be possible by 2010 if all economic measures were applied.

TABLE 12.1
COMPARISON OF BC COMMERCIAL BUILDING ELECTRICITY FORECASTS
MAPPED TO BC HYDRO 1988 COMMERCIAL BUILDING SALES

	FROZEN EFFICIENCY FORECAST		TECHNOLOGICAL POTENTIAL			TECHNOLOGICAL POTENTIAL			SOCIAL PLUS TECHNOLOGICAL POTENTIAL			ECONOMIC POTENTIAL		
			SAVINGS GWh/yr	GWh/yr	% Red'n ²	SAVINGS GWh/yr	GWh/yr	% Red'n ²	SAVINGS GWh/yr	GWh/yr	% Red'n ²	SAVINGS GWh/yr	GWh/yr	% Red'n ²
	GW/h/yr	% Increase ¹												
1988	7,935	--	--	7,935	--	--	--	--	--	--	--	--	--	--
2000 HIGH GROWTH	11,426	44%	6,285	5,142	55%	6,856	4,571	60%	6,170	5,256	54%	6,170	5,256	54%
2010 HIGH GROWTH	13,807	74%	8,974	4,832	65%	9,389	4,418	68%	7,870	5,937	57%	7,870	5,937	57%
2000 LOW GROWTH	10,077	27%	5,643	4,434	56%	6,046	4,031	60%	5,442	4,636	54%	5,442	4,636	54%
2010 LOW GROWTH	11,268	42%	7,324	3,944	65%	7,775	3,493	69%	6,535	4,732	58%	6,535	4,732	58%

Note: ¹ Percent increase over 1988 consumption.

² Percent reduction over Frozen Efficiency Forecast for the given year.

**FIGURE 12.1 BC Commercial Sector Electricity Forecasts
High Growth**

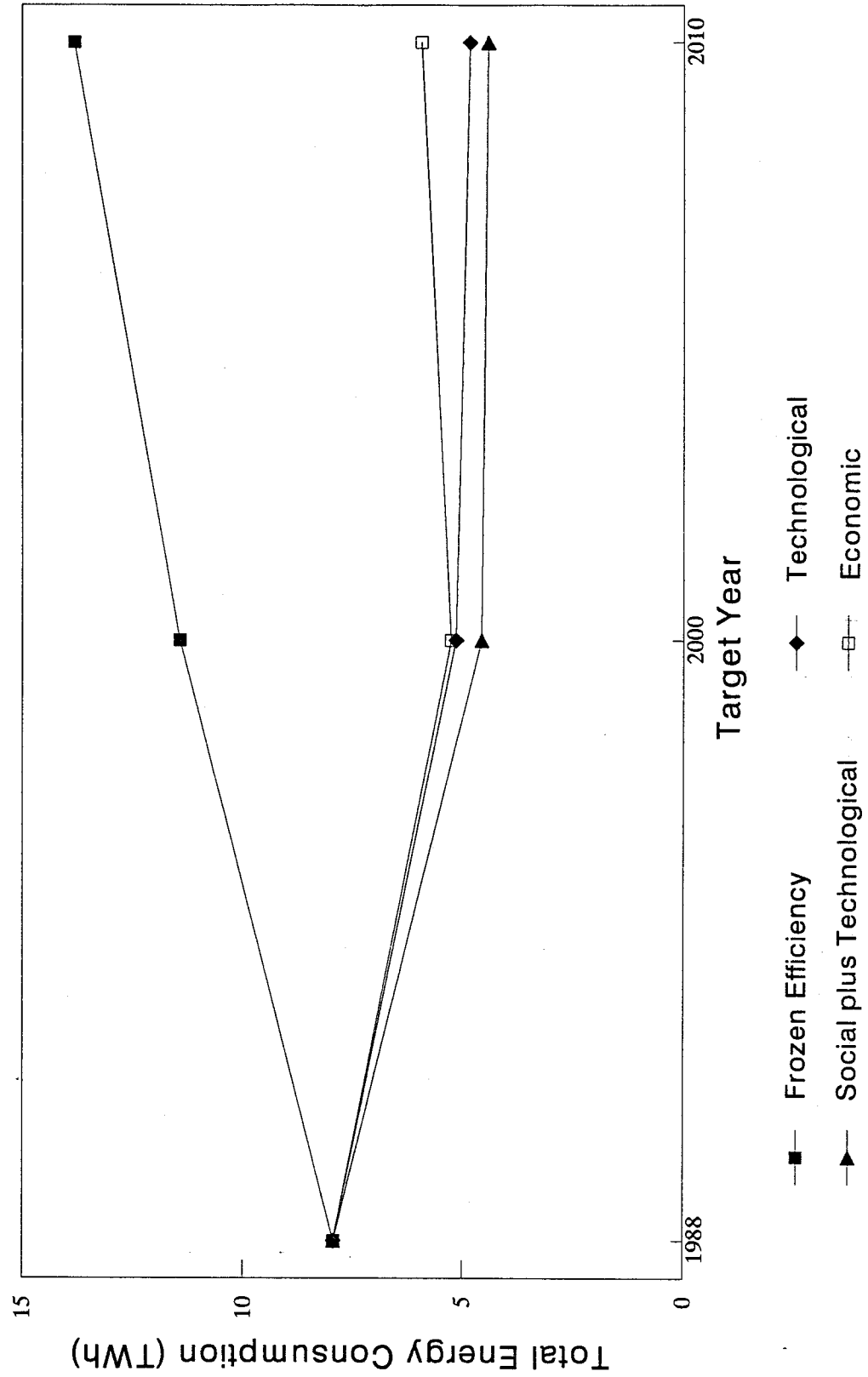
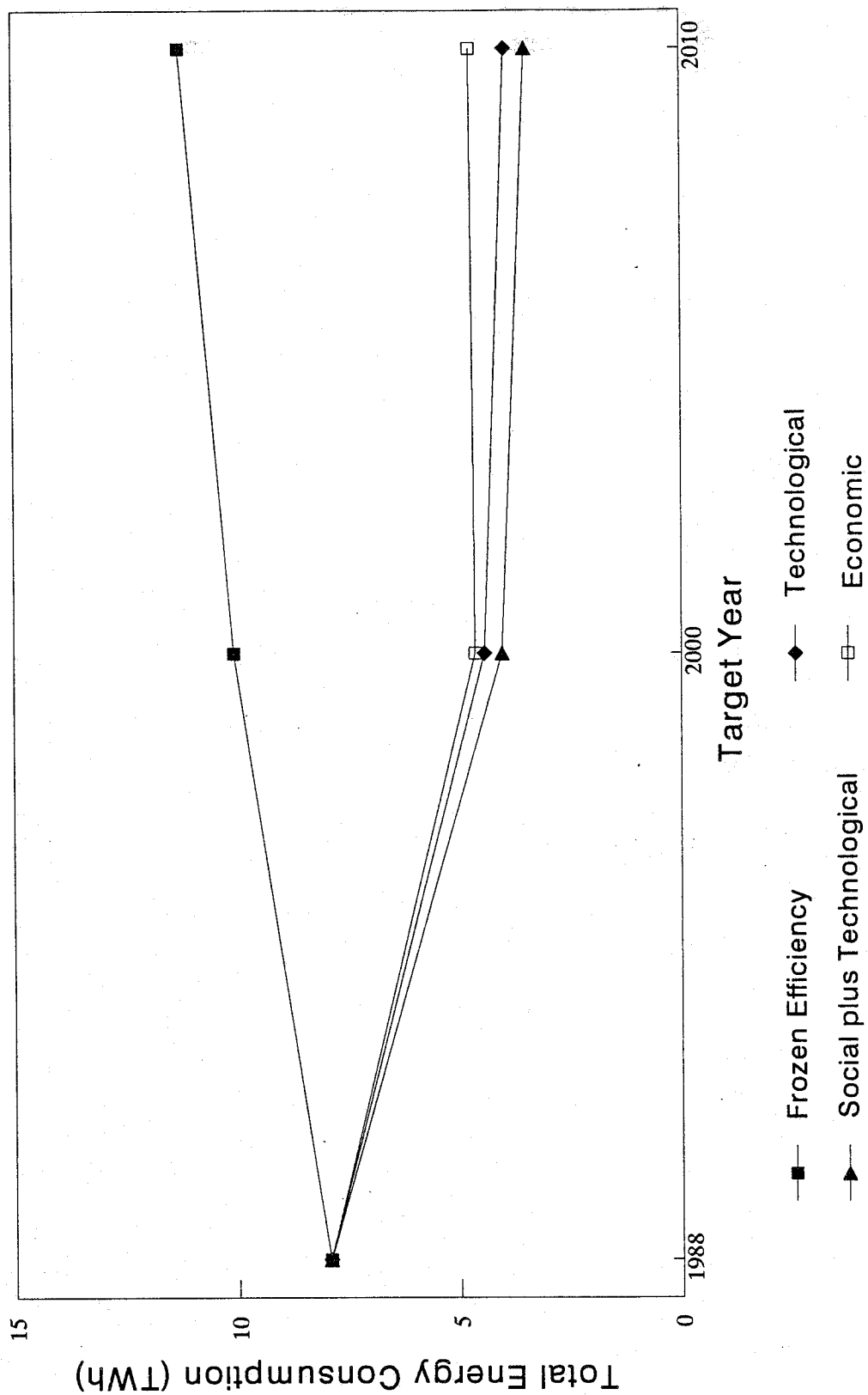


**FIGURE 12.2 BC Commercial Sector Electricity Forecasts
Low Growth**



BC Hydro 1991 - 1993 Conservation Potential Review - Commercial Sector Final Report

The forecasts show significant conservation potential that is available in BC commercial buildings through the unconstrained use of technological and operational social measures. Most of this potential is also economic, and electricity demand well below current (1988) sales to commercial buildings would be possible by 2010 if all economic measures were applied.

13. COMMENTS AND RECOMMENDATIONS

13.1 Data Sources

The following data sources were considered to be of relatively good quality:

- Lighting configuration assumptions and EUIs in typical existing and new buildings.
- Envelope characteristics in typical existing and new buildings.
- Performance and cost information on conventional and most commercially available efficient technologies.

These data were based on either local experience of the study team and local building owners, or on reliable international sources. There were also no significant variations between data sources.

Other sources were less reliable as follows:

- Building floor space data was inadequate, even for building segments such as schools and hospitals where there is a single jurisdiction, and reliable estimates could be expected.
- Commercial sector sales data is not disaggregated consistently by SIC code. This occurs most often in multiple use buildings where it is not clear to what building category or SIC the sales should be allocated.
- While some local BC interviews provided insight, there is not much information available locally or in the literature on operational practice. This prevented quantification and costing of improvements in maintenance and scheduling.
- Good estimates of space and water heater fuel shares were not available for existing or new buildings, and local opinion was divided.
- Differences in ventilation rates between existing and new buildings also varied considerably between data sources.
- The performance and cost of emerging technologies and those not yet widely available in North America were often difficult to obtain. Several useful case

studies were found, however, and more definitive data will become available as these technologies are used more widely in North American buildings.

13.2 Suggestions for Future Work Under the Conservation Potential Review

The following suggestions are made regarding future work on the Conservation Potential Review of the Commercial Sector:

Availability of Efficient Technologies

Many of the efficient lighting, cooling and other technologies identified in this study are not readily available in BC. The technological and economic savings identified in this study will not be achieved unless BC manufacturers and distributors are encouraged to become familiar with these technologies, and make them available to those leading the way in advanced building design, construction, and renovation. Close watch should be kept on demonstration projects and case studies which use these new technologies and design features.

Cream Skimming

There is a temptation in any conservation initiative to implement low cost measures first which result in modest efficiency gains, but which also make high efficiency gains less cost effective. This is particularly true in the Commercial Sector with envelope upgrade (walls and windows), lighting redesign, and HVAC equipment replacement where the opportunity to upgrade occurs infrequently. Programs should concentrate on bundles of both low and high cost measures, allowing the latter to be cross subsidized by the former and to maximize economic viability.

Additional Data

Floorspace information for all BC commercial buildings should be available through the BC Assessment Authority within 12 months. BC Hydro should continue to work closely with the Authority to ensure that building classifications and the treatment of mixed use buildings are well documented, and then re-run the calibration and Scenarios in this study.

Further information should also be obtained on heating fuel shares, ventilation rates, office equipment efficiency and efficiency trends, and the quantitative effects of current operational practice.

Fuel Substitution

The study did not address the technological, social or economic potential of substituting other fuels for electricity in BC or the selection of the most cost effective fuels for new buildings. This analysis should form part of any future integrated resource planning by BC Hydro.

APPENDIX 1

CAMPBELL-GODELL REPORT 1988

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1. Municipal Data: (all figures in square feet)

Nanaimo

Office: 660,000
Retail: 2,436,000
Rental: 4,238 units = 3,729,440 sq. ft.
Population: 82,180

Kelowna

Office: 1,240,000
Retail: 2,700,000
Rental: 4,091 units = 3,600,080 sq. ft.
Population: 80,000

Prince George

Office: 802,000
Retail: 1,095,000
Rental: 4,130 units = 3,634,400 sq. ft.
Population: 67,621

Victoria (Capital Regional District)

Office: 5,690,000
Retail: 5,420,531
Rental: 25,537 units = 22,472,560 sq. ft.
Population: 241,450

2. Restaurants:

Number of licensed restaurant seats in B.C. = 486,531

Area allotted per seat = 12 sq. ft.

Total area for dining areas in licensed restaurants = 5,838,372 (data supplied by Wendy Lowe, Liquor Control Board, 1-387-1254)

Number of unlicensed restaurant seats in B.C. = 973,062

Total dining area for unlicensed restaurants = 11,676,744 (Data supplied by Mr. King, B.C. Restaurants Assn.)

Average allotment for kitchen space = 6.83 sq. ft. per seat (ratio supplied by Grant Olson, Laventhol & Horwath)

Total area for kitchen space in licensed and unlicensed restaurants: 9,969,020.

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3. Grocery:

Large food retail -- Safeway has 93 stores in B.C.; average size per store = 25,000 sq. ft. Safeway holds approximately 35% of market share in B.C. -- this estimate is corroborated by figures from the Central Statistics Bureau compilation of B.C. businesses (total of 261 large retail outlets -- stores with more than 20 employees)

Total Safeway area: 2,325,000

Total large food retail: 6,525,000 (estimate using Safeway model).

Small food retail: 7-11 has 147 stores in B.C.; average size per store = 2,000 sq. ft. Central Statistics Bureau lists 4,722 small retail outlets (under 20 employees); using 7-11 as a model, the figure for small retail can be estimated at 9,444,000 sq. ft.

4. Hospitals:

Total number of hospital beds in B.C.: acute 11,511; intermediate 16,670; extended 7,274 (long term care).

Average area allotted per bed: 409.02 sq. ft.

Source: Cal McIvar, Dept. of Planning and Construction, Ministry of Health, Victoria

5. Prisons:

Estimated area for federal prisons (1,104,872) quoted by Dan Denis of corrections Canada (1-854-2695).

Area of provincial correctional institutes based on number of inmates (2,200) X per bed allotment used for hospitals. Accurate information should be available through Ken Nygaard at the Solicitor General's Office (1-387-6366).

6. Motels:

Number of motel units = 33,921 (B.C. Motels and Resorts Association)

Average unit size = 319 sq. ft. (Travel Industry Assn.)

Total area: 10,820,799 sq. ft. + 10% hallway space = 11,902,878

7. Hotels:

Number of hotel units = 35,241 (StatsCan)

Average unit size = 358 sq. ft. (Travel Industry Assn.)

Total unit area: 12,616,278 sq. ft. + 15% amenity space = 14,508,719

8. Apartment Buildings:

Total # apartment units in B.C. = 251,560

Breakdown: 190,140 - 5 storeys or less

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61,420 - 5 storeys or more (StatsCan)

Average area per unit = 800 sq. ft.

Breakdown: 1 bedroom 650 sq. ft.

2 bedroom 800 sq. ft.

3 bedroom 950 sq. ft.

(averages supplied by Helmut Pastrick, C.M.H.A.)

Total unit area 201,248,000 + 10% hallway space = 221,372,800

9. Mobile Homes:

Number of mobile homes in B.C. = 29,550 (StatsCan)

Average size (single wide): 924 sq. ft.

Average size (double width): 1,248 sq. ft.

Single-wides account for 75% of total (22,162) multiplied by 924 = 20,478,150

Double-wides = 25% of total (7,387) multiplied by 1248 = 9,219,600

Total area: 29,697,750 sq. ft.

(Mobile home information supplied by Dan Diehart of Moduline Industries, 1-493-0122)

ADDITIONAL CONTACTS

Canadian Warehousing Association (Toronto)

Barry Robbins, Municipal Planning, G.V.R.D. 432-6350

Mr. King, Restaurant & Food Services Assn. of B.C. 298-5956

Ralph Shandley, B.C. Assessment Authority 1-479-7131

Grant Olson, Laventhol & Horwath 684-0373

Mark Sakai, Urbanics Consultants 669-2724

Centre for Human Settlement 228-5254

Dennis Burnaul, Oberti Oberto Architects 662-7796

Mowe Warwicke, Capital Regional District 1-388-4421

Ted Sebastian, Planning, City of Vancouver 873-7458

Darrel Hurst, Royal Lepage 683-3111

Bob Griffiths, B.C. Grocer Magazine 299-7311

Tom Proctor, 7-11 Division Office 299-0711

Canada Safeway Division Office 687-4833

APPENDIX 2

BC HYDRO FLOOR AREA ASSUMPTIONS

APPENDIX 2
B.C. HYDRO CURRENT ASSUMPTIONS

B.C. HYDRO SEGMENTS	FLOOR AREA (m ²)	CURRENT DATA SOURCE	DESCRIPTION
OFFICE/ADMINISTRATION	7,500,000	The floor area for this segment was derived using two methodologies. The first one was based on floor area estimates from the CAMPBELL GOODELL CONSULTANTS 1988 quantification of commercial floor space. The report provided office space floor area estimates for 4 regions. A per capita office area for each region was calculated which was then used to calculate the total floor area for the province of B.C. using total population. The second method relied on B.C. HYDRO sales data and average intensities from the BEAS database.	INCOMPLETE
RETAIL	6,740,000	The floor area for this segment was derived using two methodologies. The CAMPBELL GOODELL CONSULTANTS 1988 quantification of commercial floor space provided retail floor space for four cities in the province of B.C. This data was used to derive an average floor area per capita which was then used to calculate total retail floor space in the province of B.C. by multiplying the total population by the developed per capita floor area. The second method derived the retail floor area through indirect means by dividing the total B.C. HYDRO sales data by intensities derived from B.C. HYDRO BEAS database.	INCOMPLETE
GROCERY	1,450,000	The CAMPBELL GOODELL CONSULTANTS 1988 quantification of commercial floor space report provides the following information on FOOD RETAIL. 93 SAFEWAY grocery stores in the province of B.C. with an average store size of 2300 m ² and a market share of 35%. This yields approximately 605,000 m ² . The Central Statistics Bureau lists 4700 small retail outlets in the province of B.C. Based on an average store size of 185 m ² obtained from 7-11 Convenience Stores, the small retail outlets average 845,000 m ² .	COMPLETE
RESTAURANTS	2,090,000	The CAMPBELL GOODELL CONSULTANTS 1988 quantification of commercial floor space report provides the following information on RESTAURANTS. The total number of licensed restaurant seats in B.C. were obtained from the Liquor Control Board. The figure of 486,500 seats was multiplied by an allotted area per seat of 1.11 m ² . Similarly the total number of seats for unlicensed restaurants was obtained from the B.C. Restaurants Ass. The number of 973,000 seats was multiplied by the allotted area per seat. Finally to the total number of seats a kitchen space allotment of 0.63 m ² /seat was added to the total.	COMPLETE
LODGING	2,450,000	The CAMPBELL GOODELL CONSULTANTS 1988 quantification of commercial floor space report provides the following information on HOTELS/MOTELS. Total number of hotel units in the province of B.C. estimated by Statistics Canada at 35,200 units. The travel industry Association estimates an average unit size of 33.3 m ² . To this, a 15% amenity space is added which yields 1,347,000 m ² . The Motel and Resorts Ass. provided the number of Motel units which were multiplied by the average unit size of 29.6 m ² to obtain a total floor area of 1,103,000 m ² .	COMPLETE
WAREHOUSE/WHOLESALE	2,800,000	The CAMPBELL GOODELL CONSULTANTS 1988 quantification of commercial floor space report provides information on Warehouse/ Wholesale from the Canadian Warehousing Association.	INCOMPLETE

APPENDIX 2
B.C. HYDRO CURRENT ASSUMPTIONS

B.C. HYDRO SEGMENTS	FLOOR AREA (m ²)	CURRENT DATA SOURCE	DESCRIPTION
HOSPITALS	1,345,000	The CAMPBELL GOODELL CONSULTANTS 1988 quantification of commercial floor space report provides information on number of hospital beds in the province of B.C. plus the average area allotted per bed. This information was obtained from the Ministry of Health	COMPLETE
NURSING HOMES	975,000	B. C. HYDRO obtained the information on Nursing Homes floor areas directly from the Ministry of Health. The floor area for independently run nursing homes was estimated indirectly by B.C. HYDRO from sales data and intensities from the BEAS database.	INCOMPLETE
UNIVERSITIES/COLLEGES	1,870,000	B.C. HYDRO obtained the information on post secondary institutions floor area directly from the Ministry of Advanced Education.	COMPLETE
SCHOOLS	5,840,000	B.C. HYDRO obtained the information on primary and secondary schools floor area directly from the Ministry of Education. The information was segregated into functioning and non-functioning schools. The non-functioning schools floor area was adjusted to take into account the lower energy consumption. Floor area from private schools was obtained by B.C. HYDRO from the Independent Schools Ass. This association has as members multiple sectoral school boards such as Protestant and Catholic School Boards.	COMPLETE
APARTMENTS	20,580,000	The CAMPBELL GOODELL CONSULTANTS 1988 quantification of commercial floor space report provides information on number of apartment building units in the province of B.C. This information was obtained from Statistics Canada. The total number of units estimated at 251,000 was multiplied by an average unit size of 74.3 m ² supplied by C.M.H.A. Finally 10% was added to the final result for common area space.	COMPLETE
TRANSPORTATION + COMMUNICATION + MISCELLANEOUS + SERVICES: INST. & OTHERS	21,720,000	B.C. HYDRO derived the floor areas for this four segments through indirect means by using actual sales data broken down by SIC code and average intensities. The intensities were obtained from either the BEAS report from B.C. HYDRO, COMMEND or intensities provided by PACIFIC NORTHWEST UTILITIES.	INCOMPLETE

APPENDIX 3

LITERATURE REVIEW OF SOCIAL PRACTICE

NON-EMPIRICAL AND NON-QUANTITATIVE STUDIES

In the published literature, the importance of operations and maintenance has evidenced itself in program failures and successes and in the experience of building and equipment experts.

Institutional Conservation Programs. One study of the U.S. Federal institutional buildings program found that dysfunctional systems were noted in the course of energy audits of several buildings. The authors suspect, cannot prove, that many retrofits contributed, rather than helped, the control problems in the building. For example, in one case, energy use increased immediately after installation of night setback thermostats. The authors observed that when controls were added, building operators stopped paying attention to building operations. In some circumstances the best operators outperformed the controls. This study recommended that programs include provisions to properly commission and maintain controls, and encourage owners to consider energy costs when budgeting for maintenance. They also recommended that operator training and maintenance should be integral with retrofits, that systems be set up for reporting building performance back to owners and operators.¹

These concerns has been confirmed through other studies involving follow-up visits to buildings served by the Bonneville Power Administration's Institutional Buildings Program² and the Federal Institutional Conservation Program.³ Among problems related to equipment design, changes in building use, and other causes, these follow-ups discovered a number of problems which were directly related to O+M deficiencies:

- One County had installed an energy management system to control several buildings. However, the staff didn't know how to operate the system, so it wasn't saving much energy. The staff was eager to improve the system's performance, and was pleased when operation training was offered.
- Visits to one institution where the energy manager had no control over the practices of individual building managers showed that buildings were chronically overcooled and lights were frequently left on in unoccupied spaces. Unnecessarily high-wattage incandescent light bulbs were used. Time clocks were not utilized.

¹ Case, Mark, et. al, "Followup and Evaluation of Non-Performing ICP Buildings", in Energy Program Evaluation: Uses, Methods, and Results, 1991 International Energy Program Evaluation Conference Proceedings, 1991

² Individual site visit reports as reviewed by the author of this memo. Also, "Changes to IBM Buildings", Frances Petersen, 1991 International Energy Program Evaluation Conference Proceedings, and "Case Study Analysis of the Institutional Buildings Program in Washington State". Rick Kunkle, Energy Program Evaluation: Conservation and Resource Management, 1989 International Energy Program Evaluation Conference Proceedings, 1989.

³ Syntectics Group, Inc, An Evaluation of the Institutional Conservation Program- Results of On-Site Analyses, Final Report, April 30, 1983, U.S. Department of Energy.

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- In one building where the operations personnel were not concerned about energy, cooling equipment was installed in such a way to make filter replacement and regular maintenance difficult. Classrooms were overcooled, then the doors were left open.
- In another building, the domestic water heaters were set for maximum temperatures and filters were dirty.
- Follow-up visits to another building indicated that the management had not pursued recommended low cost/no cost measures, including delamping, reducing space heating and domestic hot water thermostat settings, turning off lights in unused areas, reducing settings of outside air dampers, and adjusting doors for closing. This was attributed to under-staffing, lack of interest, and the absence of any program within the institution to manage energy costs.
- In one institution, intake of outside air for ventilation systems were unbalanced, and an easily accessible and cleanable intake vent was found to be 60% clogged by debris. This institution had a centralized energy manager who did not grant authority to building managers to initiate O+M practices, and did not have the resources to manage energy in all of the buildings himself.
- Under the Federal program, building managers generally took actions which were required by the program sponsor as a preconditions for incentives. However, where repeated action or continued vigilance was required to assure continued savings (lower water heat temperature, reduce exterior lighting, change filters, put up a sign asking for occupants to close the door), vigilance often lapsed after the incentive was received. For example, when building operators changed in one building, three heating coils which had been disconnected as unneeded were reconnected.

Another review of the Bonneville Power Administration Institutional Buildings Program itemized reasons why savings in some buildings fell below expectations. Many of the reasons involved replacement of poorly specified equipment which did not meet user needs or changes in building space use. However, other examples included:

- Supply air reset controls in a health building were supplanted manual by control by the building manager.
- An optimal start function in an educational building was not used because nobody understood it.
- Unused space in a school became occupied, and controls were not extended to apply to this area.

A third review of the same data provided another example of conservation hardware failure due to absence of appropriate behaviour. This one involved a programmable thermostat which mis-scheduled heat after a power outage disoriented its timeclock.

Commercial Incentive Pilot Program.⁴ Another study involved visits to buildings which participated in Bonneville's Commercial Incentive Pilot Program, but reduced loads were less than expected. The authors were unable to explain more than about half of the difference between actual and estimated load decreases based on their observations (this may indicate that a significant proportion of the shortfalls were related to behaviour, but also may reflect inadequate engineering knowledge of equipment performance among both energy auditors and post-installation inspectors). Many of the phenomena they observed were related to equipment failure or changes in building use which may have affected loads without reducing savings. The latter has both behavioral and hardware elements. There were some problems which were related to behaviour more directly. One building manager had overridden a timeclock. Another had replaced efficient lamps with inefficient, but was planning to replace the fixtures entirely soon with more efficient ones.

Washington State Institutional Pilot Project.⁵ An additional O+M pilot was funded by the Bonneville Power Administration and operated through the Washington State Energy Office (WSEO). WSEO instituted a free-standing service consisting of free operations and maintenance audits, on-site instruction of maintenance staff, identification of opportunities to save energy with a payback of one year or less, and reimbursement of between \$300 and \$2,000 for installation of these low-cost measures in one building per participant. The customers were required to make an individual available for training, install all feasible low-cost measures, and develop an energy consumption monitoring system and report results.

Two thirds of the institutions participating in the initial round of the program chose to invest some of their own funds in low-cost measures in addition to the money provided by WSEO. The training was praised by the building operators. Almost half thought it led directly to energy saving actions. It is unclear how much of the activity under this program was "social" conservation versus low-cost capital conservation. There also was no impact analysis.

⁴ "Building Site Visits as a Supplement to Program Evaluation". Hickman, Curtis, and Steele, Tim, Energy Program Evaluation: Uses, Methods, and Results, 1991 International Energy Program Evaluation Conference Proceedings, 1989

⁵ Washington State Energy Office, Institutional Operations and Maintenance Energy Savings Demonstration Program -- Evaluation, Part One, Bonneville Power Administration, 1986.

Institutional Building Operator Training.⁶ The Bonneville Power Administration has also offered O+M training as an auxiliary service to their Institutional Buildings Program. The training was in a classroom setting, and was not specific to the equipment operated by various institutions. Evaluations indicated that the training was well received, and that participants thought that it was likely to result in energy savings. There were no direct site visits or billing data analyses to verify the affects of the training.

Measure Life Study.⁷ A study under which commercial equipment laboratory and field experts were interviewed indicated that O+M practices are inadequate among most users, and that the lack of proper care is dramatically curtailing the life and efficacy of many efficiency measures. The main problems were the lack of regularly scheduled calibration, cleaning, and lubrication of HVAC equipment. Less concern was expressed about operation of refrigeration equipment, presumably because the groceries who own the largest common refrigeration systems are more interested in maintenance due to their high energy costs, but possibly also because fewer of the interviewees were refrigeration experts. Several measures which were thought to be particularly vulnerable were given variable measure lives, with the higher values attainable only through proper equipment care. These are shown below.

Measure	Min/Max Average Measure Life
Economizer:	10-15 years
Chiller Strainer Cycle System	15-25 years
Air-to-Air Heat Pump	5-15 years*
Water-Air Packaged Heat Pump	11-15 years*
Heat recovery from	
Refrigerator Condensers	10-15 years
Low Leakage Dampers	5-11 years

*These items were judged likely to be replaced with similar equipment with similar efficiencies. Thus, there would be a measure replacement cost, but the savings would continue.

⁶ David M. Dornbusch, Inc., Institutional Buildings Program Evaluation -- Energy Auditor Training Follow-Up, Bonneville Power Administration, June, 1984

⁷ Gordon, Frederick M., et. al., "Use of Commercial Energy Efficiency Measure Service Life Estimates in Program and Resource Planning", in Proceedings of 1988 ACEEE Summer Study on Energy Efficiency in Buildings, 1988, ACEEE, Wash., D.C., also McRae, Marjorie, Rufo, Michael, And Baylon, David, Service Life of Energy Conservation Measures, Final Report, July 14, 1987, Bonneville Power Administration.

MEASURED SAVINGS FROM EFFICIENCY PROGRAMS WITH A STRONG BEHAVIORAL COMPONENT AND REDUCED SAVINGS FROM PROGRAMS DUE TO INEFFICIENT OPERATOR BEHAVIOUR

Studies which estimate the sensitivity of savings to building operation behaviour are relatively rare. However, enough information exists to provide a general range of possible savings.

Institutional Buildings Programs Installation Follow-ups. One analysis of the followup activity for the Bonneville Power Administration Institutional Building Program did attempt to compare the actual versus estimated savings for measures which are sensitive to behaviour of building operators or occupants ("Active measures") versus other measures ("Passive measures"). The results are presented below:

Percent of predicted electronic savings actually achieved:⁸

Percent of Savings:	# of Buildings:	
	Active ECMs	Passive ECMs
0-25%	2	0
25-50%	5	5
50-75%	4	4
75-100%	9	17

A weighted average of the above results would provide average savings of 63% of predicted for active measures and 74% for passive measures. The ratio of these two, 84%, might be one indicator of the level of achievable savings if active measures were properly designed, installed, and maintained. This would imply that savings from active measures should be discounted by some fraction of the 16% for normal behaviour, and that some part of the additional 16% savings might be returned if optimal behaviour were to occur. This would also imply that, where conservation measures are not applied (either because systems are already optimal or additional measures are not feasible) some fraction of the 16% savings might be achieved with optimal behaviour alone.

It should be noted that this is a creative and tenuous extrapolation from a study which involved both a limited sample, limited data, and a great deal of interpretive judgement. The estimated savings also were developed without a comparison group. However, this may be a useful cross-check on other sources of information.

⁸ Kunkle, Rick, op. cit.

Western Montana Institution Pilot Project.⁹ A pilot program managed by the Western Montana Operation and Maintenance Grants Project funded the development of individual Operations and Maintenance (O&M) manuals for various institutions in Western Montana. A very simple evaluation of billing data indicated that energy was saved in 13 out of the 18 buildings involved in the program. The average energy savings was estimated to be 12 percent for all types of energy, but that included savings from capital investments which the institutions took as a follow-up to development of the manuals and from other programs that the participants were involved in. Review of how the institutions responded to the manuals indicated that, while some institutions fully employed the manual, others kept it on a shelf away from the maintenance crews, and it was never used. The \$1,600 cost for hiring a contractor to develop the manual exceeded the annual cost of energy for the six smallest of the nineteen buildings participating in the program (generally in tiny Montana towns). For some larger customers, \$1600 was not sufficient to cover all of the equipment in the building.

New Building Code Study. Another study involved site visits and metering of newer office buildings in Seattle that were built under a code requirement that required building simulation to assess compliance. The study noted that lighting EUI's as modeled by designers were 15-29% lower than those encountered in buildings for the same equipment. The relatively small error was thought to be the result of compensating errors, with lighting power densities and occupancy overestimated and hours of operation underestimated. A couple of site observations indicated potential for better building management:

- Lights were often turned on during the weekend and left on until Monday.
- Many lights were left on continuously, especially in rest rooms and isolated areas.

The same study found that predicted HVAC use was 8-31% of actual use, and predicted fan and pump use were 24-64% of actual use. Many of the reasons related to limitations of the modelling, longer hours of operation due to poor equipment design, longer building use schedules than anticipated, computer-related cooling loads, higher plug loads driving internal gains, etc. However, some of the causes related to sub-optimal building management, including dampers stuck open, bad setpoints for night setback, heating coils which run continuously at night and during the summer, and equipment cycling problems (possibly indicating a poor control regime). Half of the HVAC equipment in one building was left on all night to prevent cycling and assist in startup.¹⁰

⁹ Montana Department of Natural Resources, "Addendum to Final Report - Western Montana Operation and Maintenance Grants Project", Bonneville Power Administration Grant # De-FG79-85BP25245, 1986.

¹⁰ "Evaluation of Performance-Based Energy Codes for Large Office Buildings". Katz, Gail, Heller, Jon, and Sumi, David, ACEEE 1990 Summer Study on Energy Efficiency in Buildings- Vol 6. Program Evaluation, ACEEE 1990

Energy Audit Programs. Studies of programs involving an energy audit but no financial incentives may provide clues as to the potential for behavioral conservation. Results of these programs should be viewed cautiously for two reasons. First, the savings may be attributable to both customer behaviour and customer investments which are not utility-subsidized. The programs also do not address all possible paths to improved efficiency through behaviour, because of their one-shot nature. Results of two such programs are presented below.

Evaluation of a Seattle City Light program for commercial and industrial customers showed that walk-through building surveys resulted in 6% savings among larger buildings but no measurable savings in smaller buildings. These results are based on comparison of pre- and post- survey billing data and comparison with a control group, making the findings particularly significant.

A more detailed building survey for large buildings resulted in 2% savings, based on before and after data, adjustment to building specific data for extraneous factors, and a control group comparison.¹¹

Another evaluation presents results of an energy audit loan program, whereby customers were billed for the cost of an energy audit only if they did not implement all measures with a payback of one year or less. The recommendations included a mix of operation and maintenance measures and low-cost capital measures. Electric energy savings based on before- and after-billing data (with no control group comparison) are shown below¹²:

¹¹ "Evaluation of Informational Conservation Programs for Commercial and Industrial Customers", Brian Coates, ACEEE 1986 Summer Study on Energy Efficiency in Buildings- Vol 6. Program Evaluation, ACEEE 1986.

¹² Portland Energy Conservation, Inc., Results of the Evaluation Project of the Commercial Building Energy Audit Loan Program Conducted by Portland Energy Conservation, Inc., Bonneville Power Administration, 1984.

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<u>Building Type</u>	<u>% Savings</u>	<u># of Facilities Analyzed</u>
Total:	10.2%	72
Assembly:	9.7%	5
Clinics:	8.2%	6
Fast Food:	15.5%	2
Restaurant:	8.6%	5
Small Retail:	14.9%	11
Large Retail:	11.7%	2
Small Office:	-.6%	12
Large Office:	9.8%	10
Lodging:	16.4%	2
Apartments:	6.6%	3
Warehouses:	16.0%	14

The variations by building type indicate both the difficulty in evaluating commercial savings with small groups of buildings, and the importance of a comparison group in such a study. However, the strong general pattern of savings is encouraging.

MARKET INDICATORS OF THE LEVEL OF BEHAVIORAL CONSERVATION ACTIVITY

There has been limited market research on behavioral conservation, per se. The one study to focus particularly on the issue¹³ indicates that the adequacy of O&M procedures varies greatly from building to building. Some causes relate to individual building management; in an institutional building program follow-up, institutions without informed management and management support for energy efficiency were found to be least likely to properly operate and maintain equipment.¹⁴ Other causes can be associated with different customer groups, as indicated below. An overview study¹⁵ of commercial sector market research indicated that there was greater overall interest in management of building energy use in buildings with the following characteristics:

- Businesses with higher energy intensity (e.g., grocery stores, fast food restaurants)
- Businesses with more floorspace under a single management (managers of large buildings, managers of several properties in a city, regional capital improvements and energy managers for chain stores who centralize energy management.)
- Owner-occupants, and long-term lessors who pay energy bills directly or through explicit rent adjustments.

Concerned Building Owners. The most interest in building energy system maintenance is exhibited in very large buildings which have private sector owner-occupants and buildings owned and operated by a corporation with centralized building management.¹⁶ Also, landlords who pay utility bills for large or numerous rental buildings have some motivation to maintain buildings and minimize operational costs. These situations are fairly common in large office complexes, mall retail developments, grocery chains, university campuses, and larger restaurant chains.

Larger chain stores, especially groceries¹⁷, and owners of very large office buildings often have exemplary energy management.

¹³ Kolb., J.O., Resources for O&M Training and Services in the Commercial Sector, Oak Ridge National Laboratories, #ORNL/CON-204, April, 1988.

¹⁴ Syntectics Group, op. cit.

¹⁵ Gordon, Frederick M., "Using Commercial Data for Strategic Program Planning", in Proceedings of 1986 ACEEE Summer Study on Energy Efficiency in Buildings, 1986, ACEEE, Wash., D.C.

¹⁶ Kolb, J.O., op. cit. Also, Baylon, David, et. al., Marketing to Centralized Decisionmakers for the Bonneville Power Administration, Ecotope, Inc., and Seton, Johnson, and Odell, for BPA, 1987.

¹⁷ Baylon, et. al., op. cit.

The staff in these buildings is not necessarily trained and capable of performing all energy efficiency-related maintenance tasks. A survey of O+M personnel concluded that "many operations personnel have insufficient training for modern HVAC and control systems installed in newer buildings".¹⁸ However, in these buildings, there is at least someone to train.

One type of activity that commonly is deferred in these buildings is major maintenance actions which take specialized engineering skill and intensive activity (e.g.: re-balancing HVAC systems in large buildings and taking care of water quality problems in chiller systems).¹⁹

Less Concerned Building Owners. For smaller buildings, and in the rental market, maintenance practices are more uneven from building to building, or disappear altogether.

- In smaller offices and most retail developments, if tenants pay energy bills, landlords are much less interested in building efficiency. They may become more interested only if a system is reaching capacity, so conservation can help them avoid a capital investment, or if the market for tenants is competitive and tenants are asking about efficiency. Some tenants take steps to operate the buildings efficiently, but many don't know what to do or don't do it.²⁰ Tenants rarely have a long-term interest in the buildings, so they care about only the most basic maintenance. As a result, building maintenance tends to be present, but minimal.
- In public buildings, the level of attention to O+M varies dramatically from institution to institution, and sometimes from building to building within the same institution.²¹ Larger institutions and institutions with large buildings often pay more attention and have more resources for O+M.

Many individual retail stores, which are often leased with shared utilities, are not well-maintained from an energy perspective. The same holds for some large retail chains with small individual facilities (e.g., some shoe and fabric stores)²².

¹⁸ Kolb, James O., "Energy Conservation Opportunities in Commercial Buildings - Training and Services for Improved O/M", in Proceedings for the ACEEE 1986 Summer Study on Energy Efficiency in Buildings, ACEEE, 1986.

¹⁹ As per discussions with Dan Wayntroob of Xenergy in 1989, and based on the author's experience with the Bonneville Power Administration's Purchase of Energy Savings Program.

²⁰ George, S.S., da Silva, J., and McRae, M.R., Impact of Short-Term Leases on Conservation Investments of Commercial Landlords and Tenants, Xenergy, Inc. for the Bonneville Power Administration, 1986

²¹ Syntectics Group, op. cit.

²² Baylon, et. al., op. cit.

LITERATURE INDICATING THE DEGREE OF INTEREST IN CONSERVATION AMONG CUSTOMERS IN BC HYDRO

A study which was performed on the market for conservation among BC Hydro customers provides some indicators of the characteristics of the customer population.²³ This provides some data on specific conservation actions and also provides a demographic point of comparison for some of the U.S. market literature. Some of the more interesting inferences follow.

Demographic Patterns

- Most of the patterns relating ownership to interest indicated by the U.S. studies are repeated in this study, with large firms, chains, owner-occupants, and long-term lessors more interested in energy. Tenants will consider operating costs in considering a building only if the difference is "significant". Most tenants don't scrutinize energy costs before moving in. Firms on long-term leases and in low-margin fields will be more interested in costs.
- Leases of five years or longer are common for offices, indicating some tenant interest in operating costs.

Who Pays?

- Triple-net leases (where the tenant pays all energy costs) are standard for offices, indicating that tenants on long-term leases are likely to be more interested in energy than landlords. Since landlords often operate the mechanical equipment in buildings, this is discouraging with regard to management of that equipment, but more encouraging for management of lighting, which tenants often control.
- In retail, energy costs are sometimes handled as an add-on to rent. Malls tend to individually meter at least lighting. Again, this may provide more motivation for management of lighting than HVAC. Mixed office/retail space tends to be individually metered, producing similar results.

Building Management Practices

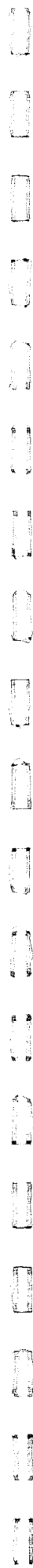
- Response to tenant needs is more important than "invisible needs" (e.g., keeping costs down.). Some property managers only make major HVAC/lighting changes or perform HVAC maintenance when responding to tenant complaints.

²³ A qualitative Assessment: Adoption of Energy-Efficient Design in New Commercial Buildings in B.C., February, 1990, Power Smart

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- Building owners are moving toward in-house labour for preventative maintenance due to high contractor costs. It is unclear that they are, as a rule, staffing to get the work done. The better managers, however, optimize plant/system operation using tradespeople or professional engineers for large organizations.
- Group relamping is not the norm. Washing of lamps and diffusers occurs every 18 months or at burnout (building maintenance services say it's every year where it is done). This doesn't impact energy use, per se, but infrequent washing could possibly lead to dissatisfaction and early removal of efficient lighting if levels are judged to be inadequate.
- Controls for HVAC and lighting schedules are common, with typical office hours being 6 AM to 6 PM. Optimal start is not common according to building managers, but is in new buildings according to mechanical engineers. Overall, this would indicate opportunities for either manual or automated schedule improvements.
- The most commonly cited barriers to conservation include management awareness, staff knowledge, ability to interpret bills, cost for some measures (e.g., Variable Speed Drives), technology concerns/ability to match technology with need, suspicion due to prior overselling of benefits of control systems.
- Building maintenance services play a small role in establishing efficiency, more often reacting to the policies of the building owner and referring other special maintenance to specialized subcontractors. This may leave no-one responsible. Building managers for larger buildings take a more active role, sometimes doing some HVAC maintenance.
- Some building owners have reduced the timing of janitor shifts, potentially resulting in reduced night-time lighting. However, "gang cleaning" of floors to spend less time on each floor is not common. There's considerable resistance to this practice because it makes individual janitors less accountable for their work. Day cleaning is even more rare.
- Building maintenance services replace lamps sometimes in smaller buildings, usually selecting the least expensive replacement.
- Sophisticated building control systems present significant problems to property managers. One said, "Building systems are designed by engineers, installed by mechanical contractors, and operated by someone who cleans floors."

The overall picture is a market with some built-in interest in management, particularly of lighting loads and much less in managing heating and cooling systems efficiently. The large buildings appear, on average, to be better-managed than the small ones. The scope and nature of the study, by presenting contrasting anecdotes of energy vigilance and disinterest, and providing little information indicating what the balance is between the two, is of limited use in gauging the relative level of efficiency in building management. A summary judgement might be that it is perhaps a little better than in most U.S. markets due to a possibly larger role played by large building owners, a provincial building agency, and building managers with multiple properties.



APPENDIX 4

SOCIAL PRACTICE QUESTIONNAIRE

BC HYDRO COMMERCIAL CONSERVATION SOCIAL CONSERVATION QUESTIONNAIRE

BC HYDRO COMMERCIAL CONSERVATION SOCIAL CONSERVATION QUESTIONNAIRE

1. For each building type listed, please discuss the ownership patterns in BC.
Use the following tables to approximate the proportion of the building space from various building types with various ownership/occupancy patterns.
Bear in mind that smaller buildings have less building space, but represent a significant proportion of the overall floorspace due to their large numbers.

OWNERSHIP TYPE:

	GOVERNMENT OWNER-OCC.	OTHER MULTIPLE BDG OWNER-OCC*	SINGLE BDG OWNER-OCC.	LEASE 5 YRS OR MORE	LEASE UNDER 5 YEARS	
SMALL OFFICE: (<3700 SQ M)	_____ %	+ _____ %	+ _____ %	+ _____ %	+ _____ %	=100%
LARGE OFFICE: (>3700 SQ M)	_____ %	+ _____ %	+ _____ %	+ _____ %	+ _____ %	=100%
NON-FOOD RETAIL:	NA	+ _____ %	+ _____ %	+ _____ %	+ _____ %	=100%
RESTAURANT/TAVERN:	NA	+ _____ %	+ _____ %	+ _____ %	+ _____ %	=100%
PRIMARY/SECONDARY SCHOOL:	_____ %	+ _____ %	+ _____ %	NA	+ NA	=100%
HOTEL/MOTEL:	NA	+ _____ %	+ _____ %	+ _____ %	+ _____ %	=100%

* MULTIPLE BUILDING OWNER-OCCUPANT MEANS CHAIN STORE OR BUSINESS WHICH OWNS AND OCCUPIES MULTIPLE SITES (e.g., large corporation with branch offices; offices owned by firm)

BC HYDRO COMMERCIAL CONSERVATION SOCIAL CONSERVATION QUESTIONNAIRE

2. For building managers for each building type, what level of priority for time and resources do you think is place on basic building operation activities which reduce energy use? (e.g., turn off lights, set back heat, service HVAC equipment? Use the table to focus discussion; fill in only those blanks where you have some knowledge.

DEFINITIONS:

- Less attentive means that lights and HVAC are often left on when unoccupied; Maintenance on HVAC may be deferred until there are occupant complaints.
- "Basics important" means that, either through manual operation or automated controls lights are turned off and HVAC is controlled appropriately to achieve much of the available savings. Resources are provided by building managers for per maintenance.
- "Proactive Management" means that the building managers will seek ways to optimize HVAC and lighting operation, encourage users to minimize energy use, They may shorten janitorial shifts on a floor at night, pay to have HVAC systems balanced, etc.

LARGE OFFICE (more than 3700 square meters):

	GOVERNMENT OWNER-OCC.	OTHER MULTIPLE BDG OWNER-OCC	SINGLE BDG OWNER-OCC.	LEASE 5 YRS OR MORE	LEASE UNDER 5 YEARS
% Less important	1. _____%	1. _____%	1. _____%	1. _____%	1. _____%
% Does the Basics	2. _____%	2. _____%	2. _____%	2. _____%	2. _____%
% Proactive Management	3. _____%	3. _____%	3. _____%	3. _____%	3. _____%
	(1+2+3 = 100%)	(1+2+3 = 100%)	(1+2+3 = 100%)	(1+2+3 = 100%)	(1+2+3 = 100%)

BC HYDRO COMMERCIAL CONSERVATION SOCIAL CONSERVATION QUESTIONNAIRE

Question 2, ctd.

SMALL OFFICE (less than 3700 square meters):

	GOVERNMENT OWNER-OCC.	OTHER MULTIPLE BDG OWNER-OCC	OTHER OWNER-OCC.	LEASE 5 YRS OR MORE	LEASE UNDER 5 YEARS
% Less important	1. _____%	1. _____%	1. _____%	1. _____%	1. _____%
% Does the Basics	2. _____%	2. _____%	2. _____%	2. _____%	2. _____%
% Proactive Management	3. _____%	3. _____%	3. _____%	3. _____%	3. _____%
	(1+2+3 = 100%)	(1+2+3 = 100%)	(1+2+3 = 100%)	(1+2+3 = 100%)	(1+2+3 = 100%)

NON-FOOD RETAIL:

	GOVERNMENT OWNER-OCC.	CHAIN STORE	OTHER OWNER-OCC.	LEASE 5 YRS OR MORE	LEASE UNDER 5 YEARS
% Less important	NA	1. _____%	1. _____%	1. _____%	1. _____%
% Does the Basics		2. _____%	2. _____%	2. _____%	2. _____%
% Proactive Management		3. _____%	3. _____%	3. _____%	3. _____%
		(1+2+3 = 100%)	(1+2+3 = 100%)	(1+2+3 = 100%)	(1+2+3 = 100%)

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BC HYDRO COMMERCIAL CONSERVATION SOCIAL CONSERVATION QUESTIONNAIRE

Question 2, ctd.

HOTEL/MOTEL:

	GOVERNMENT OWNER-OCC.	CHAIN OWNER	OTHER OWNER-OCC.	LEASE 5 YRS OR MORE	LEASE UNDER 5 YEARS
% Less important	NA	1. _____%	1. _____%	1. _____%	1. _____%
% Does the Basics		2. _____%	2. _____%	2. _____%	2. _____%
% Proactive Management		3. _____% (1+2+3 = 100%)	3. _____% (1+2+3 = 100%)	3. _____% (1+2+3 = 100%)	3. _____% (1+2+3 = 100%)

RESTAURANT/TAVERN:

	GOVERNMENT OWNER-OCC.	CHAIN OWNER	OTHER OWNER-OCC.	LEASE 5 YRS OR MORE	LEASE UNDER 5 YEARS
% Less important	NA	1. _____%	1. _____%	1. _____%	1. _____%
% Does the Basics		2. _____%	2. _____%	2. _____%	2. _____%
% Proactive Management		3. _____% (1+2+3 = 100%)	3. _____% (1+2+3 = 100%)	3. _____% (1+2+3 = 100%)	3. _____% (1+2+3 = 100%)

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BC HYDRO COMMERCIAL CONSERVATION SOCIAL CONSERVATION QUESTIONNAIRE

Question 2, ctd.

PRIMARY/SECONDARY SCHOOL

	GOVERNMENT OWNER-OCC.	MULTI-SITE OWNER	OTHER OWNER-OCC.	LEASE 5 YRS OR MORE	LEASE UNDER 5 YEARS
% Less important	1. _____ %	1. _____ %	1. _____ %	NA	NA
% Does the Basics	2. _____ %	2. _____ %	2. _____ %		
% Proactive Management	3. _____ %	3. _____ %	3. _____ %		
	(1+2+3 = 100%)	(1+2+3 = 100%)	(1+2+3 = 100%)		

BC HYDRO COMMERCIAL SECTOR SOCIAL CONSERVATION QUESTIONNAIRE

3. CONSERVATION OVERALL

- *A. For the more interested building managers, where has their primary focus been in energy efficiency?
- *B. Where do you perceive that they have not focused adequate attention?
- *C. Do you know of any documented BC examples of building managers who reduced their electric energy use through changes in building operation or user behavior?
- D. What level of training is required or provided for building operators?
- E. What is the level of importance for re-training and upgrading operator knowledge when there is staff turnover, new equipment is installed, or new operating procedures are introduced?
- F. Are you familiar with any building owners who have installed "energy-efficient equipment"? If so, have you heard of any complaints or concerns regarding the equipment, its use, or performance?

4. LIGHTING SCHEDULES

- *A. Do you see much potential for trimming operating schedules for lighting through better staff and occupant management practices?
- *B. Do you see this potential as greatest among certain building or owner types?

Which?

BC HYDRO COMMERCIAL SECTOR SOCIAL CONSERVATION QUESTIONNAIRE

- *C. Is the potential focused primarily in indoor or outdoor lighting, or both?
- *D. About how many hours/day of "trimmable" operating time do you see?
- *E. What proportion of the lighting in the building or building areas do you think this would affect?
- F. Are lighting controls (timers, EMS) usually in good repair and properly set to efficiently meet user needs?
- G. How often do you see lighting control systems overridden?
- H. Do you think that most building operators who have control systems know how to use them?
- I. In what building types/setting do users typically control their lights?
- J. What sort of behavior have you seen regarding turning lights off when leaving, particularly where local switching has been installed?
- K. Is security a common issue? If so, what proportion of building lighting is typically left "on" for security?

5. LIGHTING PERSISTENCE

- *A. Are you familiar with any building owners with reflector fixtures? If so, do you know if they are cleaning them periodically (every 1-2 years)?
- B. Have you heard any complaints about decreased lighting quality as these fixtures get older?

BC HYDRO COMMERCIAL SECTOR SOCIAL CONSERVATION QUESTIONNAIRE

- C. Among the in-house custodial services, is replacement of efficient bulbs with similarly efficient bulbs universal, common, or infrequent?
- D. Among contract lighting maintenance services, is replacement of efficient bulbs with similarly efficient bulbs universal, common, or infrequent?

6. HVAC SCHEDULES

- *A. In general do you see much potential for trimming operating schedules for heating and cooling through better staff and occupant management practices?
- *B. Do you see this potential as greatest among certain building or owner types?

Which?

- *C. About how many hours/day of "trimmable" operating time do you see?
- D. Are HVAC controls (timers, EMS) usually in good repair and properly set to efficiently meet occupant needs?
- E. How often do you see the control systems overridden?
- F. Do you think that most building operators who have control systems know how to use them?
- G. In what areas of the buildings or types of systems do the occupants, as opposed to the operators, typically control their HVAC equipment?

BC HYDRO COMMERCIAL SECTOR SOCIAL CONSERVATION QUESTIONNAIRE

H. What sort of behavior have you seen regarding turning HVAC equipment off when leaving?

7. HVAC O&M

A. What sort of HVAC systems are predominant in each building type?

Small Office

Large Office

Non-Food Retail

Restaurant/Tavern

School

Hotel/Motel

*B. For electric heating and cooling, how do you assess the overall level of maintenance (e.g., belt tightening, lubrication, cleaning filters)? Does it vary by size of business?

*C. In particular, do you think that ventilation for the central systems is well-balanced?

D. In what types of buildings is maintenance likely to be scheduled periodically versus occur only when buildings break down? Are any building types likely to not have any maintenance program at all? If so, which?

*E. Do you know if outside air controls are typically set or controlled to provide appropriate quantities of outside air?

BC HYDRO COMMERCIAL SECTOR SOCIAL CONSERVATION QUESTIONNAIRE

- F. Where economizers are in place, what is your observation as to their operation, performance, and reliability?

8. SHELL

- A. How careful do you think most occupants are about leaving doors and windows open?
- B. Given the presence of sealed windows and automatic doors, where do you think this is still a real issue? Consider the building types you know with respect to heated, cooled, and refrigerated areas.

9. DOMESTIC WATER HEAT

- A. How commonplace are chronic hot water faucet leaks?
- B. Do you see many opportunities for users to decrease their hot water use through more careful habits?
- C. Where showers are present, are they controlled manually or are there Automatic cutoff controls?

10. OTHER

- A. Other than better hardware, what other opportunities do you see for building operators and occupants to significantly increase energy efficiency?

APPENDIX 5

OPERATIONAL UPGRADE MEASURES

OPERATION AND MAINTENANCE (O&M) MEASURES

(a) Envelope & General Building

1. Scheduling

Optimize occupancy schedules
Optimize use of building areas
Optimize use of parking areas during off hours and reduce fan and lighting energy

2. Maintenance

Replace broken windows
Maintain doors between heated and unheated spaces
Clean windows and skylights

3. Other

Ensure caulking and sealing on windows is intact
Use high reflectivity paint in areas with artificial lighting

(b) Heating Ventilation and Air Conditioning

1. Scheduling

Set heating thermostat to no more than 70°F (21°C) when building is occupied
Set heating thermostat to no more than 60°F (16°C) when building is unoccupied
Set cooling thermostat to no less than 77°F (25°C) when building is occupied
Turn off air conditioning when building is unoccupied
Close outside air dampers during system start when heating or cooling and when building is unoccupied
Schedule morning startup in accordance with outdoor temperature
Reduce fan operation when the building is unoccupied
Turn off heating or cooling (but not fans) 30 minutes prior to the end of the occupied period

2. Maintenance

Maintain air filters, coils, and air distribution inlets and outlets
Maintain correct belt tensions
Maintain dampers and linkages
Inspect damper for proper air volumes and leakage when closed
Clean fan blades and coils annually
Repair leaks in ducts and plenums
Repair damaged or missing duct and pipe insulation
Check heating and cooling coils on an annual basis for valve leaks: reset or replace as required
Check setpoints on control valves

3. Other

Separate heating and cooling set points on a combination heating/cooling thermostat
Set heating thermostat to no more than 70°F (21°C) when building is occupied
Set heating thermostat to no more than 60°F (16°C) when building is unoccupied
Set cooling thermostat to no less than 77°F (25°C) when building is occupied
Turn off air conditioning when building is unoccupied
Install locking thermostats to prevent unauthorized settings
Close outside air dampers during system start when heating or cooling and when building is unoccupied
Verify performance of heating, ventilation and air conditioning timers and controls
Correct over ventilation of building
Balance HVAC systems whenever tenants/occupants/space use changes and relocate thermostats required
Interlock exhaust and supply fans so that they run in tandem and over- or under pressurization of the building is prevented

(c) **Water Heating**

1. Scheduling

Limit operation of circulation pump during unoccupied times

2. Maintenance

Repair damaged or missing tank and pipe insulation
Repair water leaks

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3. Other

Reduce water temperature; in most cases 110°F (43°C) is sufficient for hand washing or 120°F (49°C) for showers

(d) **Lighting**

1. Scheduling

Light building only during occupied periods, develop a list of items to switch off when leaving

Mark switches to identify lighting that should be off when not needed

Label the light switches or provide a colour coded floor plan next to the switches

Instruct cleaning crews and staff to turn off lights when the space is unoccupied

Reset exterior lighting time clocks seasonally

Control exterior lighting with photocell on, time clock off

2. Maintenance

Clean fixture lenses, lamps and diffusers regularly

Clean walls and ceiling to improve reflectivity

Verify performance of lighting control timers

Verify photocell operation

3. Other

Instigate group relamping program

Remove fixture lenses if not require for glare control

(e) **Power**

1. Scheduling

Turn off office machines when not in use

2. Maintenance

Repair compressed air leaks

(f) Refrigeration

1. Scheduling

Shut-off ice makers when unneeded

2. Maintenance

Clean condensing unit coils

Defrost refrigerator and freezers when ice builds up

Maintain refrigerator case door gaskets, piping and wiring penetrations seals

3. Other

Verify sufficient refrigerant capacity

APPENDIX 6

TYPICAL BUILDING PROFILES

The building profiles contained in this Appendix are statistical representations of typical existing and new buildings that might be found in each of the 12 building segments analysed in the Conservation Potential Review. In building segments where a wide variety of building envelopes and energy using equipment is found in BC, the values for energy loads and intensities in individual buildings may vary significantly from the "representative" values given in the profiles. The representative data is based on the combined experience of BC Hydro and BC energy management experts.

BUILDING PROFILE

Page 1

SPACE HEATING							
Heating Plant Type	Gas fired fire tube boiler producing hot water.						
Core Space (Ventilation) Heating Type & Medium	Hot water via heating coils in central AHU. Also present terminal reheat coils in the space.						
Perimeter Space (Envelope) Heating Type & Medium	Hot water perimeter radiators or terminal reheat systems installed in perimeter Some induction systems also present						
Total Heating Load (MJ/m².yr) (Tertiary Load)	383.8						
Maint. & Scheduling Factor (M+SF)	1.14						
	EUI / COP	Fossil	Elec.	Res.	A/A HP	W. S. HP	H/R Chiller
	EUI (kWh/ft².yr)	0.65	1.00	2.30	2.50	4.50	
	EUI (MJ/m².yr)	17.4	11.3	4.9	4.5	2.5	
		673	438	190	175	97	
	EUI = Tertiary Load X M+SF/Eff.						

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Large Office (> 3,700 m²)

Page 2

SPACE COOLING			
A/C Plant Type	Centrifugal chillers used by 75% of the stock. Screw or helical chillers used by 15% of the stock. The remainder stock uses reciprocating chillers.		
A/C seasonal COP	4.2		
A/C Plant Control Mode	Chiller load control based on fixed chilled water temperature set at 5.5 °C (42 °F). Fixed condenser water temperature control set at 29.4 °C (85 °F).		
Distribution System for Perimeter	Perimeter load met mostly with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F). Some induction systems present in older buildings that circulate chilled water.		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m²/Ton)	45.21		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	280.0		
Internal Loads:			
Lighting (W/m²)	30.24		
People (W/m²)	10.70		
Plug Loads (W/m²)	9.00		
Maint. & Scheduling Factor (M+SF)	1.14	EUI kWh/ft².yr	2.0
EUI = Tertiary Load X M+SF/COP		MJ/m².yr	76.0

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	8.00		
Pump Connected Load (W/m²)	3.00		
Fan Control Type	In 60% of the stock, supply and return fans on main AHU under VAV control. Minimum ventilation set at 50%. In the other 40% of the stock fans are CAV. Exhaust fans tend to operate continuously or manual ON/OFF control from MCC. Some scheduling control through time clocks or FMS.		
Pump Control Type	Manual ON/OFF control from MCC by building operator or through an FMS. FMS is estimated to be present in 25% of the stock.		
Fan Average Operation (hrs./yr.)	3000		
Pump Average Operation (hrs./yr.)	3000		
Maint. & Scheduling Factor (M+SF)	1.14	EUI kWh/ft².yr	3.5
		MJ/m².yr	135.4

SERVICE HOT WATER			
Service Hot Water Plant Type	190 L (50 Gal) dedicated water heater		
Service Hot Water Load (MJ/m².yr) (Tertiary Load)			
		Fossil	Elec. Res.
		Eff.	
		EUI (kWh/ft².yr)	
Wetting Use Percentage			
		0.65	1.00
		0.2	0.1
		7.23	4.70
	0.90		

COOKING EQUIPMENT			
Small residential appliances/ microwave ovens			
		Fossil	Elec. Res.
		Eff.	
		EUI (kWh/ft².yr)	
		0.55	1.00
		0.2	0.1
		7.27	4.00

REFRIGERATION EQUIPMENT			
single dedicated fixed capacity compressors on small fridges			EUI kWh/ft².yr
			0.3
			MJ/m².yr
			12.4

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	9.00		
Operating Time (hrs./yr.)	3500		
			EUI kWh/ft².yr
			2.9
			MJ/m².yr
			113.4

MISCELLANEOUS EQUIPMENT			
			EUI kWh/ft².yr
			1.1
			MJ/m².yr
			43.2

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Small Office (< 3,700 m²)

Page 1

CONSTRUCTION	
Wall U value (W/m².°C)	0.81
Roof U value (W/m².°C)	0.71
Glazing U value (W/m².°C)	5.68
Glazing Type	single pane/tinted with blinds/drapes
Window/Wall Ratio (WIWAR) (%)	0.30
Shading Coefficient (SC)	0.70
Infiltration Rate (L/s.m²)	1.52

GENERAL LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	1022	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m²)	34.8	0%	0%	100%	0%	0%	0%	0%	100.0%
Operating Time (Hrs./yr.)	3100								
Scheduling Factor (SF)	1.20								
Floor Fraction (GLFF)	0.75								
		EUI = Load X Hrs. X SF X GLFF							

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Small Office (< 3,700 m²)

Page 2

SPACE COOLING			
A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a roof top heating/cooling unit or a split system		
A/C seasonal COP	2.6		
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat		
Distribution System for Perimeter	Perimeter load met mostly with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m ² /Ton)	45.21		
Total Cooling Load (MJ/m ² .yr) (Tertiary Load)	280.0		
Internal Loads:			
Lighting (W/m ²)	30.24		
People (W/m ²)	10.70		
Plug Loads (W/m ²)	9.00		
Maint. & Scheduling Factor (M+SF)	1.16	EUI kWh/ft ² .yr	3.2
EUI = Tertiary Load X M+SF/COP		MJ/m ² .yr	124.9

HVAC ELECTRICITY			
Fan Connected Load (W/m ²)	7.50		
Pump Connected Load (W/m ²)	1.50		
Fan Control Type	ON/OFF control from room thermostat. Exhaust fans tend to operate continuously.		
Pump Control Type	ON/OFF control from MCC		
Fan Average Operation (hrs./yr.)	3000		
Pump Average Operation (hrs./yr.)	3000		
Maint. & Scheduling Factor (M+SF)	1.16	EUI kWh/ft ² .yr	2.9
		MJ/m ² .yr	112.8

SERVICE HOT WATER														
Service Hot Water Plant Type	38 – 75 L (10 – 20 Gal) dedicated water heater													
Service Hot Water load (MJ/m ² .yr) (Tertiary Load)	4.70	<table border="1"> <thead> <tr> <th></th> <th>Fossil</th> <th>Elec. Res.</th> </tr> </thead> <tbody> <tr> <td>Eff.</td> <td>0.65</td> <td>1.00</td> </tr> <tr> <td>EUI (kWh/ft².yr)</td> <td>0.2</td> <td>0.1</td> </tr> <tr> <td>EUI (MJ/m².yr)</td> <td>7.23</td> <td>4.70</td> </tr> </tbody> </table>		Fossil	Elec. Res.	Eff.	0.65	1.00	EUI (kWh/ft ² .yr)	0.2	0.1	EUI (MJ/m ² .yr)	7.23	4.70
	Fossil	Elec. Res.												
Eff.	0.65	1.00												
EUI (kWh/ft ² .yr)	0.2	0.1												
EUI (MJ/m ² .yr)	7.23	4.70												
Wetting Use Percentage	0.90													

COOKING EQUIPMENT															
Small residential appliances/ microwave ovens	<table border="1"> <thead> <tr> <th></th> <th>Fossil</th> <th>Elec. Res.</th> </tr> </thead> <tbody> <tr> <td>Eff.</td> <td>0.55</td> <td>1.00</td> </tr> <tr> <td>EUI (kWh/ft².yr)</td> <td>0.2</td> <td>0.1</td> </tr> <tr> <td>EUI (MJ/m².yr)</td> <td>7.27</td> <td>4.00</td> </tr> </tbody> </table>		Fossil	Elec. Res.	Eff.	0.55	1.00	EUI (kWh/ft ² .yr)	0.2	0.1	EUI (MJ/m ² .yr)	7.27	4.00		
	Fossil	Elec. Res.													
Eff.	0.55	1.00													
EUI (kWh/ft ² .yr)	0.2	0.1													
EUI (MJ/m ² .yr)	7.27	4.00													

REFRIGERATION EQUIPMENT		EUI kWh/ft ² .yr	0.3
single dedicated fixed capacity compressors on small fridges		MJ/m ² .yr	12.4

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m ²)	9.00		
Operating Time (hrs./yr.)	3500		
		EUI kWh/ft ² .yr	2.9
		MJ/m ² .yr	113.4

MISCELLANEOUS EQUIPMENT		EUI kWh/ft ² .yr	0.3
			12.9

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Non-Food Retail

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.85
Roof U value (W/m ² .°C)	0.57
Glazing U value (W/m ² .°C)	5.68
Glazing Type	single pane clear
Window/Wall Ratio (WIWAR) (%)	0.20
Shading Coefficient (SC)	0.85
Infiltration Rate (L/s.m ²)	1.52

GENERAL LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	881	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	44.4	20%	0%	60%	0%	0%	20%	0%	100.0%
Operating Time (Hrs./yr.)	4300								
Scheduling Factor (SF)	1.20								
Floor Fraction (GLFF)	0.40								
EUI = Load X Hrs. X SF X GLFF								EUI kWh/m ² .yr	8.5
								MJ/m ² .yr	329.7

SERVICE AREA LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	323	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	19.2	30%	0%	70%	0%	0%	0%	0%	100.0%
Operating Time (Hrs./yr.)	6500								
Scheduling Factor (SF)	1.20								
Floor Fraction (SLFF)	0.55								
EUI = Load X Hrs. X SF X SLFF								EUI kWh/m ² .yr	7.7
								MJ/m ² .yr	296.7

OTHER (HIGH BAY) LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	323	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	11.8	0%	0%	0%	0%	0%	100%	0%	100.0%
Operating Time (Hrs./yr.)	4000								
Scheduling Factor (SF)	1.20								
Floor Fraction (OLFF)	0.05								
EUI = Load X Hrs. X SF X OLFF								EUI kWh/m ² .yr	0.3
								MJ/m ² .yr	10.2

ALL LIGHTING END-USES	EUI TOTAL	kWh/m ² .yr	16.4
		MJ/m ² .yr	638.8

VENTILATION (AIR DISTRIBUTION)	
System Description	Roof Top heating/cooling. CAV single zone. Some VAV single zone in the larger retail malls. Typical air flow rates of 3.8 L/s.m ² .
Outside Air (L/s.person)	7.00
Economizer	Enthalpy based if present (manufacturers of R/T equipment typically opt for an an enthalpy based econo to fit in their equipment). Incidence estimated at 20%
Control mode	Damper mixed air control in units with economizer only. Remainder of stock use use fixed fresh air, no damper control. Room thermostat control, ON/OFF, or multistage
Set Point (Summer)	22.2 °C (72 °F)
Set Point (Winter)	21.1 °C (70 °F)

SPACE HEATING																																																	
Heating Plant Type		Atmospheric or incremental boilers present in some buildings. Direct gas fired roof top heating/cooling units are the most common source of ventilation/core heat.																																															
Core Space (Ventilation) Heating Type & Medium		Majority of buildings served by forced air roof top heatin/cooling units. Some incremental water source heat pumps estimated at 5% of the total segment.																																															
Perimeter Space (Envelope) Heating Type & Medium		Forced air roof top heating/cooling units are the predominant source of perimeter heat. Electric baseboard heating is present in an estimated 15% of the segment																																															
Total Heating Load (MJ/m².yr) (Tertiary Load)		180.0																																															
Maint. & Scheduling Factor (M+SF)		1.18																																															
EUI = Tertiary Load X M+SF/Eff.																																																	
		<table><tr><th></th><th>Fossil</th><th>Elec.</th><th>Res.</th><th>A/A</th><th>HP</th><th>W. S.</th><th>HP</th><th>H/R</th><th>Chiller</th></tr><tr><td>Eff./COP</td><td>0.65</td><td>1.00</td><td>2.30</td><td>2.50</td><td>4.50</td><td></td><td></td><td></td><td></td></tr><tr><td>EUI (kWh/m².yr)</td><td>8.3</td><td>5.4</td><td>2.3</td><td>2.2</td><td>1.2</td><td></td><td></td><td></td><td></td></tr><tr><td>EUI (MJ/m².yr)</td><td>321</td><td>209</td><td>91</td><td>84</td><td>48</td><td></td><td></td><td></td><td></td></tr></table>									Fossil	Elec.	Res.	A/A	HP	W. S.	HP	H/R	Chiller	Eff./COP	0.65	1.00	2.30	2.50	4.50					EUI (kWh/m².yr)	8.3	5.4	2.3	2.2	1.2					EUI (MJ/m².yr)	321	209	91	84	48				
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B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Non-Food Retail

Page 2

SPACE COOLING			
A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a roof top heating/cooling unit or a split system		
A/C seasonal COP	2.8		
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat		
Distribution System for Perimeter	Perimeter load met mostly with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m²/Ton)	33.31		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	380.0		
Internal Loads:			
Lighting (W/m²)	28.91		
People (W/m²)	2.40		
Plug Loads (W/m²)	3.70		
Maint. & Scheduling Factor (M+SF)	1.16		
EUI = Tertiary Load X M+SF/COP		EUI kWh/ft².yr	4.4
		MJ/m².yr	169.5

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	5.00		
Pump Connected Load (W/m²)	1.00		
Fan Control Type	ON/OFF control from room thermostat. Exhaust fans tend to operate continuously.		
Pump Control Type	In most cases the presence of pumps is limited to a DHW circulating pump. Control is usually from a starter or MCC.		
Fan Average Operation (hrs./yr.)	4300		
Pump Average Operation (hrs./yr.)	3000		
Maint. & Scheduling Factor (M+SF)	1.16		
		EUI kWh/ft².yr	2.8
		MJ/m².yr	102.3

SERVICE HOT WATER			
Service Hot Water Plant Type	38 – 75 L (10 – 20 Gal) dedicated water heater		
Service Hot Water load (MJ/m².yr) (Tertiary Load)	1.80		
Wetting Use Percentage	0.90		
		Eff.	Fossil Elec. Res.
		EUI (kWh/ft².yr)	0.1 0.0
		EUI (MJ/m².yr)	2.48 1.60

COOKING EQUIPMENT			
Small residential appliances/ microwave ovens			
		Eff.	Fossil Elec. Res.
		EUI (kWh/ft².yr)	0.2 0.1
		EUI (MJ/m².yr)	7.45 4.10

REFRIGERATION EQUIPMENT		EUI kWh/ft².yr	0.2
single dedicated fixed capacity compressors on small fridges		MJ/m².yr	9.5

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	3.70		
Operating Time (hrs./yr.)	4500		
		EUI kWh/ft².yr	1.5
		MJ/m².yr	59.9

MISCELLANEOUS EQUIPMENT		EUI kWh/ft².yr	0.2
			8.5

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Food Retail

Page 2

SPACE COOLING			
A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a roof top heating/cooling unit or a split system		
A/C seasonal COP	2.8		
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat		
Distribution System for Perimeter	Perimeter load met mostly with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m²/Ton)	45.21		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	280.0		
Internal Loads:			
Lighting (W/m²)	25.55		
People (W/m²)	8.10		
Plug Loads (W/m²)	3.70		
Maint. & Scheduling Factor (M+SF)	1.18	EUI kWh/t².yr	3.3
EUI = Tertiary Load X M+SF/COP		MJ/m².yr	127.1

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	8.00		
Pump Connected Load (W/m²)	1.00		
Fan Control Type	ON/OFF control from room thermostat. Exhaust fans tend to operate continuously.		
Pump Control Type	In most cases the presence of pumps is limited to a DHW circulating pump. Control is usually from a starter or MCC.		
Fan Average Operation (hrs./yr.)	3300		
Pump Average Operation (hrs./yr.)	3000		
Maint. & Scheduling Factor (M+SF)	1.18	EUI kWh/t².yr	3.2
		MJ/m².yr	124.9

SERVICE HOT WATER															
Service Hot Water Plant Type	190 L (50 Gal) dedicated water heater														
Service Hot Water load (MJ/m².yr) (Tertiary Load)	19.30	<table border="1"> <thead> <tr> <th></th> <th>Fossil</th> <th>Elec. Res.</th> </tr> </thead> <tbody> <tr> <td>Eff.</td> <td>0.65</td> <td>1.00</td> </tr> <tr> <td>EUI (kWh/t².yr)</td> <td>0.8</td> <td>0.5</td> </tr> <tr> <td>EUI (MJ/m².yr)</td> <td>29.69</td> <td>19.30</td> </tr> </tbody> </table>			Fossil	Elec. Res.	Eff.	0.65	1.00	EUI (kWh/t².yr)	0.8	0.5	EUI (MJ/m².yr)	29.69	19.30
	Fossil	Elec. Res.													
Eff.	0.65	1.00													
EUI (kWh/t².yr)	0.8	0.5													
EUI (MJ/m².yr)	29.69	19.30													
Wetting Use Percentage	0.90														

COOKING EQUIPMENT															
Commercial ovens in bakery used for baking goods/pastries/cakes	<table border="1"> <thead> <tr> <th></th> <th>Fossil</th> <th>Elec. Res.</th> </tr> </thead> <tbody> <tr> <td>Eff.</td> <td>0.55</td> <td>1.00</td> </tr> <tr> <td>EUI (kWh/t².yr)</td> <td>6.1</td> <td>3.4</td> </tr> <tr> <td>EUI (MJ/m².yr)</td> <td>236.36</td> <td>130.00</td> </tr> </tbody> </table>				Fossil	Elec. Res.	Eff.	0.55	1.00	EUI (kWh/t².yr)	6.1	3.4	EUI (MJ/m².yr)	236.36	130.00
	Fossil	Elec. Res.													
Eff.	0.55	1.00													
EUI (kWh/t².yr)	6.1	3.4													
EUI (MJ/m².yr)	236.36	130.00													

REFRIGERATION EQUIPMENT		EUI kWh/t².yr	38.5
single dedicated or large multiplexed compressors serving commercial refrigerated cases		MJ/m².yr	1492.4

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	3.70		
Operating Time (hrs./yr.)	5800		
		EUI kWh/t².yr	2.0
		MJ/m².yr	77.3

MISCELLANEOUS EQUIPMENT		EUI kWh/t².yr	2.5
			97.0

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Restaurant/Tavern

Page 2

SPACE COOLING															
A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a roof top heating/cooling unit or a split system														
A/C seasonal COP	2.8														
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat														
Distribution System for Perimeter	Perimeter load met mostly with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).														
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)														
Typical Connected Load (m²/Ton)	39.55														
Total Cooling Load (MJ/m².yr) (Tertiary Load)	320.0														
Internal Loads:															
Lighting (W/m²)	23.40														
People (W/m²)	24.40														
Plug Loads (W/m²)	2.60														
Maint. & Scheduling Factor (M+SF)	1.18	EUI kWh/ft².yr	3.7												
EUI = Tertiary Load X M+SF/COP		MJ/m².yr	145.2												
HVAC ELECTRICITY															
Fan Connected Load (W/m²)	14.00														
Pump Connected Load (W/m²)	0.50														
Fan Control Type	ON/OFF control from room thermostat. Exhaust fans tend to operate continuously.														
Pump Control Type	In most cases the presence of pumps is limited to a DHW circulating pump. Control is usually from a starter or MCC.														
Fan Average Operation (hrs./yr.)	8500														
Pump Average Operation (hrs./yr.)	3500														
Maint. & Scheduling Factor (M+SF)	1.18	EUI kWh/ft².yr	10.2												
		MJ/m².yr	394.0												
SERVICE HOT WATER															
Service Hot Water Plant Type	190 L (50 Gal) dedicated water heater plus some instantaneous heater use														
Service Hot Water load (MJ/m².yr) (Tertiary Load)	327.00	<table border="1"> <thead> <tr> <th></th> <th>Fossil</th> <th>Elec. Res.</th> </tr> </thead> <tbody> <tr> <td>Eff.</td> <td>0.65</td> <td>1.00</td> </tr> <tr> <td>EUI (kWh/ft².yr)</td> <td>13.0</td> <td>8.4</td> </tr> <tr> <td>EUI (MJ/m².yr)</td> <td>503.08</td> <td>327.00</td> </tr> </tbody> </table>			Fossil	Elec. Res.	Eff.	0.65	1.00	EUI (kWh/ft².yr)	13.0	8.4	EUI (MJ/m².yr)	503.08	327.00
	Fossil	Elec. Res.													
Eff.	0.65	1.00													
EUI (kWh/ft².yr)	13.0	8.4													
EUI (MJ/m².yr)	503.08	327.00													
Wetting Use Percentage	0.50														
COOKING EQUIPMENT															
commercial ovens, grilles	<table border="1"> <thead> <tr> <th></th> <th>Fossil</th> <th>Elec. Res.</th> </tr> </thead> <tbody> <tr> <td>Eff.</td> <td>0.55</td> <td>1.00</td> </tr> <tr> <td>EUI (kWh/ft².yr)</td> <td>19.7</td> <td>10.8</td> </tr> <tr> <td>EUI (MJ/m².yr)</td> <td>761.82</td> <td>419.00</td> </tr> </tbody> </table>				Fossil	Elec. Res.	Eff.	0.55	1.00	EUI (kWh/ft².yr)	19.7	10.8	EUI (MJ/m².yr)	761.82	419.00
	Fossil	Elec. Res.													
Eff.	0.55	1.00													
EUI (kWh/ft².yr)	19.7	10.8													
EUI (MJ/m².yr)	761.82	419.00													
REFRIGERATION EQUIPMENT															
single dedicated fixed capacity compressors serving commercial grade refrigerators and freezers			<table border="1"> <thead> <tr> <th></th> <th>EUI kWh/ft².yr</th> <th>EUI MJ/m².yr</th> </tr> </thead> <tbody> <tr> <td></td> <td>5.7</td> <td>220.0</td> </tr> </tbody> </table>		EUI kWh/ft².yr	EUI MJ/m².yr		5.7	220.0						
	EUI kWh/ft².yr	EUI MJ/m².yr													
	5.7	220.0													
OFFICE (PLUG-IN) EQUIPMENT															
Connected Load (W/m²)	2.60														
Operating Time (hrs./yr.)	4500														
		EUI kWh/ft².yr	1.1												
		MJ/m².yr	42.1												
MISCELLANEOUS EQUIPMENT															
		EUI kWh/ft².yr	2.7												
			103.0												

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Hotels/Motels

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.57
Roof U value (W/m ² .°C)	0.38
Glazing U value (W/m ² .°C)	5.88
Glazing Type	single pane clear with drapes
Window/Wall Ratio (W/WAR) (%)	0.35
Shading Coefficient (SC)	0.50
Infiltration Rate (L/s.m ²)	1.52

GENERAL LIGHTING								
Light Level (Lux)	181							
Connected Load (W/m ²)	15.8							
Operating Time (Hrs./yr.)	3000							
Scheduling Factor (SF)	1.05							
Floor Fraction (GLFF)	0.85							
PERCENT SHARE OF LIGHTING SYSTEMS PRESENT								
INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL	
75%	0%	20%	0%	0%	5%	0%	100.0%	
EUI = Load X Hrs. X SF X GLFF							EUI kWh/ft ² .yr	3.9
							MJ/m ² .yr	152.3

SERVICE AREA LIGHTING								
Light Level (Lux)	215							
Connected Load (W/m ²)	25.8							
Operating Time (Hrs./yr.)	5900							
Scheduling Factor (SF)	1.05							
Floor Fraction (SLFF)	0.10							
PERCENT SHARE OF LIGHTING SYSTEMS PRESENT								
INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL	
100%	0%	0%	0%	0%	0%	0%	100.0%	
EUI = Load X Hrs. X SF X SLFF							EUI kWh/ft ² .yr	1.5
							MJ/m ² .yr	57.1

OTHER (HIGH BAY) LIGHTING								
Light Level (Lux)	323							
Connected Load (W/m ²)	14.3							
Operating Time (Hrs./yr.)	8780							
Scheduling Factor (SF)	1.05							
Floor Fraction (OLFF)	0.05							
PERCENT SHARE OF LIGHTING SYSTEMS PRESENT								
INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL	
10%	0%	0%	20%	0%	70%	0%	100.0%	
EUI = Load X Hrs. X SF X OLFF							EUI kWh/ft ² .yr	0.6
							MJ/m ² .yr	23.7

ALL LIGHTING END-USES		EUI TOTAL	kWh/ft ² .yr	6.0
			MJ/m ² .yr	233.2

VENTILATION (AIR DISTRIBUTION)	
System Description	Large hotels have built-up AHU with proportional control of dampers and discharge air. These units normally serve the common areas. Ventilation air for suites is provided by through-the-wall room units. Roof top heat cool units used to serve small common areas or found in small hotews/motels
Outside Air (L/s.person)	11.80
Economizer	Dry bulb or enthalpy based present only in large AHU's. with return air
Control mode	Proportional control in large equipment, ON/OFF for small roof top units
Set Point (Summer)	Occupant defined
Set Point (Winter)	Occupant defined

SPACE HEATING	
Heating Plant Type	Gas fired fire tube boilers present in the larger hotels. Atmospheric "incremental" boilers also present. Gas fired roof top and electric room units used
Core Space (Ventilation) Heating Type & Medium	Hot water via heating coils in central AHU used in larger hotels. Smaller hotels and motels will use gas fired roof top heatin/cooling to serve the core.
Perimeter Space (Envelope) Heating Type & Medium	Larger hotels will have hot water fan coils in every suite. Smaller hotels and motels will have through the wall electric heating/cooling units. Approximately 5% A/A HP.
Total Heating Load (MJ/m ² .yr) (Tertiary Load)	240.0
Maint. & Scheduling Factor (M+SF)	1.12
EUI = Tertiary Load X M+SF/Eff.	
Eff./COP	Fossil Elec. Res. A/A HP W. S. HP H/R Chiller
EUI (kWh/r ² .yr)	0.85 1.00 2.30 2.50 4.50
EUI (MJ/m ² .yr)	10.7 8.9 3.0 2.8 1.5
	414 269 117 108 60

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Hotels/Motels

Page 2

SPACE COOLING			
A/C Plant Type	Large hotels will have a central centrifugal chiller serving the building core services. Suites served by fan coils or packaged compartmental through-the-wall units		
A/C seasonal COP	3.0		
A/C Plant Control Mode	Fixed chilled water and condenser water setpoints for large centrifugal chillers. Packaged through-the-wall DX A/C units operate on fixed head pressure control.		
Distribution System for Perimeter	Some large hotels with central chillers will supply chilled water to fan coils in the suites. The majority will have a compartmental through-the-wall DX A/C unit.		
Distribution System for Core	Chilled water serving fan coils in some large hotels. Roof top or split DX systems in the majority of buildings supplying conditioned air at 12.8 °C (55 °F).		
Typical Connected Load (m²/Ton)	63.29		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	200.0		
Internal Loads:			
Lighting (W/m²)	18.71		
People (W/m²)	8.40		
Plug Loads (W/m²)	4.00		
Maint. & Scheduling Factor (M+SF)	1.12		
EUI = Tertiary Load X M+SF/COP		EUI kWh/ft².yr	1.9
		MJ/m².yr	74.7

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	1.50		
Pump Connected Load (W/m²)	0.50		
Fan Control Type	Control of fan on compartmental room unit through a thermostat located in the suite Other Fans serving common areas controlled by room Thermostat. Exhaust fans operate continuously.		
Pump Control Type	ON/OFF control from MCC		
Fan Average Operation (hrs./yr.)	8000		
Pump Average Operation (hrs./yr.)	3500		
Maint. & Scheduling Factor (M+SF)	1.12		
		EUI kWh/ft².yr	1.1
		MJ/m².yr	43.3

SERVICE HOT WATER			
Service Hot Water Plant Type	Dedicated Service water boiler coupled to storage tank		
Service Hot Water load (MJ/m².yr) (Tertiary Load)			
	Eff.	Fossil	Elec. Res.
	EUI (kWh/ft².yr)	4.0	2.6
		EUI (MJ/m².yr)	153.85
Wetting Use Percentage	0.40		

COOKING EQUIPMENT			
commercial ovens, grilles			
	Eff.	Fossil	Elec. Res.
	EUI (kWh/ft².yr)	3.2	1.8
		EUI (MJ/m².yr)	123.27

REFRIGERATION EQUIPMENT		EUI kWh/ft².yr	0.3
single dedicated fixed capacity compressors serving commercial grade refrigerators and freezers		MJ/m².yr	12.8

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	4.00		
Operating Time (hrs./yr.)	8000		
		EUI kWh/ft².yr	2.2
		MJ/m².yr	86.4

MISCELLANEOUS EQUIPMENT		EUI kWh/ft².yr	0.4
			14.2

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Warehouse/Wholesale

Page 2

SPACE COOLING			
A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a rooftop heating/cooling unit, split system or a window unit. A/C unit typically serves office area only.		
A/C seasonal COP	2.5		
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat		
Distribution System for Perimeter	Perimeter load met mostly with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m ² /Ton)	63.29		
Total Cooling Load (MJ/m ² .yr) (Tertiary Load)	200.0		
Internal Loads:			
Lighting (W/m ²)	18.35		
People (W/m ²)	2.50		
Plug Loads (W/m ²)	3.30		
Maint. & Scheduling Factor (M+SF)	1.18		
EUI = Tertiary Load X M+SF/COP		EUI kWh/ft ² .yr	2.4
		MJ/m ² .yr	94.4

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	0.70		
Pump Connected Load (W/m²)	0.60		
Fan Control Type	ON/OFF control from room thermostat. Exhaust fans tend to operate continuously.		
Pump Control Type	In most cases the presence of pumps is limited to a DHW circulating pump. Control is usually from a starter or MCC.		
Fan Average Operation (hrs./yr.)	2200		
Pump Average Operation (hrs./yr.)	2500		
Maint. & Scheduling Factor (M+ SF)	1.18		
		EUI kWh/ft².yr	0.3
		MJ/m².yr	12.9

SERVICE HOT WATER			
Service Hot Water Plant Type	Small dedicated 75 L (20 Gal) hot water heater		
Service Hot Water load (MJ/m ² .yr) (Tertiary Load)	1.80		
Wetting Use Percentage	0.90		
		Fossil	Elec. Res.
		Eff.	
		EUI (kWh/ft ² .yr)	0.1
		EUI (MJ/m ² .yr)	2.77

COOKING EQUIPMENT			
Small residential appliances/ microwave ovens			
		Fossil	Elec. Res.
		Eff.	
		EUI (kWh/ft ² .yr)	0.2
		EUI (MJ/m ² .yr)	7.27

REFRIGERATION EQUIPMENT		EUI kWh/ft ² .yr	0.5
Industrial refrigeration equipment in refrigerated warehouses. Assume 7% of total floor area and EUI of 275 MJ/m ² .yr		MJ/m ² .yr	19.0

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m ²)	3.30		
Operating Time (hrs./yr.)	3500		
		EUI kWh/ft ² .yr	1.1
		MJ/m ² .yr	41.6

MISCELLANEOUS EQUIPMENT		EUI kWh/ft ² .yr	0.5
			19.0

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Hospitals

Page 2

SPACE COOLING			
A/C Plant Type	Centrifugal chillers used by 75% of the stock. Screw or helical chillers used by 15% of the stock. The remainder stock uses reciprocating chillers.		
A/C seasonal COP	4.5		
A/C Plant Control Mode	Chiller load control based on fixed chilled water temperature set at 5.5 °C (42 °F). Fixed condenser water temperature control set at 29.4 °C (85 °F).		
Distribution System for Perimeter	Perimeter load met mostly with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F). Some induction systems present in older buildings that circulate chilled water.		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m²/Ton)	28.13		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	450.0		
Internal Loads:			
Lighting (W/m²)	17.49		
People (W/m²)	20.20		
Plug Loads (W/m²)	13.00		
Maint. & Scheduling Factor (M+SF)	1.10	EUI kWh/ft².yr	2.8
EUI = Tertiary Load X M+SF/COP		MJ/m².yr	110.0

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	10.00		
Pump Connected Load (W/m²)	3.00		
Fan Control Type	AHU's serving O.R.'s, intensive care and critical areas provide continuous ventilation. Systems might display an unocc/unocc. mode selected from the conditioned space. Non-critical areas with have a 75% incidence of VAV systems. Rest will be CAV. Control will be manual ON/OFF through MCC or auto through time clocks or FMS.		
Pump Control Type	Manual ON/OFF control from MCC by building operator or through an FMS. FMS is estimated to be present in 50% of the stock.		
Fan Average Operation (hrs./yr.)	5800		
Pump Average Operation (hrs./yr.)	4400		
Maint. & Scheduling Factor (M+SF)	1.10	EUI kWh/ft².yr	7.3
		MJ/m².yr	282.0

SERVICE HOT WATER															
Service Hot Water Plant Type	Service water storage tank served by main heating plant.	<table border="1"> <thead> <tr> <th></th> <th>Fossil</th> <th>Elec. Res.</th> </tr> </thead> <tbody> <tr> <td>Eff.</td> <td>0.85</td> <td>1.00</td> </tr> <tr> <td>EUI (kWh/ft².yr)</td> <td>5.6</td> <td>3.6</td> </tr> <tr> <td>EUI (MJ/m².yr)</td> <td>215.38</td> <td>140.00</td> </tr> </tbody> </table>			Fossil	Elec. Res.	Eff.	0.85	1.00	EUI (kWh/ft².yr)	5.6	3.6	EUI (MJ/m².yr)	215.38	140.00
	Fossil	Elec. Res.													
Eff.	0.85	1.00													
EUI (kWh/ft².yr)	5.6	3.6													
EUI (MJ/m².yr)	215.38	140.00													
Service Hot Water load (MJ/m².yr) (Tertiary Load)	140.00														
Wetting Use Percentage	0.30														

COOKING EQUIPMENT															
commercial ovens, grilles	<table border="1"> <thead> <tr> <th></th> <th>Fossil</th> <th>Elec. Res.</th> </tr> </thead> <tbody> <tr> <td>Eff.</td> <td>0.55</td> <td>1.00</td> </tr> <tr> <td>EUI (kWh/ft².yr)</td> <td>2.9</td> <td>1.8</td> </tr> <tr> <td>EUI (MJ/m².yr)</td> <td>110.81</td> <td>61.00</td> </tr> </tbody> </table>				Fossil	Elec. Res.	Eff.	0.55	1.00	EUI (kWh/ft².yr)	2.9	1.8	EUI (MJ/m².yr)	110.81	61.00
	Fossil	Elec. Res.													
Eff.	0.55	1.00													
EUI (kWh/ft².yr)	2.9	1.8													
EUI (MJ/m².yr)	110.81	61.00													

REFRIGERATION EQUIPMENT		EUI kWh/ft².yr	0.8
single dedicated fixed capacity compressors serving commercial grade refrigerators and freezers		MJ/m².yr	25.0

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	13.00		
Operating Time (hrs./yr.)	3500		
		EUI kWh/ft².yr	4.2
		MJ/m².yr	163.8

MISCELLANEOUS EQUIPMENT		EUI kWh/ft².yr	0.5
			20.0

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Nursing Homes

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.57
Roof U value (W/m ² .°C)	0.57
Glazing U value (W/m ² .°C)	3.28
Glazing Type	double pane clear with drapes
Window/Wall Ratio (WIWAR) (%)	0.30
Shading Coefficient (SC)	0.50
Infiltration Rate (L/s.m ²)	1.52

GENERAL LIGHTING	
Light Level (Lux)	269
Connected Load (W/m²)	13.7
Operating Time (Hrs./yr.)	3400
Scheduling Factor (SF)	1.05
Floor Fraction (GLFF)	0.65

PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
20%	0%	80%	0%	0%	0%	0%	100.0%

EUI = Load X Hrs. X SF X GLFF

EUI kWh/ft².yr3.0
MJ/m².yr114.7

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Nursing Homes

Page 2

SPACE COOLING			
A/C Plant Type	Suites will be served by compartmental through-the-wall DX A/C units. Some might have fan coils. Roof top DX A/C units or split systems used to serve common areas.		
A/C seasonal COP	2.6		
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat		
Distribution System for Perimeter	Perimeter load met mostly with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m ² /Ton)	63.29		
Total Cooling Load (MJ/m ² .yr) (Tertiary Load)	200.0		
Internal Loads:			
Lighting (W/m ²)	12.12		
People (W/m ²)	2.60		
Plug Loads (W/m ²)	3.00		
Maint. & Scheduling Factor (M+SF)	1.10		
EUI = Tertiary Load X M+SF/COP		EUI kWh/ft ² .yr	2.2
		MJ/m ² .yr	84.8

HVAC ELECTRICITY			
Fan Connected Load (W/m ²)	2.50		
Pump Connected Load (W/m ²)	3.00		
Fan Control Type	Make-up air unit fan serving common areas operates continuously. Fans serving other areas might be manually operated or on time clocks.		
Pump Control Type	ON/OFF control from MCC		
Fan Average Operation (hrs./yr.)	7300		
Pump Average Operation (hrs./yr.)	4400		
Maint. & Scheduling Factor (M+SF)	1.10		
		EUI kWh/ft ² .yr	0.8
		MJ/m ² .yr	32.8

SERVICE HOT WATER			
Service Hot Water Plant Type	Dedicated service water heater with storage tank		
Service Hot Water load (MJ/m ² .yr) (Tertiary Load)	104.00		
Wetting Use Percentage	0.70		
		Fossil	Elec. Res.
		Eff.	0.65 1.00
		EUI (kWh/ft ² .yr)	4.1 2.7
		EUI (MJ/m ² .yr)	160.00 104.00

COOKING EQUIPMENT			
commercial ovens, grilles			
		Fossil	Elec. Res.
		Eff.	0.55 1.00
		EUI (kWh/ft ² .yr)	0.6 0.3
		EUI (MJ/m ² .yr)	23.27 12.80

REFRIGERATION EQUIPMENT		EUI kWh/ft ² .yr
single dedicated fixed capacity compressors serving commercial grade refrigerators and freezers		30.0

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m ²)	3.00		
Operating Time (hrs./yr.)	3400		
		EUI kWh/ft ² .yr	0.9
		MJ/m ² .yr	36.7

MISCELLANEOUS EQUIPMENT		EUI kWh/ft ² .yr
		12.8

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Universities/Colleges

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.47
Roof U value (W/m ² .°C)	0.47
Glazing U value (W/m ² .°C)	5.88
Glazing Type	single pane clear with drapes
Window/Wall Ratio (WIWAR) (%)	0.35
Shading Coefficient (SC)	0.70
Infiltration Rate (L/s.m ²)	1.52

GENERAL LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	484	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	20.7	10%	0%	70%	10%	0%	10%	0%	100.0%
Operating Time (Hrs./yr.)	4000								
Scheduling Factor (SF)	1.15								
Floor Fraction (GLFF)	0.65								
		EUI = Load X Hrs. X SF X GLFF							
		EUI kWh/m ² .yr 5.8							
		MJ/m ² .yr 223.0							

SERVICE AREA LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	215	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	11.0	20%	0%	80%	0%	0%	0%	0%	100.0%
Operating Time (Hrs./yr.)	4500								
Scheduling Factor (SF)	1.15								
Floor Fraction (SLFF)	0.35								
		EUI = Load X Hrs. X SF X SLFF							
		EUI kWh/m ² .yr 1.8							
		MJ/m ² .yr 71.6							

OTHER (HIGH BAY) LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	215	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	0.0	0%	0%	0%	0%	0%	0%	0%	0.0%
Operating Time (Hrs./yr.)	0								
Scheduling Factor (SF)	0								
Floor Fraction (OLFF)	0								
		EUI = Load X Hrs. X SF X OLFF							
		EUI kWh/m ² .yr 0.0							
		MJ/m ² .yr 0.0							

ALL LIGHTING END-USES	EUI TOTAL	kWh/m ² .yr	7.6
		MJ/m ² .yr	294.6

VENTILATION (AIR DISTRIBUTION)		
System Description	Built-up central AHU. CAV single zone or CAV with reheat. VAV also present which is estimated to have a penetration of 35% of total segment. Typical air flow rates of 3.8 – 5.1 L/s.m² (0.75 – 1.0 CFM/R²). Unit ventilators might also be present in newer buildings.	
Outside Air (L/s.person)	12.00	
Economizer	Yes Dry Bulb based set to switch at 15.5 °C (60 °F)	
Control mode	Modulating dampers with "damper mixed air control" plus fixed discharge air temperature. Very little incidence of reset control via room or return air. Proportional control only some PI & PID control via DDC.	
Set Point (Summer)	12.8 – 17.8 °C (55 – 64 °F)	Discharge Air Temperature
Set Point (Winter)	15.5 – 18.3 °C (60 – 65 °F)	Discharge Air Temperature

SPACE HEATING	
Heating Plant Type	Gas fired fire tube boiler producing hot water. Atmospheric or incremental boilers also present.
Core Space (Ventilation) Heating Type & Medium	Hot water via heating coils in central AHU. Also present terminal reheat coils in the space.
PerimeterSpace (Envelope) Heating Type & Medium	Hot water perimeter radiators or terminal reheat systems installed in perimeter
Total Heating Load (MJ/m ² .yr) (Tertiary Load)	470.0
Maint. & Scheduling Factor (M+SF)	1.12
EUI = Tertiary Load X M+SF/Eff.	
Eff./COP	0.85
EUI (kWh/ft ² .yr)	20.9
EUI (MJ/m ² .yr)	810

Fossil	Elec.	Res.	A/A HP	W. S.	HP	H/R Chiller
1.00	2.30	2.50	4.50			
20.9	13.8	5.9	5.4	3.0		
810	526	229	211	117		

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Schools

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.47
Roof U value (W/m ² .°C)	0.47
Glazing U value (W/m ² .°C)	5.68
Glazing Type	single pane clear with drapes
Window/Wall Ratio (WIWAR) (%)	0.35
Shading Coefficient (SC)	0.70
Infiltration Rate (L/s.m ²)	1.52

GENERAL LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	430	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	18.4	10%	0%	80%	0%	0%	10%	0%	100.0%
Operating Time (Hrs./yr.)	2500								
Scheduling Factor (SF)	1.20								
Floor Fraction (GLFF)	0.65								
								EUI kWh/ft ² .yr	3.3
								MJ/m ² .yr	129.3

SERVICE AREA LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	215	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	9.1	10%	0%	90%	0%	0%	0%	0%	100.0%
Operating Time (Hrs./yr.)	4500								
Scheduling Factor (SF)	1.20								
Floor Fraction (SLFF)	0.35								
								EUI kWh/ft ² .yr	1.6
								MJ/m ² .yr	62.3
EUI = Load X Hrs. X SF X SLFF									

OTHER (HIGH BAY) LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	215	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	0.0	0%	0%	0%	0%	0%	0%	0%	0.0%
Operating Time (Hrs./yr.)	0								
Scheduling Factor (SF)	0								
Floor Fraction (OLFF)	0								
								EUI kWh/ft ² .yr	0.0
								MJ/m ² .yr	0.0
EUI = Load X Hrs. X SF X OLFF									

ALL LIGHTING END-USES	EUI TOTAL kWh/ft ² .yr	4.9
	MJ/m ² .yr	191.5

VENTILATION (AIR DISTRIBUTION)	
System Description	Built-up central AHU. CAV single zone or CAV with reheat. VAV present in some schools. Typical air flow rates of 3.8 – 5.1 L/s.m ² (0.75 – 1.0 CFM/ft ²). Unit ventilators or "Herman Nelson" through the wall present in the newer schools.
Outside Air (L/s.person)	7.08
Economizer	Yes Dry Bulb based set to switch at 15.5 °C (60 °F)
Control mode	Modulating dampers with "damper mixed air control" plus fixed discharge air. temperature. Very little incidence of reset control via room ore return air. Proportional cpntrol only some PI & PID via DDC control.
Set Point (Summer)	22.2 °C (72 °F) cooling present
Set Point (Winter)	21.1 °C (70 °F)

SPACE HEATING																																													
Heating Plant Type	Gas fired fire tube boiler producing hot water. Atmospheric or incremental boilers also present.																																												
Core Space (Ventilation) Heating Type & Medium	Hot water via heating coils in central AHU. Also present terminal reheat coils in the space.																																												
Perimeter Space (Envelope) Heating Type & Medium	Hot water perimeter radiators or terminal reheat systems installed in perimeter																																												
Total Heating Load (MJ/m².yr) (Tertiary Load)	207.0																																												
Maint. & Scheduling Factor (M+SF)	1.12																																												
EUI = Tertiary Load X M+SF/eff.																																													
	<table><tr><th></th><th>Fossil</th><th>Elec.</th><th>Res.</th><th>A/A</th><th>HP</th><th>W.</th><th>S.</th><th>HP</th><th>H/R</th><th>Chiller</th></tr><tr><td>Eff/COP</td><td>0.65</td><td>1.00</td><td>2.30</td><td></td><td></td><td></td><td></td><td>2.50</td><td></td><td>4.50</td></tr><tr><td>EUI (kWh/m².yr)</td><td>9.2</td><td>6.0</td><td>2.6</td><td></td><td></td><td></td><td></td><td>2.4</td><td></td><td>1.3</td></tr><tr><td>EUI (MJ/m².yr)</td><td>357</td><td>232</td><td>101</td><td></td><td></td><td></td><td></td><td>93</td><td></td><td>52</td></tr></table>		Fossil	Elec.	Res.	A/A	HP	W.	S.	HP	H/R	Chiller	Eff/COP	0.65	1.00	2.30					2.50		4.50	EUI (kWh/m².yr)	9.2	6.0	2.6					2.4		1.3	EUI (MJ/m².yr)	357	232	101					93		52
	Fossil	Elec.	Res.	A/A	HP	W.	S.	HP	H/R	Chiller																																			
Eff/COP	0.65	1.00	2.30					2.50		4.50																																			
EUI (kWh/m².yr)	9.2	6.0	2.6					2.4		1.3																																			
EUI (MJ/m².yr)	357	232	101					93		52																																			

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Schools

Page 2

SPACE COOLING			
A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a roof top heating/cooling unit, split system or a window unit.		
A/C seasonal COP	2.6		
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat		
Distribution System for Perimeter	Perimeter load met mostly with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m²/Ton)	63.29		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	200.0		
Internal Loads:			
Lighting (W/m²)	15.17		
People (W/m²)	132.40		
Plug Loads (W/m²)	1.00		
Maint. & Scheduling Factor (M+SF)	1.12		
EUI = Tertiary Load X M+SF/COP		EUI kWh/ft².yr	2.2
		MJ/m².yr	86.2

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	1.00		
Pump Connected Load (W/m²)	0.50		
Fan Control Type	Manual ON/OFF control of AHU CAV fans from MCC scheduled by building operator. Some auto control through time clocks or FMS. Schools with unit ventilators provide ON/OFF control through room thermostat.		
Pump Control Type	Manual ON/OFF control from MCC by building operator or through an FMS. FMS is estimated to be present in 10% of the stock.		
Fan Average Operation (hrs./yr.)	2500		
Pump Average Operation (hrs./yr.)	2500		
Maint. & Scheduling Factor (M+SF)	1.12		
		EUI kWh/ft².yr	0.4
		MJ/m².yr	15.1

SERVICE HOT WATER			
Service Hot Water Plant Type	Dedicated service water heater with storage tank		
Service Hot Water load (MJ/m².yr) (Tertiary Load)	22.00		
Wetting Use Percentage	0.50		
		Fossil	Elec. Res.
		Eff.	0.65
		EUI (kWh/ft².yr)	0.9
		EUI (MJ/m².yr)	33.85
			22.00

COOKING EQUIPMENT			
commercial ovens, grilles			
		Fossil	Elec. Res.
		Eff.	0.55
		EUI (kWh/ft².yr)	0.2
		EUI (MJ/m².yr)	8.73
			4.80

REFRIGERATION EQUIPMENT			EUI kWh/ft².yr	0.3
single dedicated fixed capacity compressors serving commercial grade refrigerators and freezers			MJ/m².yr	10.0

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	1.00		
Operating Time (hrs./yr.)	2500		
		EUI kWh/ft².yr	0.2
		MJ/m².yr	9.0

MISCELLANEOUS EQUIPMENT			EUI kWh/ft².yr	0.0
				0.4

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
High Rise Apartments

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.57
Roof U value (W/m ² .°C)	0.47
Glazing U value (W/m ² .°C)	4.54
Glazing Type	single pane clear with blinds/drapes
Window/Wall Ratio (WIWAR) (%)	0.30
Shading Coefficient (SC)	0.70
Infiltration Rate (L/s.m ²)	1.52

GENERAL LIGHTING								
Light Level (Lux)	181							
Connected Load (W/m²)	17.8							
Operating Time (Hrs./yr.)	1200							
Scheduling Factor (SF)	1.05							
Floor Fraction (GLFF)	0.85							
PERCENT SHARE OF LIGHTING SYSTEMS PRESENT								
INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL	
80%	0%	10%	0%	0%	0%	0%	100.0%	
EUI = Load X Hrs. X SF X GLFF							EUI kWh/ft².yr	1.8
							MJ/m².yr	68.8

SERVICE AREA LIGHTING	
Light Level (Lux)	215
Connected Load (W/m²)	22.0
Operating Time (Hrs./yr.)	8760
Scheduling Factor (SF)	1.05
Floor Fraction (SLFF)	0.15

PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
80%	0%	20%	0%	0%	0%	0%	100.0%

EUI = Load X Hrs. X SF X SLFF

EUI kWh/ft².yr

MJ/m².yr

2.8

109.1

OTHER (HIGH BAY) LIGHTING	
Light Level (Lux)	323
Connected Load (W/m²)	0.0
Operating Time (Hrs./yr.)	0
Scheduling Factor (SF)	0
Floor Fraction (OLFF)	0

PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
0%	0%	0%	0%	0%	0%	0%	0.0%

EUI = Load X Hrs. X SF X OLFF

EUI kWh/m².yr

0.0

MJ/m².yr

0.0

ALL LIGHTING END-USES	EUI TOTAL	kWh/m ² .yr	4.8
		MJ/m ² .yr	177.9

VENTILATION (AIR DISTRIBUTION)	
System Description	Constant volume make-up air unit serving corridors, common areas, main lobby
Outside Air (L/s.person)	7.08
Economizer	Not present
Control mode	Dixed discharge air temperature or room thermostat control.
Set Point (Summer)	
Set Point (Winter)	21.1 – 25.5 °C (70 – 78 °F)

SPACE HEATING																													
Heating Plant Type	Gas fired atmospheric or incremental boilers producing hot water. In electric heated buildings heating will be by gas fired make-up air unit & electric baseboards in suites.																												
Core Space (Ventilation) Heating Type & Medium	Make-up air unit with either a hot water heating coil or direct gas fired heating.																												
Perimeter Space (Envelope) Heating Type & Medium	Hot water perimeter radiation or electric resistance baseboards. Also some through the wall heat pumps in condominiums																												
Total Heating Load (MJ/m ² .yr) (Tertiary Load)	412.5																												
Maint. & Scheduling Factor (M+SF)	1.18																												
EUI = Tertiary Load X M+SF/Eff.																													
<table><tr><td>Eff./COP</td><td>Fossil</td><td>Elec.</td><td>Res.</td><td>A/A HP</td><td>W. S. HP</td><td>H/R Chiller</td></tr><tr><td>EUI (kWh/m².yr)</td><td>0.85</td><td>1.00</td><td>2.30</td><td>2.50</td><td>4.50</td><td></td></tr><tr><td>EUI (MJ/m².yr)</td><td>19.3</td><td>12.8</td><td>5.5</td><td>5.0</td><td>2.8</td><td></td></tr><tr><td></td><td>749</td><td>487</td><td>212</td><td>195</td><td>108</td><td></td></tr></table>		Eff./COP	Fossil	Elec.	Res.	A/A HP	W. S. HP	H/R Chiller	EUI (kWh/m ² .yr)	0.85	1.00	2.30	2.50	4.50		EUI (MJ/m ² .yr)	19.3	12.8	5.5	5.0	2.8			749	487	212	195	108	
Eff./COP	Fossil	Elec.	Res.	A/A HP	W. S. HP	H/R Chiller																							
EUI (kWh/m ² .yr)	0.85	1.00	2.30	2.50	4.50																								
EUI (MJ/m ² .yr)	19.3	12.8	5.5	5.0	2.8																								
	749	487	212	195	108																								

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
High Rise Apartments

Page 2

SPACE COOLING			
A/C Plant Type	Suites will be served by compartmental through-the-wall DX A/C units. Some might have fan coils. Roof top DX A/C units or split systems used to serve common areas.		
A/C seasonal COP	2.6		
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat		
Distribution System for Perimeter	Perimeter load met mostly with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m²/Ton)	63.29		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	200.0		
Internal Loads:			
Lighting (W/m²)	18.46		
People (W/m²)	2.60		
Plug Loads (W/m²)	6.00		
Maint. & Scheduling Factor (M+SF)	1.18		
EUI = Tertiary Load X M+SF/COP		EUI kWh/ft².yr	2.3
		MJ/m².yr	90.8

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	1.50		
Pump Connected Load (W/m²)	1.00		
Fan Control Type	Make-up air unit fan serving common areas operates continuously. Fans on through the wall units in individual suites controlled by room thermostats.		
Pump Control Type	ON/OFF control from MCC		
Fan Average Operation (hrs./yr.)	5800		
Pump Average Operation (hrs./yr.)	3500		
Maint. & Scheduling Factor (M+SF)	1.18		
		EUI kWh/ft².yr	1.3
		MJ/m².yr	51.8

SERVICE HOT WATER			
Service Hot Water Plant Type	Dedicated service water heater with storage tank		
Service Hot Water load (MJ/m².yr) (Tertiary Load)	100.00		
Wetting Use Percentage	0.70		
		Fossil	Elec. Res.
		Eff.	0.65
		EUI (kWh/ft².yr)	4.0
		EUI (MJ/m².yr)	153.85
			100.00

COOKING EQUIPMENT			
residential stove			
		Fossil	Elec. Res.
		Eff.	0.55
		EUI (kWh/ft².yr)	0.9
		EUI (MJ/m².yr)	34.55
			19.00

REFRIGERATION EQUIPMENT			
small residential type fridge			
		EUI kWh/ft².yr	0.9
		MJ/m².yr	36.0

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	6.00		
Operating Time (hrs./yr.)	2500		
		EUI kWh/ft².yr	1.4
		MJ/m².yr	54.0

MISCELLANEOUS EQUIPMENT			
		EUI kWh/ft².yr	0.3
			12.8

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Miscellaneous

Page 1

CONSTRUCTION		
Wall U value (W/m ² .°C)	0.85	
Roof U value (W/m ² .°C)	0.47	
Glazing U value (W/m ² .°C)	4.20	
Glazing Type	single pane clear	
Window/Wall Ratio (WIWAR) (%)	0.25	
Shading Coefficient (SC)	0.70	
Infiltration Rate (L/s.m ²)	1.52	

GENERAL LIGHTING			PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	484		INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	21.8		10%	0%	60%	10%	10%	5%	5%	100.0%
Operating Time (Hrs./yr.)	3000									
Scheduling Factor (SF)	1.10									
Floor Fraction (GLFF)	0.80									
EUI = Load X Hrs. X SF X GLFF									EUI kWh/ft ² .yr	5.4
									MJ/m ² .yr	207.3

SERVICE AREA LIGHTING			PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	215		INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	11.0		20%	0%	80%	0%	0%	0%	0%	100.0%
Operating Time (Hrs./yr.)	5800									
Scheduling Factor (SF)	1.10									
Floor Fraction (SLFF)	0.15									
EUI = Load X Hrs. X SF X SLFF									EUI kWh/ft ² .yr	1.0
									MJ/m ² .yr	38.5

OTHER (HIGH BAY) LIGHTING			PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	323		INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	11.7		0%	0%	0%	20%	0%	80%	0%	100.0%
Operating Time (Hrs./yr.)	3000									
Scheduling Factor (SF)	1.10									
Floor Fraction (OLFF)	0.05									
EUI = Load X Hrs. X SF X OLFF									EUI kWh/ft ² .yr	0.2
									MJ/m ² .yr	6.9

ALL LIGHTING END-USES	EUI TOTAL	kWh/ft ² .yr	6.5
		MJ/m ² .yr	252.7

VENTILATION (AIR DISTRIBUTION)	
System Description	Roof Top heating/cooling. CAV single zone. Typical air flow rates of 3.8 L/s.m ² .
Outside Air (L/s.person)	7.08
Economizer	Enthalpy based if present (manufacturers of R/T equipment typically opt for an enthalpy based econo to fit in their equipment). Incidence estimated at 20%
Control mode	Fixed fresh air, no damper control. Room thermostat control, ON/OFF, or multistage
Set Point (Summer)	22.2 °C (72 °F)
Set Point (Winter)	21.1 °C (70 °F)

SPACE HEATING																																																						
Heating Plant Type		Atmospheric or incremental boilers present in some buildings. Direct gas fired roof top heating/cooling units are the most common source of ventilation/core heat.																																																				
Core Space (Ventilation) Heating Type & Medium		Majority of buildings served by forced air roof top heatin/cooling units. Some incremental water source heat pumps.																																																				
Perimeter Space (Envelope) Heating Type & Medium		Forced air roof top heating/cooling units are the predominant source of perimeter heat. Electric baseboard heating is present in an estimated 20% of the segment.																																																				
Total Heating Load (MJ/m ² .yr) (Tertiary Load)		500.0																																																				
Maint. & Scheduling Factor (M+SF)		1.14																																																				
EUI = Tertiary Load X M+SF/Eff.																																																						
		<table><tr><th></th><th>Fossil</th><th>Elec.</th><th>Res.</th><th>A/A</th><th>HP</th><th>W.</th><th>S.</th><th>HP</th><th>H/R</th><th>Chiller</th></tr><tr><td>Eff./COP</td><td>0.65</td><td>1.00</td><td>2.30</td><td>2.50</td><td>4.50</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>EUI (kWh/ft².yr)</td><td>22.6</td><td>14.7</td><td>8.4</td><td>5.9</td><td>3.3</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>EUI (MJ/m².yr)</td><td>877</td><td>570</td><td>248</td><td>228</td><td>127</td><td></td><td></td><td></td><td></td><td></td></tr></table>										Fossil	Elec.	Res.	A/A	HP	W.	S.	HP	H/R	Chiller	Eff./COP	0.65	1.00	2.30	2.50	4.50						EUI (kWh/ft ² .yr)	22.6	14.7	8.4	5.9	3.3						EUI (MJ/m ² .yr)	877	570	248	228	127					
	Fossil	Elec.	Res.	A/A	HP	W.	S.	HP	H/R	Chiller																																												
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B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

Existing Buildings
Miscellaneous

Page 2

SPACE COOLING			
A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a roof top heating/cooling unit or a split system		
A/C seasonal COP	2.8		
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat		
Distribution System for Perimeter	Perimeter load met mostly with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m²/Ton)	63.29		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	200.0		
Internal Loads:			
Lighting (W/m²)	19.68		
People (W/m²)	4.00		
Plug Loads (W/m²)	3.00		
Maint. & Scheduling Factor (M+SF)	1.14		
EUI = Tertiary Load X M+SF/COP		EUI kWh/ft².yr	2.3
		MJ/m².yr	87.7

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	5.00		
Pump Connected Load (W/m²)	0.00		
Fan Control Type	ON/OFF control from room thermostat. Exhaust fans tend to operate continuously.		
Pump Control Type	In most cases the presence of pumps is limited to a DHW circulating pump. Control is usually from a starter or MCC.		
Fan Average Operation (hrs./yr.)	3000		
Pump Average Operation (hrs./yr.)	0		
Maint. & Scheduling Factor (M+SF)	1.14		
		EUI kWh/ft².yr	1.8
		MJ/m².yr	61.6

SERVICE HOT WATER															
Service Hot Water Plant Type	(38–75L) 10–20 Gal. dedicated water heater.														
Service Hot Water load (MJ/m².yr) (Tertiary Load)	4.00														
Wetting Use Percentage	0.90														
		<table><tr><td></td><td>Fossil</td><td>Elec. Res.</td></tr><tr><td>Eff.</td><td>0.65</td><td>1.00</td></tr><tr><td>EUI (kWh/ft².yr)</td><td>0.2</td><td>0.1</td></tr><tr><td>EUI (MJ/m².yr)</td><td>6.15</td><td>4.00</td></tr></table>			Fossil	Elec. Res.	Eff.	0.65	1.00	EUI (kWh/ft².yr)	0.2	0.1	EUI (MJ/m².yr)	6.15	4.00
	Fossil	Elec. Res.													
Eff.	0.65	1.00													
EUI (kWh/ft².yr)	0.2	0.1													
EUI (MJ/m².yr)	6.15	4.00													

COOKING EQUIPMENT			
		Fossil	Elec. Res.
	Eff.	0.55	1.00
Small residential appliances/ microwave ovens	EUI (kWh/m².yr)	0.0	0.0
	EUI (MJ/m².yr)	0.00	0.00

REFRIGERATION EQUIPMENT	EUI kWh/ft².yr	0.0
single dedicated fixed capacity compressors on small fridges	MJ/m².yr	0.0

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	3.00		
Operating Time (hrs./yr.)	3000		
		EUI kWh/ft².yr	0.8
		MJ/m².yr	32.4

MISCELLANEOUS EQUIPMENT	EUI kWh/ft².yr	0.3
	MJ/m².yr	12.0

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Large Office (> 3,700 m²)

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.51
Roof U value (W/m ² .°C)	0.45
Glazing U value (W/m ² .°C)	3.28
Glazing Type	Double pane/tinted with blinds
Window/Wall Ratio (WIWAR) (%)	0.35
Shading Coefficient (SC)	0.59
Infiltration Rate (L/s.m ²)	1.52

GENERAL LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT						
Light Level (Lux)	968	INC	CFL	FL4	FL8	MV	MH	HPS
Connected Load (W/m ²)	32.9	0%	0%	100%	0%	0%	0%	0%
Operating Time (Hrs./yr.)	3100	TOTAL						
Scheduling Factor (SF)	1.15	0%	0%	100%	0%	0%	0%	100.0%
Floor Fraction (GLFF)	0.75	EUI = Load X Hrs. X SF X GLFF						
		EUI kWh/m ² .yr						
		MJ/m ² .yr						
		8.2						
		317.1						

SERVICE AREA LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT						
Light Level (Lux)	323	INC	CFL	FL4	FL8	MV	MH	HPS
Connected Load (W/m ²)	18.5	20%	0%	80%	0%	0%	0%	0%
Operating Time (Hrs./yr.)	5900	TOTAL						
Scheduling Factor (SF)	1.15	20%	0%	80%	0%	0%	0%	100.0%
Floor Fraction (SLFF)	0.20	EUI = Load X Hrs. X SF X SLFF						
		EUI kWh/m ² .yr						
		MJ/m ² .yr						
		2.1						
		80.5						

OTHER (HIGH BAY) LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT						
Light Level (Lux)	323	INC	CFL	FL4	FL8	MV	MH	HPS
Connected Load (W/m ²)	11.7	0%	0%	0%	0%	0%	95%	5%
Operating Time (Hrs./yr.)	5000	TOTAL						
Scheduling Factor (SF)	1.15	0%	0%	0%	0%	0%	95%	100.0%
Floor Fraction (OLFF)	0.05	EUI = Load X Hrs. X SF X OLFF						
		EUI kWh/m ² .yr						
		MJ/m ² .yr						
		0.3						
		12.1						

ALL LIGHTING END-USES	EUI TOTAL	kWh/m ² .yr	10.6
		MJ/m ² .yr	409.6

VENTILATION (AIR DISTRIBUTION)		
System Description	Built-up central or compartmental AHU on every floor. VAV system is presently considered the standard with an incidence of use of 100%. Typical air flow rates of 3.8 – 5.1 L/s.m ² (0.75 – 1.0 CFM/ft ²)	
Outside Air (L/s.person)	9.44	
Economizer	Yes Half of systems are enthalpy based, other half are dry bulb based. All new large offices equipped with an FMS that provides floating economizer control	
Control mode	Modulating dampers with "damper mixed air control" plus fixed discharge air temperature. DDC control via an FMS system considered the standard in all new large offices.	
Set Point (Summer)	12.8 – 17.8 °C (55 – 64 °F)	Discharge Air Temperature
Set Point (Winter)	15.5 – 18.3 °C (60 – 65 °F)	Discharge Air Temperature

SPACE HEATING																																													
Heating Plant Type	Gas fired fire tube boiler producing hot water. Some electric resistance baseboard heating serving the building perimeter.																																												
Core Space (Ventilation) Heating Type & Medium	Hot water via heating coils in central AHU.																																												
Perimeter Space (Envelope) Heating Type & Medium	Hot water perimeter radiators installed in perimeter. Some electric baseboards present in some buildings																																												
Total Heating Load (MJ/m².yr) (Tertiary Load)	130.0																																												
Maint. & Scheduling Factor (M+SF)	1.14																																												
EUI = Tertiary Load X M+SF/eff.																																													
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	Fossil	Elec.	Res.	A/A	HP	W.	S.	HP	H/R	Chiller																																			
Eff./COP	0.65	1.00	2.30		2.50				4.50																																				
EUI (kWh/m².yr)	5.9	3.8	1.7		1.5				0.9																																				
EUI (MJ/m².yr)	228	148	64		59				33																																				

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Large Office (> 3,700 m²)

Page 2

SPACE COOLING			
A/C Plant Type	Centrifugal chillers used exclusively		
A/C seasonal COP	4.2		
A/C Plant Control Mode	Chiller load control based on fixed chilled water temperature set at 5.5 °C (42 °F). Fixed condenser water temperature control set at 29.4 °C (85 °F).		
Distribution System for Perimeter	Perimeter load met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m²/Ton)	45.21		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	280.0		
Internal Loads:			
Lighting (W/m²)	28.58		
People (W/m²)	10.70		
Plug Loads (W/m²)	15.00		
Maint. & Scheduling Factor (M+SF)	1.14		
EUI = Tertiary Load X M+SF/COP		EUI kWh/ft².yr	2.0
		MJ/m².yr	76.0

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	8.00		
Pump Connected Load (W/m²)	3.00		
Fan Control Type	Supply and return fans on main AHU under VAV control. Supply/Return and exhaust fans under automated scheduling via FMS.		
Pump Control Type	All pumps controlled by FMS to minimize operation during unoccupied hrs.		
Fan Average Operation (hrs./yr.)	3000		
Pump Average Operation (hrs./yr.)	3000		
Maint. & Scheduling Factor (M+SF)	1.14		
		EUI kWh/ft².yr	3.5
		MJ/m².yr	135.4

SERVICE HOT WATER			
Service Hot Water Plant Type	190 L (50 Gal) dedicated water heater		
Service Hot Water load (MJ/m².yr) (Tertiary Load)	4.70		
Wetting Use Percentage	0.90		
		Fossil	Elec. Res.
		Eff.	0.65
		EUI (kWh/ft².yr)	0.2
		EUI (MJ/m².yr)	7.23
		1.00	0.1
		4.7	

COOKING EQUIPMENT			
Small residential appliances/ microwave ovens			
		Fossil	Elec. Res.
		Eff.	0.55
		EUI (kWh/ft².yr)	0.2
		EUI (MJ/m².yr)	7.27
		1.00	0.1
		4.00	

REFRIGERATION EQUIPMENT		EUI kWh/ft².yr	0.3
single dedicated fixed capacity compressors on small fridges		MJ/m².yr	12.4

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	15.00		
Operating Time (hrs./yr.)	3500		
		EUI kWh/ft².yr	4.9
		MJ/m².yr	189.0

MISCELLANEOUS EQUIPMENT		EUI kWh/ft².yr	1.1
		MJ/m².yr	43.2

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Small Office (< 3,700 m²)

Page 1

CONSTRUCTION	
Wall U value (W/m².°C)	0.45
Roof U value (W/m².°C)	0.34
Glazing U value (W/m².°C)	3.28
Glazing Type	Double pane/tinted with blinds/drapes
Window/Wall Ratio (WIWAR) (%)	0.30
Shading Coefficient (SC)	0.59
Infiltration Rate (L/s.m²)	1.52

GENERAL LIGHTING	
Light Level (Lux)	968
Connected Load (W/m²)	32.9
Operating Time (Hrs./yr.)	3100
Scheduling Factor (SF)	1.20
Floor Fraction (GLFF)	0.75

PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
0%	0%	100%	0%	0%	0%	0%	100.0%

$$EUI = Load \times Hrs. \times SF \times GLFF$$

EUI kWh/m².yr	8.5
MJ/m².yr	330.8

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Small Office (< 3,700 m²)

Page 2

SPACE COOLING	
A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a roof top heating/cooling unit or a split system
A/C seasonal COP	2.6
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat
Distribution System for Perimeter	Perimeter load met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)
Typical Connected Load (m²/Ton)	50.63
Total Cooling Load (MJ/m².yr) (Tertiary Load)	250.0
Internal Loads:	
Lighting (W/m²)	28.58
People (W/m²)	10.70
Plug Loads (W/m²)	15.00
Maint. & Scheduling Factor (M+SF)	1.18
EUI = Tertiary Load X M+SF/COP	
EUI kWh/ft².yr	2.9
MJ/m².yr	111.5

HVAC ELECTRICITY	
Fan Connected Load (W/m²)	10.90
Pump Connected Load (W/m²)	5.50
Fan Control Type	ON/OFF control from room thermostat. Exhaust fans tend to operate continuously.
Pump Control Type	ON/OFF control from MCC
Fan Average Operation (hrs./yr.)	3000
Pump Average Operation (hrs./yr.)	3000
Maint. & Scheduling Factor (M+SF)	1.18
EUI kWh/ft².yr	3.7
MJ/m².yr	145.0

SERVICE HOT WATER	
Service Hot Water Plant Type	38 – 75 L (10 – 20 Gal) dedicated water heater
Service Hot Water load (MJ/m².yr) (Tertiary Load)	4.70
Wetting Use Percentage	0.90

	Fossil	Elec. Res.
Eff.	0.65	1.00
EUI (kWh/ft².yr)	0.2	0.1
EUI (MJ/m².yr)	7.23	4.7

COOKING EQUIPMENT	
Small residential appliances/ microwave ovens	

	Fossil	Elec. Res.
Eff.	0.55	1.00
EUI (kWh/ft².yr)	0.2	0.1
EUI (MJ/m².yr)	7.27	4.00

REFRIGERATION EQUIPMENT	
single dedicated fixed capacity compressors on small fridges	

	EUI kWh/ft².yr
	0.3
	MJ/m².yr 12.4

OFFICE (PLUG-IN) EQUIPMENT	
Connected Load (W/m²)	15.00
Operating Time (hrs./yr.)	3500
EUI kWh/ft².yr	4.9
MJ/m².yr	189.0

MISCELLANEOUS EQUIPMENT	
EUI kWh/ft².yr	0.3
MJ/m².yr	12.9

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Non-Food Retail

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.45
Roof U value (W/m ² .°C)	0.28
Glazing U value (W/m ² .°C)	3.28
Glazing Type	Double pane clear
Window/Wall Ratio (WIWAR) (%)	0.20
Shading Coefficient (SC)	0.80
Infiltration Rate (L/s.m ²)	1.52

GENERAL LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	881	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	44.4	20%	0%	50%	10%	0%	20%	0%	100.0%
Operating Time (Hrs./yr.)	4300								
Scheduling Factor (SF)	1.20								
Floor Fraction (GLFF)	0.40								
		EUI = Load X Hrs. X SF X GLFF							
		EUI kWh/ft ² .yr 8.5							
		MJ/m ² .yr 329.7							

SERVICE AREA LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	323	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	18.5	20%	0%	80%	0%	0%	0%	0%	100.0%
Operating Time (Hrs./yr.)	6500								
Scheduling Factor (SF)	1.20								
Floor Fraction (SLFF)	0.55								
		EUI = Load X Hrs. X SF X SLFF							
		EUI kWh/ft ² .yr 6.8							
		MJ/m ² .yr 254.4							

OTHER (HIGH BAY) LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	323	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	11.8	0%	0%	0%	0%	0%	100%	0%	100.0%
Operating Time (Hrs./yr.)	4000								
Scheduling Factor (SF)	1.20								
Floor Fraction (OLFF)	0.05								
		EUI = Load X Hrs. X SF X OLFF							
		EUI kWh/ft ² .yr 0.3							
		MJ/m ² .yr 10.2							

ALL LIGHTING END-USES	EUI TOTAL	kWh/ft ² .yr	15.3
		MJ/m ² .yr	594.2

VENTILATION (AIR DISTRIBUTION)	
System Description	Roof Top heating/cooling. CAV single zone. Roof tops larger than 4700 L/s (10,000 CFM) normally VAV. Typical air flow rates of 3.8 L/s.m ² .
Outside Air (L/s.person)	4.72
Economizer	Enthalpy based if present (manufacturers of R/T equipment typically opt for an enthalpy based econo to fit in their equipment). Incidence estimated at 30%
Control mode	Fixed fresh air, no damper control. Room thermostat control, ON/OFF, or multistage
Set Point (Summer)	22.2 °C (72 °F)
Set Point (Winter)	21.1 °C (70 °F)

SPACE HEATING	
Heating Plant Type	Atmospheric or incremental boilers present in some buildings. Direct gas fired roof top heating/cooling units are the most common source of ventilation/core heat.
Core Space (Ventilation) Heating Type & Medium	Majority of buildings served by forced air roof top heating/cooling units. Some incremental water source heat pumps estimated at 5% of the total segment.
Perimeter Space (Envelope) Heating Type & Medium	Forced air roof top heating/cooling units are the predominant source of perimeter heat. Electric baseboard heating is present in an estimated 15% of the segment
Total Heating Load (MJ/m ² .yr) (Tertiary Load)	65.0
Maint. & Scheduling Factor (M+SF)	1.16
EUI = Tertiary Load X M+SF/Eff.	
Eff./COP	Fossil Elec. Res. A/A HP W. S. HP H/R Chiller
EUI (kWh/ft ² .yr)	0.65 1.00 2.30 2.50 4.50
EUI (MJ/m ² .yr)	3.0 1.9 0.8 0.8 0.4
	118 75 33 30 17

BUILDING PROFILE

Page 2

HVAC ELECTRICITY	
Fan Connected Load (W/m²)	5.00
Pump Connected Load (W/m²)	1.00
Fan Control Type	ON/OFF control from room thermostat. Exhaust fans tend to operate continuously.
Pump Control Type	In most cases the presence of pumps is limited to a DHW circulating pump. Control is usually from a starter or MCC.
Fan Average Operation (hrs./yr.)	4300
Pump Average Operation (hrs./yr.)	3000
Maint. & Scheduling Factor (M+SF)	1.18

EUI kWh/ft².yr	2.8
MJ/m².yr	102.3

COOKING EQUIPMENT		Fossil	Elec. Res.
Eff.		0.55	1.00
EUI (kWh/m ² .yr)		0.2	0.1
EUI (MJ/m ² .yr)		7.45	4.10

OFFICE (PLUG-IN) EQUIPMENT						
Connected Load (W/m²)	3.70					
Operating Time (hrs./yr.)	4500					
		<table><tr><td>EUI kWh/m².yr</td><td>1.5</td></tr><tr><td>MJ/m².yr</td><td>59.9</td></tr></table>	EUI kWh/m².yr	1.5	MJ/m².yr	59.9
EUI kWh/m².yr	1.5					
MJ/m².yr	59.9					

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B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Food Retail

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.23
Roof U value (W/m ² .°C)	0.34
Glazing U value (W/m ² .°C)	3.28
Glazing Type	Double pane clear
Window/Wall Ratio (WIWAR) (%)	0.10
Shading Coefficient (SC)	0.80
Infiltration Rate (L/s.m ²)	1.52

GENERAL LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	988	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m²)	41.4	10%	0%	50%	30%	0%	10%	0%	100.0%
Operating Time (Hrs./yr.)	5800								
Scheduling Factor (SF)	1.05								
Floor Fraction (GLFF)	0.40								
		EUI = Load X Hrs. X SF X GLFF							

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Food Retail

Page 2

SPACE COOLING

A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a roof top heating/cooling unit or a split system	
A/C seasonal COP	2.6	
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat	
Distribution System for Perimeter	Perimeter load met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).	
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)	
Typical Connected Load (m²/Ton)	230.14	
Total Cooling Load (MJ/m².yr) (Tertiary Load)	55.0	
Internal Loads:		
Lighting (W/m²)	27.73	
People (W/m²)	8.10	
Plug Loads (W/m²)	3.70	
Maint. & Scheduling Factor (M+SF)	1.18	
EUI = Tertiary Load X M+SF/COP		
		EUI kWh/ft².yr 0.8 MJ/m².yr 25.0

HVAC ELECTRICITY

Fan Connected Load (W/m²)	2.00	
Pump Connected Load (W/m²)	0.50	
Fan Control Type	ON/OFF control from room thermostat. Exhaust fans tend to operate continuously.	
Pump Control Type	In most cases the presence of pumps is limited to a DHW circulating pump. Control is usually from a starter or MCC.	
Fan Average Operation (hrs./yr.)	3300	
Pump Average Operation (hrs./yr.)	3000	
Maint. & Scheduling Factor (M+SF)	1.18	
		EUI kWh/ft².yr 0.9 MJ/m².yr 34.4

SERVICE HOT WATER

Service Hot Water Plant Type	190 L (50 Gal) dedicated water heater		Fossil	Elec. Res.
		Eff.	0.65	1.00
Service Hot Water load (MJ/m².yr)	19.30	EUI (kWh/ft².yr)	0.8	0.5
(Tertiary Load)		EUI (MJ/m².yr)	29.69	19.3
Wetting Use Percentage	0.90			

COOKING EQUIPMENT

Commercial ovens in bakery used for baking goods/pastries/cakes	Eff.	0.55	1.00
	EUI (kWh/m².yr)	12.6	6.9
	EUI (MJ/m².yr)	489.09	269.00

REFRIGERATION EQUIPMENT

single dedicated or large multiplexed compressors serving commercial refrigerated cases		EUI kWh/ft².yr 38.5 MJ/m².yr 1492.4

OFFICE (PLUG-IN) EQUIPMENT

Connected Load (W/m²)	3.70		
Operating Time (hrs./yr.)	5800		
		EUI kWh/ft².yr 2.0 MJ/m².yr 77.3	

MISCELLANEOUS EQUIPMENT

		EUI kWh/ft².yr 2.5 MJ/m².yr 97.0

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Restaurant/Tavern

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.34
Roof U value (W/m ² .°C)	0.19
Glazing U value (W/m ² .°C)	3.28
Glazing Type	Double pane clear with blinds/drapes
Window/Wall Ratio (WIWAR) (%)	0.25
Shading Coefficient (SC)	0.59
Infiltration Rate (L/s.m ²)	3.05

GENERAL LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	215	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m²)	21.0	90%	0%	10%	0%	0%	0%	0%	100.0%
Operating Time (Hrs./yr.)	4500								
Scheduling Factor (SF)	1.05								
Floor Fraction (GLFF)	0.65								
		EUI kWh/m².yr 8.0							
		MUE3/yr 233.3							

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Restaurant/Tavern

Page 2

SPACE COOLING	
A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a roof top heating/cooling unit or a split system
A/C seasonal COP	2.6
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat.
Distribution System for Perimeter	Perimeter load met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)
Typical Connected Load (m²/Ton)	39.55
Total Cooling Load (MJ/m².yr) (Tertiary Load)	320.0
Internal Loads:	
Lighting (W/m²)	23.29
People (W/m²)	24.40
Plug Loads (W/m²)	2.60
Maint. & Scheduling Factor (M+SF)	1.18
EUI = Tertiary Load X M+SF/COP	
EUI kWh/ft².yr 3.7 MJ/m².yr 145.2	

HVAC ELECTRICITY	
Fan Connected Load (W/m²)	17.30
Pump Connected Load (W/m²)	3.00
Fan Control Type	ON/OFF control from room thermostat. Exhaust fans tend to operate continuously.
Pump Control Type	In most cases the presence of pumps is limited to a DHW circulating pump. Control is usually from a starter or MCC.
Fan Average Operation (hrs./yr.)	4500
Pump Average Operation (hrs./yr.)	3500
Maint. & Scheduling Factor (M+SF)	1.18
EUI kWh/ft².yr 4.1 MJ/m².yr 160.0	

SERVICE HOT WATER													
Service Hot Water Plant Type	190 L (50 Gal) dedicated water heater plus some instantaneous heater use												
Service Hot Water load (MJ/m².yr) (Tertiary Load)	327.00												
Wetting Use Percentage	0.50												
<table border="1"> <thead> <tr> <th></th> <th>Fossil</th> <th>Elec. Res.</th> </tr> </thead> <tbody> <tr> <td>Eff.</td> <td>0.65</td> <td>1.00</td> </tr> <tr> <td>EUI (kWh/ft².yr)</td> <td>13.0</td> <td>8.4</td> </tr> <tr> <td>EUI (MJ/m².yr)</td> <td>503.08</td> <td>327.0</td> </tr> </tbody> </table>			Fossil	Elec. Res.	Eff.	0.65	1.00	EUI (kWh/ft².yr)	13.0	8.4	EUI (MJ/m².yr)	503.08	327.0
	Fossil	Elec. Res.											
Eff.	0.65	1.00											
EUI (kWh/ft².yr)	13.0	8.4											
EUI (MJ/m².yr)	503.08	327.0											

COOKING EQUIPMENT													
commercial ovens, grilles	<table border="1"> <thead> <tr> <th></th> <th>Fossil</th> <th>Elec. Res.</th> </tr> </thead> <tbody> <tr> <td>Eff.</td> <td>0.55</td> <td>1.00</td> </tr> <tr> <td>EUI (kWh/ft².yr)</td> <td>17.2</td> <td>9.5</td> </tr> <tr> <td>EUI (MJ/m².yr)</td> <td>666.36</td> <td>368.50</td> </tr> </tbody> </table>		Fossil	Elec. Res.	Eff.	0.55	1.00	EUI (kWh/ft².yr)	17.2	9.5	EUI (MJ/m².yr)	666.36	368.50
	Fossil	Elec. Res.											
Eff.	0.55	1.00											
EUI (kWh/ft².yr)	17.2	9.5											
EUI (MJ/m².yr)	666.36	368.50											

REFRIGERATION EQUIPMENT	
single dedicated fixed capacity compressors serving commercial grade refrigerators and freezers	EUI kWh/ft².yr 5.7 MJ/m².yr 220.0

OFFICE (PLUG-IN) EQUIPMENT	
Connected Load (W/m²)	2.60
Operating Time (hrs./yr.)	4500
EUI kWh/ft².yr 1.1 MJ/m².yr 42.1	

MISCELLANEOUS EQUIPMENT	
EUI kWh/ft².yr 2.7 MJ/m².yr 103.0	

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Hotels/Motels

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.45
Roof U value (W/m ² .°C)	0.28
Glazing U value (W/m ² .°C)	3.28
Glazing Type	double pane clear with drapes
Window/Wall Ratio (W/WAR) (%)	0.35
Shading Coefficient (SC)	0.83
Infiltration Rate (L/s.m ²)	3.05

GENERAL LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	215	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m²)	20.2	70%	5%	20%	0%	0%	5%	0%	100.0%
Operating Time (Hrs./yr.)	3000								
Scheduling Factor (SF)	1.05								
Floor Fraction (GLFF)	0.85								
		EUI = Load X Hrs. X SF X GLFF							

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Hotels/Motels

Page 2

SPACE COOLING			
A/C Plant Type	Large hotels will have a central centrifugal chiller serving the building core services. Suites served by fan coils or packaged compartmental through-the-wall units		
A/C seasonal COP	3.0		
A/C Plant Control Mode	Fixed chilled water and condenser water setpoints for large centrifugal chillers. Packaged through-the-wall DX A/C units operate on fixed head pressure control.		
Distribution System for Perimeter	Some large hotels with central chillers will supply chilled water to fan coils in the suites. The majority will have a compartmental through-the-wall DX A/C unit.		
Distribution System for Core	Chilled water serving fan coils in some large hotels. Roof top or split DX systems in the majority of buildings supplying conditioned air at 12.8 °C (55 °F).		
Typical Connected Load (m²/Ton)	83.29		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	200.0		
Internal Loads:			
Lighting (W/m²)	20.47		
People (W/m²)	8.40		
Plug Loads (W/m²)	4.00		
Maint. & Scheduling Factor (M+SF)	1.12	EUI kWh/ft².yr	1.9
EUI = Tertiary Load X M+SF/COP		MJ/m².yr	74.7

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	1.50		
Pump Connected Load (W/m²)	0.50		
Fan Control Type	Control of fan on compartmental room unit through a thermostat located in the suite. Other Fans serving common areas controlled by room Thermostat. Exhaust fans operate continuously.		
Pump Control Type	ON/OFF control from MCC		
Fan Average Operation (hrs./yr.)	6000		
Pump Average Operation (hrs./yr.)	3500		
Maint. & Scheduling Factor (M+SF)	1.12	EUI kWh/ft².yr	1.1
		MJ/m².yr	43.3

SERVICE HOT WATER			
Service Hot Water Plant Type	Dedicated Service water boiler coupled to storage tank		
Service Hot Water load (MJ/m².yr) (Tertiary Load)			
		Fossil	Elec. Res.
		Eff.	
Wetting Use Percentage			
		Fossil	Elec. Res.
		Eff.	

COOKING EQUIPMENT			
commercial ovens, grilles			
		Fossil	Elec. Res.
		Eff.	

REFRIGERATION EQUIPMENT	EUI kWh/ft².yr	0.3
single dedicated fixed capacity compressors serving commercial grade refrigerators and freezers	MJ/m².yr	12.6

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	4.00		
Operating Time (hrs./yr.)	6000		
		EUI kWh/ft².yr	2.2
		MJ/m².yr	88.4

MISCELLANEOUS EQUIPMENT	EUI kWh/ft².yr	0.4
	MJ/m².yr	14.2

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Warehouse/Wholesale

Page 2

SPACE COOLING			
A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a rooftop heating/cooling unit, split system or a window unit. A/C unit typically serves office area only.		
A/C seasonal COP	2.5		
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat		
Distribution System for Perimeter	Perimeter load met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m²/Ton)	63.29		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	200.0		
Internal Loads:			
Lighting (W/m²)	17.68		
People (W/m²)	2.50		
Plug Loads (W/m²)	3.30		
Maint. & Scheduling Factor (M+SF)	1.18		
EUI = Tertiary Load X M+SF/COP		EUI kWh/m².yr	2.4
		MJ/m².yr	94.4

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	0.70		
Pump Connected Load (W/m²)	0.60		
Fan Control Type	ON/OFF control from room thermostat. Exhaust fans tend to operate continuously.		
Pump Control Type	In most cases the presence of pumps is limited to a DHW circulating pump. Control is usually from a starter or MCC.		
Fan Average Operation (hrs./yr.)	2200		
Pump Average Operation (hrs./yr.)	2500		
Maint. & Scheduling Factor (M+SF)	1.18		
		EUI kWh/m².yr	0.3
		MJ/m².yr	12.9

SERVICE HOT WATER			
Service Hot Water Plant Type	Small dedicated 75 L (20 Gal) hot water heater		
Service Hot Water load (MJ/m².yr) (Tertiary Load)		Fossil	Elec. Res.
	1.80	0.65	1.00
		0.1	0.0
		2.77	1.8
Wetting Use Percentage	0.90		

COOKING EQUIPMENT			
Small residential appliances/ microwavve ovens		Fossil	Elec. Res.
		0.55	1.00
		0.2	0.1
		7.27	4.00

REFRIGERATION EQUIPMENT		EUI kWh/m².yr	0.5
Industrial refrigeration equipment in refrigerated warehouses. Assume 7% of total floor area and EUI of 275 MJ/m².yr		MJ/m².yr	19.0

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	3.30		
Operating Time (hrs./yr.)	3500		
		EUI kWh/m².yr	1.1
		MJ/m².yr	41.8

MISCELLANEOUS EQUIPMENT		EUI kWh/m².yr	0.5
		MJ/m².yr	19.0

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Hospitals

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.42
Roof U value (W/m ² .°C)	0.40
Glazing U value (W/m ² .°C)	3.28
Glazing Type	Double pane clear with drapes
Window/Wall Ratio (WIWAR) (%)	0.30
Shading Coefficient (SC)	0.59
Infiltration Rate (L/s.m ²)	0.30

GENERAL LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	538	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m²)	22.9	10%	0%	90%	0%	0%	0%	0%	100.0%
Operating Time (Hrs./yr.)	2500								
Scheduling Factor (SF)	1.05								
Floor Fraction (GLFF)	0.40								
		EUI = Load X Hrs. X SF X GLFF							

BUILDING PROFILE

Page 2

MISCELLANEOUS EQUIPMENT	EUI kWh/R ² .yr	0.5
	MJ/m ² .yr	20.0

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Nursing Homes

Page 1

CONSTRUCTION									
Wall U value (W/m ² .°C)	0.45								
Roof U value (W/m ² .°C)	0.40								
Glazing U value (W/m ² .°C)	3.28								
Glazing Type	Double pane clear with drapes								
Window/Wall Ratio (W/WAR) (%)	0.30								
Shading Coefficient (SC)	0.58								
Infiltration Rate (L/s.m ²)	1.52								

GENERAL LIGHTING									
Light Level (Lux)	215	PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Connected Load (W/m ²)	18.3	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Operating Time (Hrs./yr.)	3400	60%	0%	40%	0%	0%	0%	0%	100.0%
Scheduling Factor (SF)	1.05								
Floor Fraction (GLFF)	0.65								
								EUI = Load X Hrs. X SF X GLFF	
								EUI kWh/m ² .yr	3.9
								MJ/m ² .yr	152.9

SERVICE AREA LIGHTING									
Light Level (Lux)	215	PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Connected Load (W/m ²)	11.0	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Operating Time (Hrs./yr.)	6100	20%	0%	80%	0%	0%	0%	0%	100.0%
Scheduling Factor (SF)	1.05								
Floor Fraction (SLFF)	0.35								
								EUI = Load X Hrs. X SF X SLFF	
								EUI kWh/m ² .yr	2.3
								MJ/m ² .yr	88.8

OTHER (HIGH BAY) LIGHTING									
Light Level (Lux)	215	PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Connected Load (W/m ²)	0.0	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Operating Time (Hrs./yr.)	0	0%	0%	0%	0%	0%	0%	0%	0.0%
Scheduling Factor (SF)	0								
Floor Fraction (OLFF)	0								
								EUI = Load X Hrs. X SF X OLFF	
								EUI kWh/m ² .yr	0.0
								MJ/m ² .yr	0.0

ALL LIGHTING END-USES										
								EUI TOTAL	kWh/m ² .yr	6.2
									MJ/m ² .yr	241.5

VENTILATION (AIR DISTRIBUTION)	
System Description	Constant volume make-up air unit serving corridors, common areas, main lobby
Outside Air (L/s.person)	16.52
Economizer	Not present
Control mode	Mixed discharge air temperature or room thermostat control.
Set Point (Summer)	
Set Point (Winter)	21.1 – 25.5 °C (70 – 78 °F)

SPACE HEATING	
Heating Plant Type	Gas fired atmospheric or incremental boilers producing hot water. In electric heated buildings heating will be by gas fired make-up air unit & electric baseboards in suites.
Core Space (Ventilation) Heating Type & Medium	Make-up air unit with either a hot water heating coil or direct gas fired heating.
Perimeter Space (Envelope) Heating Type & Medium	Hot water perimeter radiation or electric resistance baseboards.
Total Heating Load (MJ/m ² .yr) (Tertiary Load)	343.9
Maint. & Scheduling Factor (M+SF)	1.10
EUI = Tertiary Load X M+SF/eff.	

	Fossil	Elec.	Res.	A/A	HP	W.	S.	HP	H/R	Chiller
Eff./COP	0.65	1.00	2.30	2.50	4.50					
EUI (kWh/m ² .yr)	15.0	9.8	4.2	3.9	2.2					
EUI (MJ/m ² .yr)	582	378	164	151	84					

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Nursing Homes

Page 2

SPACE COOLING			
A/C Plant Type	Suites will be served by compartmental through-the-wall DX A/C units. Some might have fan coils. Roof top DX A/C units or split systems used to serve common areas.		
A/C seasonal COP	2.8		
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat		
Distribution System for Perimeter	Perimeter load met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m²/Ton)	63.29		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	200.0		
Internal Loads:			
Lighting (W/m²)	15.74		
People (W/m²)	2.60		
Plug Loads (W/m²)	3.00		
Maint. & Scheduling Factor (M+SF)	1.10	EUI kWh/ft².yr	2.2
EUI = Tertiary Load X M+SF/COP		MJ/m².yr	84.8

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	2.50		
Pump Connected Load (W/m²)	3.00		
Fan Control Type	Make-up air unit fan serving common areas operates continuously. Fans serving other areas might be manually operated or on time clocks.		
Pump Control Type	ON/OFF control from MCC		
Fan Average Operation (hrs./yr.)	7300		
Pump Average Operation (hrs./yr.)	4400		
Maint. & Scheduling Factor (M+SF)	1.10	EUI kWh/ft².yr	0.8
		MJ/m².yr	32.6

SERVICE HOT WATER			
Service Hot Water Plant Type	Dedicated service water heater with storage tank		
Service Hot Water load (MJ/m².yr) (Tertiary Load)			Fossil
			Elec. Res.
			Eff.
			EUI (kWh/ft².yr)
			EUI (MJ/m².yr)
Wetting Use Percentage	0.70		

COOKING EQUIPMENT			
commercial ovens, grilles			Fossil
			Elec. Res.
			Eff.
			EUI (kWh/ft².yr)
			EUI (MJ/m².yr)

REFRIGERATION EQUIPMENT	EUI kWh/ft².yr	0.8
single dedicated fixed capacity compressors serving commercial grade refrigerators and freezers	MJ/m².yr	30.0

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	3.00		
Operating Time (hrs./yr.)	3400		
		EUI kWh/ft².yr	0.9
		MJ/m².yr	36.7

MISCELLANEOUS EQUIPMENT	EUI kWh/ft².yr	0.3
	MJ/m².yr	12.8

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Universities/Colleges

Page 1

CONSTRUCTION			
Wall U value (W/m ² .°C)	0.47		
Roof U value (W/m ² .°C)	0.28		
Glazing U value (W/m ² .°C)	3.28		
Glazing Type	Double pane clear with drapes		
Window/Wall Ratio (WIWAR) (%)	0.35		
Shading Coefficient (SC)	0.59		
Infiltration Rate (L/s.m ²)	1.52		

GENERAL LIGHTING			
Light Level (Lux)	846		
Connected Load (W/m ²)	22.1		
Operating Time (Hrs./yr.)	4000		
Scheduling Factor (SF)	1.15		
Floor Fraction (GLFF)	0.85		
		EUI = Load X Hrs. X SF X GLFF	
		EUI kWh/ft ² .yr	8.1
		MJ/m ² .yr	238.2

SERVICE AREA LIGHTING			
Light Level (Lux)	215		
Connected Load (W/m ²)	11.0		
Operating Time (Hrs./yr.)	4500		
Scheduling Factor (SF)	1.15		
Floor Fraction (SLFF)	0.35		
		EUI = Load X Hrs. X SF X SLFF	
		EUI kWh/ft ² .yr	1.8
		MJ/m ² .yr	71.6

OTHER (HIGH BAY) LIGHTING			
Light Level (Lux)	323		
Connected Load (W/m ²)	0.0		
Operating Time (Hrs./yr.)	0		
Scheduling Factor (SF)	0		
Floor Fraction (OLFF)	0		
		EUI = Load X Hrs. X SF X OLFF	
		EUI kWh/ft ² .yr	0.0
		MJ/m ² .yr	0.0

ALL LIGHTING END-USES		EUI TOTAL	kWh/ft ² .yr 8.0
			MJ/m ² .yr 309.8

VENTILATION (AIR DISTRIBUTION)	
System Description	Built-up central or compartmental AHU on every floor. VAV system is presently considered the standard with a incidence of use of 100%. Typical air flow rates of 3.8 – 5.1 L/s.m ² (0.75 – 1.0 CFM/ft ²)
Outside Air (L/s.person)	9.44
Economizer	Yes Half of systems are enthalpy based, othewr half are dry bulb based. All new large offices equipped with an FMS that provides floating economizer control
Control mode	Modulating dampers with "damper mixed air control" plus fixed discharge air temperature. DDC control via an FMS system considered the standard in all new large offices.
Set Point (Summer)	12.8 – 17.8 °C (55 – 64 °F)
Set Point (Winter)	15.5 – 18.3 °C (60 – 65 °F)
	Discharge Air Temperature

SPACE HEATING	
Heating Plant Type	Gas fired fire tube boiler producing hot water. Atmospheric or incremental boilers also present.
Core Space (Ventilation) Heating Type & Medium	Hot water via heating coils in central AHU. Also present terminal reheat coils in the space.
Perimeter Space (Envelope) Heating Type & Medium	Hot water perimeter radiators or terminal reheat systems installed in perimeter
Total Heating Load (MJ/m ² .yr) (Tertiary Load)	470.0
Maint. & Scheduling Factor (M+SF)	1.12
EUI = Tertiary Load X M+SF/Eff.	

	Fossil	Elec.	Res.	A/A	HP	W.	S.	HP	H/R	Chiller
Eff./COP	0.85	1.00	2.30	2.50	4.50					
EUI (kWh/ft ² .yr)	20.9	13.8	5.9	5.4	3.0					
EUI (MJ/m ² .yr)	810	526	229	211	117					

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Universities/Colleges

Page 2

SPACE COOLING

A/C Plant Type	Centrifugal chillers used by 75% of the stock. Screw or helical chillers used by 15% of the stock. The remainder stock uses reciprocating chillers.		
A/C seasonal COP	4.2		
A/C Plant Control Mode	Chiller load control based on fixed chilled water temperature set at 5.5 °C (42 °F). Fixed condenser water temperature control set at 29.4 °C (85 °F).		
Distribution System for Perimeter	Perimeter load met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m²/Ton)	83.29		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	200.0		
Internal Loads:			
Lighting (W/m²)	18.23		
People (W/m²)	132.40		
Plug Loads (W/m²)	5.00		
Maint. & Scheduling Factor (M+SF)	1.12	EUI kWh/ft².yr	1.4
EUI = Tertiary Load X M+SF/COP		MJ/m².yr	53.3

HVAC ELECTRICITY

Fan Connected Load (W/m²)	10.20		
Pump Connected Load (W/m²)	3.00		
Fan Control Type	Supply and return fans on main AHU under VAV control. Supply/Return and exhaust fans under automated scheduling via FMS.		
Pump Control Type	All pumps controlled by FMS to minimize operation during unoccupied hrs.		
Fan Average Operation (hrs./yr.)	3000		
Pump Average Operation (hrs./yr.)	3500		
Maint. & Scheduling Factor (M+SF)	1.12	EUI kWh/ft².yr	4.3
		MJ/m².yr	165.7

SERVICE HOT WATER

Service Hot Water Plant Type	Dedicated service water heater with storage tank		
Service Hot Water load (MJ/m².yr) (Tertiary Load)		Fossil	Elec. Res.
		Eff.	
		EUI (kWh/ft².yr)	
	53.80	0.65	1.00
		2.1	1.4
		82.77	53.8
Wetting Use Percentage	0.40		

COOKING EQUIPMENT

commercial ovens, grilles		Fossil	Elec. Res.
		Eff.	
		EUI (kWh/ft².yr)	
		0.55	1.00
		1.0	0.6
		40.00	22.00

REFRIGERATION EQUIPMENT

single dedicated fixed capacity compressors serving commercial grade refrigerators and freezers

EUI kWh/ft².yr	0.3
MJ/m².yr	10.0

OFFICE (PLUG-IN) EQUIPMENT

Connected Load (W/m²)	5.00		
Operating Time (hrs./yr.)	4000		
		EUI kWh/ft².yr	1.9
		MJ/m².yr	72.0

MISCELLANEOUS EQUIPMENT

EUI kWh/ft².yr	0.4
MJ/m².yr	15.0

B.C. HYDRO CONSERVATION POTENTIAL REVIEW - COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Schools

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.28
Roof U value (W/m ² .°C)	0.23
Glazing U value (W/m ² .°C)	5.68
Glazing Type	Single pane clear with drapes
Window/Wall Ratio (WIWAR) (%)	0.35
Shading Coefficient (SC)	0.59
Infiltration Rate (L/s.m ²)	1.52

GENERAL LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	538	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	18.4	0%	0%	80%	10%	0%	10%	0%	100.0%
Operating Time (Hrs./yr.)	2500								
Scheduling Factor (SF)	1.20								
Floor Fraction (GLFF)	0.70								
EUI = Load X Hrs. X SF X GLFF								EUI kWh/m ² .yr	3.8
								MJ/m ² .yr	139.4

SERVICE AREA LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	215	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	9.1	10%	0%	90%	0%	0%	0%	0%	100.0%
Operating Time (Hrs./yr.)	4500								
Scheduling Factor (SF)	1.20								
Floor Fraction (SLFF)	0.30								
EUI = Load X Hrs. X SF X SLFF								EUI kWh/m ² .yr	1.4
								MJ/m ² .yr	53.4

OTHER (HIGH BAY) LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	323	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m ²)	0.0	0%	0%	0%	0%	0%	0%	0%	0.0%
Operating Time (Hrs./yr.)	0								
Scheduling Factor (SF)	0								
Floor Fraction (OLFF)	0								
EUI = Load X Hrs. X SF X OLFF								EUI kWh/m ² .yr	0.0
								MJ/m ² .yr	0.0

ALL LIGHTING END-USES	EUI TOTAL	kWh/m ² .yr	5.0
		MJ/m ² .yr	192.8

VENTILATION (AIR DISTRIBUTION)	
System Description	Built-up central AHU. CAV single zone or CAV with reheat. VAV present in some schools. Typical air flow rates of 3.8 - 5.1 L/s.m ² (0.75 - 1.0 CFM/m ²). Unit ventilators or "Herman Nelson" through the wall ventilators present in the newer schools
Outside Air (L/s.person)	7.08
Economizer	Yes Dry Bulb based set to switch at 15.5 °C (60 °F)
Control mode	Modulating dampers with "damper mixed air control" plus fixed discharge air. temperature. Very little incidence of reset control via room ore return air. Proportional control only some PI & PID via DDC.
Set Point (Summer)	12.8 - 17.8 °C cooling available
Set Point (Winter)	18.3 °C (65 °F)

SPACE HEATING																									
Heating Plant Type	Gas fired fire tube boiler producing hot water. Atmospheric or incremental boilers also present.																								
Core Space (Ventilation) Heating Type & Medium	Hot water via heating coils in central AHU. Also present terminal reheat coils in the space.																								
Perimeter Space (Envelope) Heating Type & Medium	Hot water perimeter radiators or terminal reheat systems installed in perimeter																								
Total Heating Load (MJ/m ² .yr) (Tertiary Load)	205.0																								
Maint. & Scheduling Factor (M+SF)	1.12																								
EUI = Tertiary Load X M+SF/eff.																									
	<table><tr><th></th><th>Fossil</th><th>Elec. Res.</th><th>A/A HP</th><th>W. S. HP</th><th>H/R Chiller</th></tr><tr><td>Eff./COP</td><td>0.85</td><td>1.00</td><td>2.30</td><td>2.50</td><td>4.50</td></tr><tr><td>EUI (kWh/m².yr)</td><td>9.1</td><td>5.9</td><td>2.6</td><td>2.4</td><td>1.3</td></tr><tr><td>EUI (MJ/m².yr)</td><td>353</td><td>230</td><td>100</td><td>92</td><td>51</td></tr></table>		Fossil	Elec. Res.	A/A HP	W. S. HP	H/R Chiller	Eff./COP	0.85	1.00	2.30	2.50	4.50	EUI (kWh/m ² .yr)	9.1	5.9	2.6	2.4	1.3	EUI (MJ/m ² .yr)	353	230	100	92	51
	Fossil	Elec. Res.	A/A HP	W. S. HP	H/R Chiller																				
Eff./COP	0.85	1.00	2.30	2.50	4.50																				
EUI (kWh/m ² .yr)	9.1	5.9	2.6	2.4	1.3																				
EUI (MJ/m ² .yr)	353	230	100	92	51																				

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
Schools

Page 2

SPACE COOLING		
A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a roof top heating/cooling unit, split system or a window unit.	
A/C seasonal COP	2.6	
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat	
Distribution System for Perimeter	Perimeter load met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).	
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)	
Typical Connected Load (m²/Ton)	63.29	
Total Cooling Load (MJ/m².yr) (Tertiary Load)	200.0	
Internal Loads:		
Lighting (W/m²)	15.65	
People (W/m²)	132.40	
Plug Loads (W/m²)	1.50	
Maint. & Scheduling Factor (M+SF)	1.12	
EUI = Tertiary Load X M+SF/COP		
		EUI kWh/ft².yr 2.2 MJ/m².yr 66.2

HVAC ELECTRICITY		
Fan Connected Load (W/m²)	1.00	
Pump Connected Load (W/m²)	0.50	
Fan Control Type	Manual ON/OFF control of AHU CAV fans from MCC scheduled by building operator. Some auto control through time clocks or FMS. Schools with unit ventilators provide ON/OFF control through room thermostat.	
Pump Control Type	Manual ON/OFF control from MCC by building operator or through an FMS. FMS is estimated to be present in 50%	
Fan Average Operation (hrs./yr.)	2500	
Pump Average Operation (hrs./yr.)	2500	
Maint. & Scheduling Factor (M+SF)	1.12	
		EUI kWh/ft².yr 0.4 MJ/m².yr 15.1

SERVICE HOT WATER														
Service Hot Water Plant Type	Dedicated service water heater with storage tank													
Service Hot Water load (MJ/m².yr) (Tertiary Load)	22.00													
Wetting Use Percentage	0.50													
		<table border="1"> <thead> <tr> <th></th><th>Fossil</th><th>Elec. Res.</th></tr> </thead> <tbody> <tr> <td>Eff.</td><td>0.65</td><td>1.00</td></tr> <tr> <td>EUI (kWh/ft².yr)</td><td>0.9</td><td>0.6</td></tr> <tr> <td>EUI (MJ/m².yr)</td><td>33.85</td><td>22.0</td></tr> </tbody> </table>		Fossil	Elec. Res.	Eff.	0.65	1.00	EUI (kWh/ft².yr)	0.9	0.6	EUI (MJ/m².yr)	33.85	22.0
	Fossil	Elec. Res.												
Eff.	0.65	1.00												
EUI (kWh/ft².yr)	0.9	0.6												
EUI (MJ/m².yr)	33.85	22.0												

COOKING EQUIPMENT														
commercial ovens, grilles		<table border="1"> <thead> <tr> <th></th><th>Fossil</th><th>Elec. Res.</th></tr> </thead> <tbody> <tr> <td>Eff.</td><td>0.55</td><td>1.00</td></tr> <tr> <td>EUI (kWh/ft².yr)</td><td>0.2</td><td>0.1</td></tr> <tr> <td>EUI (MJ/m².yr)</td><td>6.73</td><td>4.80</td></tr> </tbody> </table>		Fossil	Elec. Res.	Eff.	0.55	1.00	EUI (kWh/ft².yr)	0.2	0.1	EUI (MJ/m².yr)	6.73	4.80
	Fossil	Elec. Res.												
Eff.	0.55	1.00												
EUI (kWh/ft².yr)	0.2	0.1												
EUI (MJ/m².yr)	6.73	4.80												

REFRIGERATION EQUIPMENT		EUI kWh/ft².yr 0.3 MJ/m².yr 10.0
single dedicated fixed capacity compressors serving commercial grade refrigerators and freezers		

OFFICE (PLUG-IN) EQUIPMENT		
Connected Load (W/m²)	1.50	
Operating Time (hrs./yr.)	2500	
		EUI kWh/ft².yr 0.3 MJ/m².yr 13.5

MISCELLANEOUS EQUIPMENT		EUI kWh/ft².yr 0.0 MJ/m².yr 0.4

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

New Buildings
High Rise Apartments

Page 1

CONSTRUCTION	
Wall U value (W/m ² .°C)	0.40
Roof U value (W/m ² .°C)	0.28
Glazing U value (W/m ² .°C)	3.28
Glazing Type	double pane clear with blinds/drapes
Window/Wall Ratio (WIWAR) (%)	0.30
Shading Coefficient (SC)	0.59
Infiltration Rate (L/s.m ²)	1.52

GENERAL LIGHTING	
Light Level (Lux)	215
Connected Load (W/m ²)	22.9
Operating Time (Hrs./yr.)	1200
Scheduling Factor (SF)	1.05
Floor Fraction (GLFF)	0.85

PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
85%	0%	15%	0%	0%	0%	0%	100.0%

EUI = Load X Hrs. X SF X GLFF

EUI kWh/ft ² .yr	2.3
MJ/m ² .yr	88.2

SERVICE AREA LIGHTING	
Light Level (Lux)	181
Connected Load (W/m ²)	9.8
Operating Time (Hrs./yr.)	8760
Scheduling Factor (SF)	1.05
Floor Fraction (SLFF)	0.15

PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
30%	0%	70%	0%	0%	0%	0%	100.0%

EUI = Load X Hrs. X SF X SLFF

EUI kWh/ft ² .yr	1.2
MJ/m ² .yr	47.7

OTHER (HIGH BAY) LIGHTING	
Light Level (Lux)	215
Connected Load (W/m ²)	0.0
Operating Time (Hrs./yr.)	0
Scheduling Factor (SF)	0
Floor Fraction (OLFF)	0

PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
0%	0%	0%	0%	0%	0%	0%	0.0%

EUI = Load X Hrs. X SF X OLFF

EUI kWh/ft ² .yr	0.0
MJ/m ² .yr	0.0

ALL LIGHTING END-USES	EUI TOTAL	kWh/ft ² .yr	3.5
		MJ/m ² .yr	135.9

VENTILATION (AIR DISTRIBUTION)	
System Description	Constant volume make-up air unit serving corridors, common areas, main lobby
Outside Air (L/s.person)	7.08
Economizer	Not present
Control mode	Mixed discharge air temperature or room thermostat control.
Set Point (Summer)	
Set Point (Winter)	21.1 – 25.5 °C (70 – 78 °F)

SPACE HEATING	
Heating Plant Type	Gas fired atmospheric or incremental boilers producing hot water. In electric heated buildings heating will be by gas fired make-up air unit & electric baseboards in suites.
Core Space (Ventilation) Heating Type & Medium	Make-up air unit with either a hot water heating coil or direct gas fired heating.
Perimeter Space (Envelope) Heating Type & Medium	Hot water perimeter radiation or electric resistance baseboards. Also some through the wall heat pumps in condominiums
Total Heating Load (MJ/m ² .yr) (Tertiary Load)	200.0
Maint. & Scheduling Factor (M+SF)	1.18

	Fossil	Elec.	Res.	A/A	HP	W.	S.	HP	H/R	Chiller
Eff./COP	0.65	1.00	2.30	2.50	4.50					
EUI (kWh/ft ² .yr)	8.4	8.1	2.8	2.4	1.4					
EUI (MJ/m ² .yr)	383	236	103	94	52					

EUI = Tertiary Load X M+SF/Eff.

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SPACE COOLING			
A/C Plant Type	Suites will be served by compartmental through-the-wall DX A/C units. Some might have fan coils. Roof top DX A/C units or split systems used to serve common areas.		
A/C seasonal COP	2.6		
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat.		
Distribution System for Perimeter	Perimeter load met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).		
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)		
Typical Connected Load (m²/Ton)	83.29		
Total Cooling Load (MJ/m².yr) (Tertiary Load)	200.0		
Internal Loads:			
Lighting (W/m²)	20.88		
People (W/m²)	2.60		
Plug Loads (W/m²)	4.00		
Maint. & Scheduling Factor (M+SF)	1.18		
EUI = Tertiary Load X M+SF/COP		EUI kWh/ft².yr	2.3
		MJ/m².yr	90.8

HVAC ELECTRICITY			
Fan Connected Load (W/m²)	1.50		
Pump Connected Load (W/m²)	1.00		
Fan Control Type	Make-up air unit fan serving common areas operates continuously. Fans on through the wall units in individual suites controlled by room thermostats.		
Pump Control Type	ON/OFF control from MCC		
Fan Average Operation (hrs./yr.)	5800		
Pump Average Operation (hrs./yr.)	3500		
Maint. & Scheduling Factor (M+SF)	1.18		
		EUI kWh/ft².yr	1.3
		MJ/m².yr	51.8

SERVICE HOT WATER			
Service Hot Water Plant Type	Dedicated service water heater with storage tank		
Service Hot Water load (MJ/m².yr) (Tertiary Load)	100.00		
Wetting Use Percentage	0.70		
		Fossil	Elec. Res.
		Eff.	0.65
		EUI (kWh/ft².yr)	1.00
		EUI (MJ/m².yr)	4.0
			2.8
			153.85
			100.0

COOKING EQUIPMENT			
residential stove			
		Fossil	Elec. Res.
		Eff.	0.55
		EUI (kWh/ft².yr)	1.00
		EUI (MJ/m².yr)	0.9
			0.5
			34.55
			19.00

REFRIGERATION EQUIPMENT			EUI kWh/ft².yr
small residential type fridge			0.9
			36.0

OFFICE (PLUG-IN) EQUIPMENT			
Connected Load (W/m²)	4.00		
Operating Time (hrs./yr.)	2500		
		EUI kWh/ft².yr	0.9
		MJ/m².yr	36.0

MISCELLANEOUS EQUIPMENT			EUI kWh/ft².yr
			0.3
			12.8

B.C. HYDRO CONSERVATION POTENTIAL REVIEW – COMMERCIAL SECTOR

BUILDING PROFILE

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CONSTRUCTION	
Wall U value (W/m ² .°C)	0.40
Roof U value (W/m ² .°C)	0.34
Glazing U value (W/m ² .°C)	5.68
Glazing Type	single pane clear
Window/Wall Ratio (WIWAR) (%)	0.25
Shading Coefficient (SC)	0.59
Infiltration Rate (L/s.m ²)	1.52

GENERAL LIGHTING		PERCENT SHARE OF LIGHTING SYSTEMS PRESENT							
Light Level (Lux)	846	INC	CFL	FL4	FL8	MV	MH	HPS	TOTAL
Connected Load (W/m²)	34.4	20%	0%	40%	10%	10%	10%	10%	100.0%
Operating Time (Hrs./yr.)	3000								
Scheduling Factor (SF)	1.10								
Floor Fraction (GLFF)	0.80								
		EUI = Load X Hrs. X SF X GLFF							

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SPACE COOLING		
A/C Plant Type	DX A/C units using reciprocating compressors. The A/C unit can be in the form of either a roof top heating/cooling unit or a split system	
A/C seasonal COP	2.8	
A/C Plant Control Mode	Fixed head pressure control. Compressor control is ON/OFF based call for cooling from room thermostat	
Distribution System for Perimeter	Perimeter load met mostly with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F).	
Distribution System for Core	Cooling load in core met with conditioned supply air at 12.8 – 17.8 °C (55 – 64 °F)	
Typical Connected Load (m²/Ton)	63.29	
Total Cooling Load (MJ/m².yr) (Tertiary Load)	200.0	
Internal Loads:		
Lighting (W/m²)	30.17	
People (W/m²)	4.00	
Plug Loads (W/m²)	3.00	
Maint. & Scheduling Factor (M+SF)	1.14	
	EUI = Tertiary Load X M+SF/COP	

EUI kWh/ft².yr	2.3
MJ/m².yr	87.7

HVAC ELECTRICITY	
Fan Connected Load (W/m²)	5.00
Pump Connected Load (W/m²)	0.00
Fan Control Type	ON/OFF control from room thermostat. Exhaust fans tend to operate continuously.
Pump Control Type	In most cases the presence of pumps is limited to a DHW circulating pump. Control is usually from a starter or MCC.
Fan Average Operation (hrs./yr.)	3000
Pump Average Operation (hrs./yr.)	0
Maint. & Scheduling Factor (M+SF)	1.14

EUI kWh/ft².yr	1.8
MJ/m².yr	61.6

SERVICE HOT WATER		
Service Hot Water Plant Type	38 – 75 L (10 – 20 Gal) dedicated water heater	
Service Hot Water load (MJ/m².yr) (Tertiary Load)	4.00	
Wetting Use Percentage	0.90	

	Fossil	Elec. Res.
Eff.	0.65	1.00
EUI (kWh/ft².yr)	0.2	0.1
EUI (MJ/m².yr)	6.15	4.0

COOKING EQUIPMENT			
Small residential appliances/ microwave ovens		Fossil	Elec. Res.
	Eff.	0.55	1.00
	EUI (kWh/ft².yr)	0.0	0.0
	EUI (MJ/m².yr)	0.00	0.00

REFRIGERATION EQUIPMENT		EUI kWh/m ² .yr	0.0
single dedicated fixed capacity compressors on small fridges		MJ/m ² .yr	0.0

OFFICE (PLUG-IN) EQUIPMENT				
Connected Load (W/m²)	3.00			
Operating Time (hrs./yr.)	3000			
			EUI kWh/m².yr	0.8
			MJ/m².yr	32.4

MISCELLANEOUS EQUIPMENT				
			EUI kWh/ft².yr	0.3
			MJ/m².yr	12.0

APPENDIX 7

CONNECTED LIGHT LOAD CALCULATION DETAILS

CONNECTED LIGHT LOAD CALCULATION DETAILS

The 6 enclosed tables display the design data used to calculate the connected light loads for each building segment in each of the three end-uses (general, service area, and other lighting) that were used in the frozen efficiency and energy conservation scenarios. The design parameters used to calculate the connected light loads include the light levels in fc (ft-candles), the efficacy of the lighting system in lumens/W, the coefficient of utilization (CU), and the light loss factor (LLF). All the above components were used to calculate the weighted average connected light loads taking into consideration the distribution of the various lighting system types that are present.

The equation shown below illustrates how this was done:

$$\text{Light Load (W/ft}^2\text{)} = \text{Light Level} / \text{Efficacy} / \text{CU} / \text{LLF}$$

This calculation was done for every lighting system type present in the building segment and multiplied by its percentage share of the total. This is shown in the equation below which was used to derive the weighted average connected light load.

$$\begin{aligned} \text{Light Load (W/ft}^2\text{)} = & \left[\frac{\text{lumens}}{\text{ft}^2} \right] \left[\frac{W}{\text{lumens}} \right] \left[\frac{1}{CU} \right] \left[\frac{1}{LLF} \right] \left[\frac{1}{\text{SHARE}_{INC}} \right] \\ & + \left[\frac{\text{lumens}}{\text{ft}^2} \right] \left[\frac{W}{\text{lumens}} \right] \left[\frac{1}{CU} \right] \left[\frac{1}{LLF} \right] \left[\frac{1}{\text{SHARE}_{CFL}} \right] \\ & + \left[\frac{\text{lumens}}{\text{ft}^2} \right] \left[\frac{W}{\text{lumens}} \right] \left[\frac{1}{CU} \right] \left[\frac{1}{LLF} \right] \left[\frac{1}{\text{SHARE}_{FL}} \right] \\ & + \dots\dots\dots\text{etc.} \end{aligned}$$

The weighted average connected light load for the years 2000 and 2010 were re-calculated assuming the following changes:

1. changes in the value of CU due to the use of specular reflectors
2. changes in the efficacy due to more efficient lighting systems (T8's plus daylighting)
3. changes in light levels
4. changes in the efficacy due to more efficient lighting systems (2-Photon Lamps plus daylighting)
5. Reduction in hours of operation due to the use of ALC's + Occ. Sensors

This was done as per the "packaging" or bundling of technologies described in sections 9, 10, and 11 of the main report. Specifically, the various technologies affect the lighting design components as follows:

1st Technology Change, Specular Reflectors

Use of specular reflectors improves the efficiency of the fixture 10 - 15% ¹. This is equivalent to increasing the CU by 10 - 15% which allows the removal of some lamps without sacrificing light levels more than 25%. In the analysis the CU is assumed to increase from 0.7 to 0.8 which is a 14% increase. The light level is also reduced by an estimated 25% to 71.2 fc (95*0.75). The reflector will cut the number of lights from 30% - 50% depending on fixture type. The new connected light load as a result of the changes is:

$$\begin{aligned}\text{Revised connected load} &= 71.2/70/0.8/0.7*10.76 \\ &= 19.5 \text{ W/m}^2\end{aligned}$$

$$\begin{aligned}\text{Revised EUI (MJ/m}^2\text{.yr)} &= 19.5*3,100*3.6/1000*1.15*0.75 \\ &= 187.7 \text{ MJ/m}^2\text{.yr}\end{aligned}$$

This represents a 34% reduction in connected load and energy consumption over the baseline fixture.

2nd Technology Change, T8 envelopes + Daylighting

Use of T8 envelopes plus daylighting for the perimeter of the building is assumed to increase the efficacy from the baseline 70 Lumens/W to 100 Lumens/W. Note that the efficacy of T8 envelopes is approximately 80 - 90 Lumens/W ². The additional increase in efficacy to 100

¹ See the following two references:

Competitek, *The State of the Art Lighting*, p. 137-138.

National Lighting Product Information Program, *Specifier Reports*, "Electronic Ballasts", The Lighting Research Center, Rensselaer Polytechnic Institute, Dec., 1991.

² i) Competitek, *The State of the Art, Lighting*, p. 123. T8 envelopes display efficacies of 78-95 Lumens/W.
ii) Competitek, *The State of the Art, Lighting*, APPENDIX H, p. 290, 292, GE & Sylvania T8 lamps display initial efficacies of 90-95 Lumens/W.
iii) Advance Transformer Co., *Realities in Retrofitting*, p. 11, F32T8 + ballast display efficacies of 84-86 Lumens/W.

Lumens/W is a surrogate method ³ to show the contribution from daylighting which allows the use of less power (through proportional dimming of ballasts) while maintaining the same light level. For example, if daylighting contribution to the perimeter allows the reduction in the light output from the perimeter lighting by 50% while maintaining the same light level, and the building perimeter represents 30% of the total floor area, the resulting new efficacy is determined as follows:

Assume T8 envelope with an efficacy of 85 Lumens/W, light level of 71.2 fc. 0.8 CU and 0.7 LLF.

$$\begin{aligned}\text{Connected light load} &= 71.2/85/0.8/0.7*10.76 \\ &= 16.1 \text{ W/m}^2\end{aligned}$$

Effective connected load or power draw with daylighting contribution

$$\begin{aligned}&= 16.1*0.7 + 16.1*.5*.3 \\ &= 13.7 \text{ W/m}^2\end{aligned}$$

$$\begin{aligned}\text{Effective efficacy} &= 71.2/13.7/0.8/0.7*10.76 \\ &= 100 \text{ Lumens/W}\end{aligned}$$

$$\begin{aligned}\text{EUI} &= 13.7*3,100*3.6/1000*1.15*0.75 \\ &= 131.9 \text{ MJ/m}^2.\text{yr}\end{aligned}$$

This represents a 54% reduction in connected load and energy consumption over the baseline fixture.

3rd Technology Change, Optimum Light Levels

Optimum light levels are made possible through the use of dimmable electronic ballasts which allow task tuning of each fixture through adjustment of the ballast max/min outputs. This reduces light levels to a weighted average of 35 fc. The reduction in connected load is proportional to the reduction in light levels which is equal to:

$$\begin{aligned}\text{connected load} &= 35/71.2*13.7 \\ &= 6.7 \text{ W/m}^2\end{aligned}$$

iv) National Lighting Product Information Program, *Specifier Report*, "Electronic Ballasts, p. 3 Table 1, efficacy of 2-32W F32 T8 lamps with electronic ballast displays an efficacy of 90 Lumens/W.

³ Competitek, *The State of the Art Lighting*, p. 196

Marbek

EUI

$$\begin{aligned} &= 6.7 \times 3,100 \times 3.6 / 1000 \times 1.15 \times 0.75 \\ &= 64.5 \text{ MJ/m}^2.\text{yr} \end{aligned}$$

This represents a 77% reduction in connected load and energy consumption over the baseline system. Note that daylighting contributes the same percentage at the reduced light levels, but a lower absolute amount of light.

4th Technology Change, 2-Photon Lamps

The use of 2-Photon Lamps which are predicted to be available in the late 1990's will provide additional savings due to much higher efficacy than these lamps display over T-8 lamps (see Section 7). These lamps are expected to display efficacies of 200 Lumens/W or more. Including perimeter daylighting will increase this value to an effective 230 Lumens/W. The resulting connected load and EUI is:

connected load

$$\begin{aligned} &= 35 / 230 / 0.8 / 0.7 \times 10.76 \\ &= 2.9 \text{ W/m}^2 \end{aligned}$$

EUI

$$\begin{aligned} &= 2.9 \times 3,100 \times 3.6 / 1000 \times 1.15 \times 0.75 \\ &= 27.9 \text{ MJ/m}^2.\text{yr} \end{aligned}$$

This represents a 90% reduction in connected load and energy consumption over the baseline system.

5th Technology Change, 2 Automatic Light Controls and Occupancy Sensors

The use of ALC's + Occupancy Sensors will reduce the hrs. of operation during the occupied period (due to intermittent use of the space) and the unoccupied period by shutting off lights completely when not needed. The reduction in operating time is estimated to be 20%. The new EUI's for the T8 lighting systems and 2-Photon Lamps would be:

	EUI (MJ/m ² .yr.) (no ALC's or Sensors)	EUI (MJ/m ² .yr.) (ALC's + Sensors)
T8 System	64.5	52
2-Photon Lamps	27.9	22.5

The reduction in energy consumption that results from the use of ALC's + Occupancy Sensors in addition to the systems above, would therefore, be 82% for T8 lighting systems and 92% for 2-Photon Lamps.

CONNECTED LIGHT LOAD TABLES ABBREVIATIONS LIST

Term	Definition
2-PH.L.	Two-photon lamp
4T8	4 foot T8 lamp; 32 watts
8T8	8 foot T8 lamp; 60 watts
40T12	40 watt T12 lamp
96T12	96 watt T12 lamp
CFL	Compact fluorescent light
Comm	Commercial
CU	Coefficient of utilization
fc	Foot candle
HPS	High pressure sodium
INC	Incandescent
Inst	Institutional
L/w	Lumens per watt
LLF	Light loss factor
Ltg Ld	Light Load
Ltg Lvl	Light Level
MH	Metal Halide
Misc	Miscellaneous
MV	Mercury Vapour
Serv	Service

BC HYDRO COMMERCIAL SECTOR – 1988 EXISTING BUILDINGS
GENERAL LIGHTING COMPONENT
BASELINE

Building Segment	Lt看 Lvl (fc)	CU LLF L/w	Percent Lt看 Share in These Systems							Lt看 Ld (W/m²)
			INC	CFL	40T12	96T12	MV	MH	HPS	
			80% 70% 15	70% 70% 50	70% 70% 60	70% 70% 60	60% 60% 45	60% 70% 65	60% 70% 90	
Large Offices (> 3,700 m²)	95		0%	0%	100%	0%	0%	0%	0%	34.8
Small Offices (< 3,700 m²)	95		0%	0%	100%	0%	0%	0%	0%	34.8
Non-Food Retail	80		20%	0%	60%	0%	0%	20%	0%	44.4
Food Retail	80		14%	0%	66%	10%	0%	10%	0%	39.8
Restaurant/Tavern	20		80%	0%	20%	0%	0%	0%	0%	22.0
Hotels/Motels	15		75%	0%	20%	0%	0%	5%	0%	15.8
Warehouse/Wholesale	40		10%	0%	20%	50%	10%	0%	10%	19.2
Hospitals	50		20%	0%	80%	0%	0%	0%	0%	27.4
Nursing Homes	25		20%	0%	80%	0%	0%	0%	0%	13.7
Universities/Colleges	45		10%	0%	70%	10%	0%	10%	0%	20.7
Schools	40		10%	0%	80%	0%	0%	10%	0%	18.4
High Rise Apt	15		90%	0%	10%	0%	0%	0%	0%	17.8
Other (Serv/Inst/Comm/Misc)	45		10%	0%	60%	10%	10%	5%	5%	21.8

BC HYDRO COMMERCIAL SECTOR – 1988 EXISTING BUILDINGS
GENERAL LIGHTING COMPONENT
UPGRADE 2000

Building Segment	Lt看 Lvl (fc)	CU LLF L/w	Percent Lt看 Share in These Systems							Lt看 Ld (W/m²)
			INC	CFL	4T8	8T8	MV	MH	HPS	
			80% 70% 15	70% 70% 50	80% 70% 100	80% 70% 100	60% 60% 45	60% 70% 65	60% 70% 90	
Large Offices (> 3,700 m²)	35		0%	0%	100%	0%	0%	0%	0%	6.7
Small Offices (< 3,700 m²)	35		0%	0%	100%	0%	0%	0%	0%	6.7
Non-Food Retail	50		0%	20%	60%	0%	0%	20%	0%	14.1
Food Retail	25		0%	14%	66%	10%	0%	10%	0%	6.3
Restaurant/Tavern	20		0%	80%	20%	0%	0%	0%	0%	7.8
Hotels/Motels	15		0%	75%	20%	0%	0%	5%	0%	5.8
Warehouse/Wholesale	40		0%	10%	20%	50%	0%	0%	20%	10.1
Hospitals	35		0%	20%	80%	0%	0%	0%	0%	8.5
Nursing Homes	25		0%	20%	80%	0%	0%	0%	0%	6.0
Universities/Colleges	35		0%	10%	70%	10%	0%	10%	0%	8.4
Schools	35		0%	10%	80%	0%	0%	10%	0%	8.3
High Rise Apt	15		0%	90%	10%	0%	0%	0%	0%	6.2
Other (Serv/Inst/Comm/Misc)	35		0%	10%	60%	10%	0%	5%	15%	8.5

BC HYDRO COMMERCIAL SECTOR – 1988 EXISTING BUILDINGS
GENERAL LIGHTING COMPONENT
UPGRADE 2010

Building Segment	Lt看 Lvl (fc)	CU LLF L/w	Percent Lt看 Share in These Systems							Lt看 Ld (W/m²)
			2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	
			80% 70% 15	70% 70% 230	80% 70% 230	80% 70% 230	60% 60% 230	60% 70% 230	60% 70% 230	
Large Offices (> 3,700 m²)	35		0%	0%	100%	0%	0%	0%	0%	2.9
Small Offices (< 3,700 m²)	35		0%	0%	100%	0%	0%	0%	0%	2.9
Non-Food Retail	50		0%	20%	60%	0%	0%	20%	0%	4.6
Food Retail	25		0%	14%	66%	10%	0%	10%	0%	2.2
Restaurant/Tavern	20		0%	80%	20%	0%	0%	0%	0%	1.9
Hotels/Motels	15		0%	75%	20%	0%	0%	5%	0%	1.4
Warehouse/Wholesale	40		0%	10%	20%	50%	0%	0%	20%	3.6
Hospitals	35		0%	20%	80%	0%	0%	0%	0%	3.0
Nursing Homes	25		0%	20%	80%	0%	0%	0%	0%	2.1
Universities/Colleges	35		0%	10%	70%	10%	0%	10%	0%	3.1
Schools	35		0%	10%	80%	0%	0%	10%	0%	3.1
High Rise Apt	15		0%	90%	10%	0%	0%	0%	0%	1.4
Other (Serv/Inst/Comm/Misc)	35		0%	10%	60%	10%	0%	5%	15%	3.2

BC HYDRO COMMERCIAL SECTOR – 1988 EXISTING BUILDINGS
SERVICE AREA LIGHTING COMPONENT
BASELINE

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems						HPS 60% 70% 90	LtgLd (W/m²)
			INC 80% 70% 15	CFL 70% 70% 50	40T12 70% 70% 60	96T12 70% 70% 60	MV 60% 60% 45	MH 60% 70% 65		
Large Offices (> 3,700 m²)	30		25%	0%	75%	0%	0%	0%	0%	17.8
Small Offices (< 3,700 m²)	30		25%	0%	75%	0%	0%	0%	0%	17.8
Non-Food Retail	30		30%	0%	70%	0%	0%	0%	0%	19.2
Food Retail	30		20%	0%	80%	0%	0%	0%	0%	16.5
Restaurant/Tavern	30		55%	0%	45%	0%	0%	0%	0%	26.1
Hotels/Motels	20		100%	0%	0%	0%	0%	0%	0%	25.6
Warehouse/Wholesale	30		0%	0%	80%	20%	0%	0%	0%	11.0
Hospitals	25		10%	0%	90%	0%	0%	0%	0%	11.4
Nursing Homes	20		10%	0%	90%	0%	0%	0%	0%	9.1
Universities/Colleges	20		20%	0%	80%	0%	0%	0%	0%	11.0
Schools	20		10%	0%	90%	0%	0%	0%	0%	9.1
High Rise Apt	20		80%	0%	20%	0%	0%	0%	0%	22.0
Other (Serv/Inst/Comm/Misc)	20		20%	0%	80%	0%	0%	0%	0%	11.0

BC HYDRO COMMERCIAL SECTOR – 1988 EXISTING BUILDINGS
SERVICE AREA LIGHTING COMPONENT
UPGRADE 2000

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems						HPS 60% 70% 90	LtgLd (W/m²)
			INC 80% 70% 15	CFL 70% 70% 50	4T8 80% 70% 100	8T8 80% 70% 100	MV 60% 60% 45	MH 60% 70% 65		
Large Offices (> 3,700 m²)	20		0%	25%	75%	0%	0%	0%	0%	5.1
Small Offices (< 3,700 m²)	20		0%	25%	75%	0%	0%	0%	0%	5.1
Non-Food Retail	20		0%	30%	70%	0%	0%	0%	0%	5.3
Food Retail	20		0%	20%	80%	0%	0%	0%	0%	4.8
Restaurant/Tavern	20		0%	55%	45%	0%	0%	0%	0%	6.6
Hotels/Motels	20		0%	100%	0%	0%	0%	0%	0%	8.8
Warehouse/Wholesale	20		0%	0%	80%	20%	0%	0%	0%	3.8
Hospitals	20		0%	10%	90%	0%	0%	0%	0%	4.3
Nursing Homes	20		0%	10%	90%	0%	0%	0%	0%	4.3
Universities/Colleges	20		0%	20%	80%	0%	0%	0%	0%	4.8
Schools	20		0%	10%	90%	0%	0%	0%	0%	4.3
High Rise Apt	20		0%	80%	20%	0%	0%	0%	0%	7.8
Other (Serv/Inst/Comm/Misc)	20		0%	20%	80%	0%	0%	0%	0%	4.8

BC HYDRO COMMERCIAL SECTOR – 1988 EXISTING BUILDINGS
SERVICE AREA LIGHTING COMPONENT
UPGRADE 2010

			Percent Ltg Share in These Systems								
Building Segment	Ltg	CU	2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	LtgLd	
	Lvl	LLF	80%	70%	80%	80%	60%	60%	60%		
	(fc)	L/w	70%	70%	70%	70%	60%	70%	70%	(W/m²)	
			15	230	230	230	230	230	230		
Large Offices (> 3,700 m*2)	20		0%	25%	75%	0%	0%	0%	0%	1.7	
Small Offices (< 3,700 m*2)	20		0%	25%	75%	0%	0%	0%	0%	1.7	
Non-Food Retail	20		0%	30%	70%	0%	0%	0%	0%	1.7	
Food Retail	20		0%	20%	80%	0%	0%	0%	0%	1.7	
Restaurant/Tavern	20		0%	55%	45%	0%	0%	0%	0%	1.8	
Hotels/Motels	20		0%	100%	0%	0%	0%	0%	0%	1.9	
Warehouse/Wholesale	20		0%	0%	80%	20%	0%	0%	0%	1.7	
Hospitals	20		0%	10%	90%	0%	0%	0%	0%	1.7	
Nursing Homes	20		0%	10%	90%	0%	0%	0%	0%	1.7	
Universities/Colleges	20		0%	20%	80%	0%	0%	0%	0%	1.7	
Schools	20		0%	10%	90%	0%	0%	0%	0%	1.7	
High Rise Apt	20		0%	80%	20%	0%	0%	0%	0%	1.9	
Other (Serv/Inst/Comm/Misc)	20		0%	20%	80%	0%	0%	0%	0%	1.7	

BC HYDRO COMMERCIAL SECTOR – 1988 EXISTING BUILDINGS
OTHER (HIGH BAY) COMPONENT
BASELINE

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems							Ltg Ld (W/m²)
			INC	CFL	40T12	96T12	MV	MH	HPS	
			80% 70% 15	70% 70% 50	70% 70% 60	70% 70% 60	60% 60% 45	60% 70% 65	60% 70% 90	
Large Offices (> 3,700 m²)	30		0%	0%	0%	0%	0%	100%	0%	11.8
Small Offices (< 3,700 m²)	30		0%	0%	0%	0%	0%	100%	0%	11.8
Non-Food Retail	30		0%	0%	0%	0%	0%	100%	0%	11.8
Food Retail	30		0%	0%	0%	0%	0%	100%	0%	11.8
Restaurant/Tavern	30		0%	0%	0%	0%	0%	0%	0%	0.0
Hotels/Motels	30		10%	0%	0%	20%	0%	70%	0%	14.3
Warehouse/Wholesale	30		0%	0%	0%	0%	0%	0%	0%	0.0
Hospitals	20		0%	0%	0%	0%	0%	100%	0%	7.9
Nursing Homes	30		0%	0%	0%	0%	0%	0%	0%	0.0
Universities/Colleges	20		0%	0%	0%	0%	0%	0%	0%	0.0
Schools	20		0%	0%	0%	0%	0%	0%	0%	0.0
High Rise Apt	30		0%	0%	0%	0%	0%	0%	0%	0.0
Other (Serv/Inst/Comm/Misc)	30		0%	0%	0%	20%	0%	80%	0%	11.7

BC HYDRO COMMERCIAL SECTOR – 1988 EXISTING BUILDINGS
OTHER (HIGH BAY) COMPONENT
UPGRADE 2000

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems							Ltg Ld (W/m²)
			INC	CFL	4T8	8T8	MV	MH	HPS	
			80% 70% 15	70% 70% 50	80% 70% 100	80% 70% 100	60% 60% 45	60% 70% 65	60% 70% 90	
Large Offices (> 3,700 m²)	30		0%	0%	0%	0%	0%	0%	100%	8.5
Small Offices (< 3,700 m²)	30		0%	0%	0%	0%	0%	0%	100%	8.5
Non-Food Retail	30		0%	0%	0%	0%	0%	0%	100%	8.5
Food Retail	30		0%	0%	0%	0%	0%	0%	100%	8.5
Restaurant/Tavern	30		0%	0%	0%	0%	0%	0%	0%	0.0
Hotels/Motels	30		0%	10%	0%	20%	0%	0%	70%	8.4
Warehouse/Wholesale	30		0%	0%	0%	0%	0%	0%	0%	0.0
Hospitals	20		0%	0%	0%	0%	0%	0%	100%	5.7
Nursing Homes	30		0%	0%	0%	0%	0%	0%	0%	0.0
Universities/Colleges	20		0%	0%	0%	0%	0%	0%	0%	0.0
Schools	20		0%	0%	0%	0%	0%	0%	0%	0.0
High Rise Apt	30		0%	0%	0%	0%	0%	0%	0%	0.0
Other (Serv/Inst/Comm/Misc)	30		0%	0%	0%	20%	0%	0%	80%	8.0

BC HYDRO COMMERCIAL SECTOR – 1988 EXISTING BUILDINGS
OTHER (HIGH BAY) COMPONENT
UPGRADE 2010

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems							Ltg Ld (W/m²)
			2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	
			80% 70% 15	70% 70% 230	80% 70% 230	80% 70% 230	60% 60% 230	60% 70% 230	60% 70% 230	
Large Offices (> 3,700 m²)	30		0%	0%	0%	0%	0%	0%	100%	3.3
Small Offices (< 3,700 m²)	30		0%	0%	0%	0%	0%	0%	100%	3.3
Non-Food Retail	30		0%	0%	0%	0%	0%	0%	100%	3.3
Food Retail	30		0%	0%	0%	0%	0%	0%	100%	3.3
Restaurant/Tavern	30		0%	0%	0%	0%	0%	0%	0%	0.0
Hotels/Motels	30		0%	10%	0%	20%	0%	0%	70%	3.1
Warehouse/Wholesale	30		0%	0%	0%	0%	0%	0%	0%	0.0
Hospitals	20		0%	0%	0%	0%	0%	0%	100%	2.2
Nursing Homes	30		0%	0%	0%	0%	0%	0%	0%	0.0
Universities/Colleges	20		0%	0%	0%	0%	0%	0%	0%	0.0
Schools	20		0%	0%	0%	0%	0%	0%	0%	0.0
High Rise Apt	30		0%	0%	0%	0%	0%	0%	0%	0.0
Other (Serv/Inst/Comm/Misc)	30		0%	0%	0%	20%	0%	0%	80%	3.2

BC HYDRO COMMERCIAL SECTOR – 1988 NEW BUILDINGS
GENERAL LIGHTING COMPONENT
BASELINE

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems							Ltg Ld (W/m²)
			INC	CFL	40T12	96T12	MV	MH	HPS	
			80% 70% 15	70% 70% 50	70% 70% 60	70% 70% 60	60% 60% 45	60% 70% 65	60% 70% 90	
Large Offices (> 3,700 m²)	90		0%	0%	100%	0%	0%	0%	0%	32.9
Small Offices (< 3,700 m²)	90		0%	0%	100%	0%	0%	0%	0%	32.9
Non-Food Retail	80		20%	0%	50%	10%	0%	20%	0%	44.4
Food Retail	90		10%	0%	50%	30%	0%	10%	0%	41.4
Restaurant/Tavern	20		75%	0%	25%	0%	0%	0%	0%	21.0
Hotels/Motels	20		70%	5%	20%	0%	0%	5%	0%	20.2
Warehouse/Wholesale	40		10%	0%	20%	50%	5%	0%	15%	18.4
Hospitals	50		10%	0%	90%	0%	0%	0%	0%	22.9
Nursing Homes	20		60%	0%	40%	0%	0%	0%	0%	18.3
Universities/Colleges	60		0%	0%	80%	10%	0%	10%	0%	22.1
Schools	50		0%	0%	80%	10%	0%	10%	0%	18.4
High Rise Apt	20		85%	0%	15%	0%	0%	0%	0%	22.9
Other (Serv/Inst/Comm/Misc)	60		20%	0%	40%	10%	10%	10%	10%	34.4

BC HYDRO COMMERCIAL SECTOR – 1988 NEW BUILDINGS
GENERAL LIGHTING COMPONENT
UPGRADE 2000

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems							Ltg Ld (W/m²)
			INC	CFL	4T8	8T8	MV	MH	HPS	
			80% 70% 15	70% 70% 50	80% 70% 100	80% 70% 100	60% 60% 45	60% 70% 65	60% 70% 90	
Large Offices (> 3,700 m²)	35		0%	0%	100%	0%	0%	0%	0%	6.7
Small Offices (< 3,700 m²)	35		0%	0%	100%	0%	0%	0%	0%	6.7
Non-Food Retail	50		0%	20%	50%	10%	0%	20%	0%	14.1
Food Retail	25		0%	10%	50%	30%	0%	10%	0%	5.9
Restaurant/Tavern	20		0%	75%	25%	0%	0%	0%	0%	7.5
Hotels/Motels	15		0%	75%	20%	0%	0%	5%	0%	5.8
Warehouse/Wholesale	40		0%	10%	20%	50%	5%	0%	15%	10.4
Hospitals	35		0%	10%	90%	0%	0%	0%	0%	7.6
Nursing Homes	20		0%	60%	40%	0%	0%	0%	0%	6.8
Universities/Colleges	35		0%	0%	80%	10%	0%	10%	0%	7.4
Schools	35		0%	0%	80%	10%	0%	10%	0%	7.4
High Rise Apt	10		0%	85%	15%	0%	0%	0%	0%	4.0
Other (Serv/Inst/Comm/Misc)	35		0%	20%	40%	10%	10%	10%	10%	11.3

BC HYDRO COMMERCIAL SECTOR – 1988 NEW BUILDINGS
GENERAL LIGHTING COMPONENT
UPGRADE 2010

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems							Ltg Ld (W/m²)
			2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	
			80% 70% 15	70% 70% 230	80% 70% 230	80% 70% 230	60% 60% 230	60% 70% 230	60% 70% 230	
Large Offices (> 3,700 m²)	35		0%	0%	100%	0%	0%	0%	0%	2.9
Small Offices (< 3,700 m²)	35		0%	0%	100%	0%	0%	0%	0%	2.9
Non-Food Retail	50		0%	20%	50%	10%	0%	20%	0%	4.6
Food Retail	25		0%	10%	50%	30%	0%	10%	0%	2.2
Restaurant/Tavern	20		0%	75%	25%	0%	0%	0%	0%	1.8
Hotels/Motels	15		0%	75%	20%	0%	0%	5%	0%	1.4
Warehouse/Wholesale	40		0%	10%	20%	50%	5%	0%	15%	3.6
Hospitals	35		0%	10%	90%	0%	0%	0%	0%	3.0
Nursing Homes	20		0%	60%	40%	0%	0%	0%	0%	1.8
Universities/Colleges	35		0%	0%	80%	10%	0%	10%	0%	3.0
Schools	35		0%	0%	80%	10%	0%	10%	0%	3.0
High Rise Apt	10		0%	85%	15%	0%	0%	0%	0%	0.9
Other (Serv/Inst/Comm/Misc)	35		0%	20%	40%	10%	10%	10%	10%	3.4

BC HYDRO COMMERCIAL SECTOR – 1988 NEW BUILDINGS
SERVICE AREA LIGHTING COMPONENT
BASELINE

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems							LtgLd (W/m²)
			INC 80% 70% 15	CFL 70% 70% 50	40T12 70% 70% 60	96T12 70% 70% 60	MV 60% 60% 45	MH 60% 70% 65	HPS 60% 70% 90	
Large Offices (> 3,700 m²)	30		20%	0%	80%	0%	0%	0%	0%	16.5
Small Offices (< 3,700 m²)	30		20%	0%	80%	0%	0%	0%	0%	16.5
Non-Food Retail	30		20%	0%	80%	0%	0%	0%	0%	16.5
Food Retail	35		20%	0%	80%	0%	0%	0%	0%	19.2
Restaurant/Tavern	25		80%	0%	20%	0%	0%	0%	0%	27.4
Hotels/Motels	20		100%	0%	0%	0%	0%	0%	0%	25.6
Warehouse/Wholesale	30		0%	0%	80%	20%	0%	0%	0%	11.0
Hospitals	25		15%	0%	85%	0%	0%	0%	0%	12.6
Nursing Homes	20		20%	0%	80%	0%	0%	0%	0%	11.0
Universities/Colleges	20		20%	0%	80%	0%	0%	0%	0%	11.0
Schools	20		10%	0%	90%	0%	0%	0%	0%	9.1
High Rise Apt	15		30%	0%	70%	0%	0%	0%	0%	9.6
Other (Serv/Inst/Comm/Misc)	15		60%	0%	40%	0%	0%	0%	0%	13.7

BC HYDRO COMMERCIAL SECTOR – 1988 NEW BUILDINGS
SERVICE AREA LIGHTING COMPONENT
UPGRADE 2000

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems							LtgLd (W/m²)
			INC 80% 70% 15	CFL 70% 70% 50	4T8 70% 70% 100	8T8 80% 70% 100	MV 60% 60% 45	MH 60% 70% 65	HPS 60% 70% 90	
Large Offices (> 3,700 m²)	20		0%	20%	80%	0%	0%	0%	0%	4.8
Small Offices (< 3,700 m²)	20		0%	20%	80%	0%	0%	0%	0%	4.8
Non-Food Retail	20		0%	20%	80%	0%	0%	0%	0%	4.8
Food Retail	20		0%	20%	80%	0%	0%	0%	0%	4.8
Restaurant/Tavern	20		0%	80%	20%	0%	0%	0%	0%	7.8
Hotels/Motels	20		0%	100%	0%	0%	0%	0%	0%	8.8
Warehouse/Wholesale	20		0%	0%	80%	20%	0%	0%	0%	3.8
Hospitals	20		0%	15%	85%	0%	0%	0%	0%	4.6
Nursing Homes	20		0%	20%	80%	0%	0%	0%	0%	4.8
Universities/Colleges	20		0%	20%	80%	0%	0%	0%	0%	4.8
Schools	20		0%	10%	90%	0%	0%	0%	0%	4.3
High Rise Apt	15		0%	30%	70%	0%	0%	0%	0%	4.0
Other (Serv/Inst/Comm/Misc)	15		0%	60%	40%	0%	0%	0%	0%	5.1

BC HYDRO COMMERCIAL SECTOR – 1988 NEW BUILDINGS
SERVICE AREA LIGHTING COMPONENT
UPGRADE 2010

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems							LtgLd (W/m²)
			2-PH.L 80% 70% 15	2-PH.L 70% 70% 230	2-PH.L 80% 70% 230	2-PH.L 80% 70% 230	2-PH.L 60% 60% 230	2-PH.L 60% 70% 230	2-PH.L 60% 70% 80	
Large Offices (> 3,700 m²)	20		0%	20%	80%	0%	0%	0%	0%	1.7
Small Offices (< 3,700 m²)	20		0%	20%	80%	0%	0%	0%	0%	1.7
Non-Food Retail	20		0%	20%	80%	0%	0%	0%	0%	1.7
Food Retail	20		0%	20%	80%	0%	0%	0%	0%	1.7
Restaurant/Tavern	20		0%	80%	20%	0%	0%	0%	0%	1.9
Hotels/Motels	20		0%	100%	0%	0%	0%	0%	0%	1.9
Warehouse/Wholesale	20		0%	0%	80%	20%	0%	0%	0%	1.7
Hospitals	20		0%	15%	85%	0%	0%	0%	0%	1.7
Nursing Homes	20		0%	20%	80%	0%	0%	0%	0%	1.7
Universities/Colleges	20		0%	20%	80%	0%	0%	0%	0%	1.7
Schools	20		0%	10%	90%	0%	0%	0%	0%	1.7
High Rise Apt	15		0%	30%	70%	0%	0%	0%	0%	1.3
Other (Serv/Inst/Comm/Misc)	15		0%	60%	40%	0%	0%	0%	0%	1.4

BC HYDRO COMMERCIAL SECTOR – 1988 NEW BUILDINGS
OTHER (HIGH BAY) COMPONENT
BASELINE

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems							Ltg Ld (W/m²)
			INC	CFL	40T12	96T12	MV	MH	HPS	
			80% 70% 15	70% 70% 50	70% 70% 60	70% 70% 60	60% 60% 45	60% 70% 65	60% 70% 90	
Large Offices (> 3,700 m²)	30		0%	0%	0%	0%	0%	95%	5%	11.7
Small Offices (< 3,700 m²)	30		0%	0%	0%	0%	0%	95%	5%	11.7
Non-Food Retail	30		0%	0%	0%	0%	0%	100%	0%	11.8
Food Retail	30		0%	0%	0%	0%	0%	100%	0%	11.8
Restaurant/Tavern	30		0%	0%	0%	0%	0%	0%	0%	0.0
Hotels/Motels	30		10%	0%	0%	20%	0%	70%	0%	14.3
Warehouse/Wholesale	30		0%	0%	0%	0%	0%	0%	0%	0.0
Hospitals	20		0%	0%	0%	0%	10%	90%	0%	8.4
Nursing Homes	20		0%	0%	0%	0%	0%	0%	0%	0.0
Universities/Colleges	30		0%	0%	0%	0%	0%	0%	0%	0.0
Schools	30		0%	0%	0%	0%	0%	0%	0%	0.0
High Rise Apt	20		0%	0%	0%	0%	0%	0%	0%	0.0
Other (Serv/Inst/Comm/Misc)	30		0%	0%	0%	20%	0%	80%	0%	11.7

BC HYDRO COMMERCIAL SECTOR – 1988 NEW BUILDINGS
OTHER (HIGH BAY) COMPONENT
UPGRADE 2000

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems							Ltg Ld (W/m²)
			INC	CFL	4T8	8T8	MV	MH	HPS	
			80% 70% 15	70% 70% 50	80% 70% 100	80% 70% 100	60% 60% 45	60% 70% 65	60% 70% 90	
Large Offices (> 3,700 m²)	30		0%	0%	0%	0%	0%	0%	100%	8.5
Small Offices (< 3,700 m²)	30		0%	0%	0%	0%	0%	0%	100%	8.5
Non-Food Retail	30		0%	0%	0%	0%	0%	50%	50%	10.2
Food Retail	30		0%	0%	0%	0%	0%	0%	100%	8.5
Restaurant/Tavern	30		0%	0%	0%	0%	0%	0%	0%	0.0
Hotels/Motels	30		0%	10%	0%	20%	0%	0%	70%	8.4
Warehouse/Wholesale	30		0%	0%	0%	0%	0%	0%	0%	0.0
Hospitals	20		0%	0%	0%	0%	0%	0%	100%	5.7
Nursing Homes	20		0%	0%	0%	0%	0%	0%	0%	0.0
Universities/Colleges	30		0%	0%	0%	0%	0%	0%	0%	0.0
Schools	30		0%	0%	0%	0%	0%	0%	0%	0.0
High Rise Apt	20		0%	0%	0%	0%	0%	0%	0%	0.0
Other (Serv/Inst/Comm/Misc)	30		0%	0%	0%	20%	0%	0%	80%	8.0

BC HYDRO COMMERCIAL SECTOR – 1988 NEW BUILDINGS
OTHER (HIGH BAY) COMPONENT
UPGRADE 2010

Building Segment	Ltg Lvl (fc)	CU LLF L/w	Percent Ltg Share in These Systems							Ltg Ld (W/m²)
			2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	2-PH.L	
			80% 70% 15	70% 70% 230	80% 70% 230	80% 70% 230	60% 60% 230	60% 70% 230	60% 70% 230	
Large Offices (> 3,700 m²)	30		0%	0%	0%	0%	0%	0%	100%	3.3
Small Offices (< 3,700 m²)	30		0%	0%	0%	0%	0%	0%	100%	3.3
Non-Food Retail	30		0%	0%	0%	0%	0%	50%	50%	3.3
Food Retail	30		0%	0%	0%	0%	0%	0%	100%	3.3
Restaurant/Tavern	30		0%	0%	0%	0%	0%	0%	0%	0.0
Hotels/Motels	30		0%	10%	0%	20%	0%	0%	70%	3.1
Warehouse/Wholesale	30		0%	0%	0%	0%	0%	0%	0%	0.0
Hospitals	20		0%	0%	0%	0%	0%	0%	100%	2.2
Nursing Homes	20		0%	0%	0%	0%	0%	0%	0%	0.0
Universities/Colleges	30		0%	0%	0%	0%	0%	0%	0%	0.0
Schools	30		0%	0%	0%	0%	0%	0%	0%	0.0
High Rise Apt	20		0%	0%	0%	0%	0%	0%	0%	0.0
Other (Serv/Inst/Comm/Misc)	30		0%	0%	0%	20%	0%	0%	80%	3.2

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