CIEEDAC

Review of Energy Supply, Consumption and GHG Emissions in British Columbia, 1990 to 2009

Prepared for:

Pacific Institute for Climate Solutions

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Executive Summary

As part of a network of centres established through an initiative of Natural Resources Canada (NRCan), the Canadian Industrial Energy End-use Data and Analysis Centre (CIEEDAC) focuses on energy information relevant to Canada's industrial sector. One of CIEEDAC's primary goals is to expand and improve the existing knowledge on energy supply and consumption, greenhouse gas emissions, cogeneration, and renewable energy by establishing processes for the regular and timely collection of reliable data. CIEEDAC provides a range of services to industry and government. It performs specific retrieval and analyses from its databases based on requests from interested parties. It also produces various reports each year, presenting the latest data on energy consumption and related information for the Canadian industrial sector.

This report, compiled for the Pacific Institute for Climate Solutions (PICS), is divided into three sections. The first section provides an overview of information relating to energy supply and consumption, greenhouse gas emissions and efficiency in British Columbia and includes total energy consumption and emissions data for all sectors and some industries from 1990 to 2009, as well as energy intensity indicators based on population and monetary production (Gross Domestic Product, GDP). Detailed data tables disaggregated by industry can be found in Appendix A.

Statistics Canada (STC) provides detailed data on energy consumption disaggregated by industry according to the 6-digit North American Industry Classification System (NAICS). STC's publication, *Report on Energy Supply and Demand* (RESD) disaggregates data by province, but the report's level of disaggregation for industry is not nearly as detailed as what NAICS allows. The RESD only disaggregates data to the 3-digit NAICS level and only for a limited number of industries. Nonetheless, the RESD is the primary data source for energy used in this report. GHG emissions data were obtained from Environment Canada's annually published *National Inventory Report* (EC 2010). This report provided both the coefficients to calculate the GHG emissions generated in the various BC sectors and an absolute value of emissions against which the calculated data could be compared. Production and population data were both retrieved from CANSIM, an STC on-line database.

Between 1990 and 2009, total energy consumption in British Columbia rose 22%. In 2009, total consumption was 1,264 PJ. Over this time, population and GDP grew by 36% and 61%, respectively. Given the greater growth rates in population and GDP compared to energy consumption, energy intensity declined by 10% per person and 24% per dollar.

Total Industrial energy consumption increased 10% and consumption in Total Manufacturing also increased 9%. Energy consumption in Transportation increased 32% while Agriculture decreased 6%. Energy consumption in the Commercial / Institutional and Residential sectors rose 32% and 27%, respectively.

Natural gas, electricity, and refined petroleum products are the major fuels of the BC economy. Consumption of these major energy sources increased by 26%, 17%, and 24%, respectively. Coal consumption, though representing a small portion of total energy consumption, increased the greatest – by 81%. Hydroelectricity continued to dominate

electricity production, though the share of HFO-fired and diesel / LFO-fired plants declined significantly over the study period, and natural gas-fired plants' share increased.

GHG emissions fluctuate over the study period peaking in 2004 and finishing the period 22% above 1990. GHG emissions intensity per capita decreased by 10% since 1990 and the indicator based on GDP decreased 24% between 1990 and 2009, roughly the same as energy intensity. From 2008 to 2009, GHG emissions per capita decreased 6%, while intensity based on GDP decreased 3%. An analysis of GHG emissions split by sector reveals that Transportation, Commercial / Institutional and Electricity emissions increase significantly at 34%, 41% and 24% respectively, Residential and Industry GHG emissions increases much more modestly at 1.5% and 8%, respectively. Agricutlrual emissions declined by 20% to a level 6% below 1990 levels.

GHG emissions resulting from the production of electricity fluctuate a lot over the study period, primarily due to variations that occur in the generation of electricity in the non-utility sub-sector. In 2009, electricity GHG emissions are 16% below 1990 levels.

The second section of this report summarizes the latest version of CIEEDAC's cogeneration database as of March 2011[1]. It identifies the size (electrical capacity, kW_e[2]), and system operator / thermal host of industrial, commercial / institutional, and district energy cogeneration facilities in British Columbia. It also includes performance characteristics of cogeneration systems operating in British Columbia and more accurate data on the users of the thermal and electric products of cogeneration systems.

In the past, CIEEDAC relied on second-hand data sources such as Statistics Canada, corporate websites, private consultants, and electric utilities to identify cogeneration facilities and compile data on their characteristics. For the last four years, CIEEDAC has gathered data on cogeneration systems directly from the system operators. CIEEDAC sends a questionnaire to each facility seeking verification of existing data and requesting new information about each site. The resulting database is more reliable and contains data that will enhance understanding of the opportunities for and limitations of cogeneration in Canada and its provinces.

The database currently contains information on 9.1 GW_e of cogeneration capacity in Canada, with British Columbia contributing 1.45 GW_e, or 16% of the national total capacity. The forest products sector has a cogeneration level of 0.82 GW_e; 56% of total operational capacity in British Columbia. The efficiency of cogeneration systems varies from a low of 63% to a high of 81%, and on average, steam turbine systems are the most efficient.

The third section of this report presents information on renewable energy in British Columbia. A database of facilities was established in 2002, using data from Statistics Canada and other sources. In this section of the report, the results are presented from the most recent data survey of two years ago, including data on the mix of renewable energy by resource / technology type, by scale (capacity and annual generation), by owner /

[1] Refer to www.cieedac.sfu.ca for more information on cogeneration data.
[2] One thousand watts of electric capacity.

operator, by green certification status, and by vintage. This report also presents survey results for a series of questions about policy.

Renewable energy provides at least 11% and was estimated to provide about 13% of the energy produced in BC in 2009 (based on extrapolations of data provided by survey respondents). The installed renewable electricity facilities represent almost 88% of the provincial total electricity capacity in that year. The installed renewable electrical capacity of 12.8 GW is dominated by hydroelectricity and cogeneration from biomass wood residue, accounting for 96.6% and 3.3% of the total respectively, with biogas, and solar photovoltaic sources accounting for only about 0.1% of BC's installed capacity.

Based on data from Statistics Canada's RESD and CANSIM databases, electricity generation in BC was the source of about 1.45 Mt of greenhouse gases (CO_2e) in 2009. This is a relatively low value compared to many other provinces in Canada and is well below the national average; it is the result of BC's high percentage of renewable sources of electricity. If these facilities were replaced with combined-cycle gas turbines, greenhouse gas emissions from electricity generation would likely be as high as 29.3 Mt CO_2e.

While CIEEDAC's annual reports on energy efficiency, cogeneration, and renewable energy contain some of the information presented here, this report provides additional information specific to British Columbia.

Acknowledgments

CIEEDAC wishes to thank the Pacific Institute for Climate Solutions, Natural Resources Canada and Environment Canada who support the work of CIEEDAC through their sponsorship and financial contributions, part of which has funded this report.

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Review of Energy Consumption, Supply and GHG Emissions in British Columbia, 1990 to 2009

1. Energy Supply, Consumption, GHG Emissions and Related Data in British Columbia

Both Canadian industry and regional Canadian governments increasingly see the need for accurate data on historic energy consumption and GHG emissions. These data are used to:

1) determine trends in energy supply, consumption and GHG emissions within Canada as a method of determining the impacts of changes in technology, processes, or attitudes about energy;
2) compare Canadian industry performance to that of other countries or other regions to remain competitive; and
3) monitor environmental impacts of energy consumption, such as levels of greenhouse gas emissions.

In order to draw proper conclusions from the data, the values must reflect reality as close as possible. As requested by the British Columbia Ministry of Energy and Mines (MEM), this section of the report presents information available from Statistics Canada (STC) on the energy intensity of British Columbia. It includes a time series of gross energy consumption, and contains intensity indicators developed using population and production as denominators to gross energy consumption. All data are disaggregated by sector and details can be found in Appendix A.

1.1. Objectives

The objectives of the first section of this report are to:

- explicitly demonstrate the quantity and quality of data available for all sectors and industries in British Columbia;
- identify trends in energy supply, consumption and GHG emissions within aggregate sectors and industries in this region; and
- identify weaknesses with respect to data collection and the impact they have on portraying a consistent picture of energy supply, consumption and GHG emissions.

1.2. Methodology

1.2.1. Data Sources

Energy Data

Statistics Canada receives its energy supply and consumption data from a number of surveys. Each supplier of energy (coal, oil products, natural gas, electricity, etc.) provides data on energy consumed to prepare their product for sale and distribution data on who receives the energy carrier once it is available for distribution. These data are collectively aligned in an energy balanced Report on Energy Supply and Demand (RESD). Because of the significant consumption of energy in the industrial sector, Statistics Canada records the consumption of

energy in industry from the *Industrial Consumption of Energy* (ICE) survey. Released in the summer of every year for the previous year, ICE provides specific detail on energy consumption in physical units. The ICE survey focuses primarily on energy and its data are considered dependable and useful for energy analysis.

The benefits and drawbacks of ICE data are:

- the survey and data verification procedure is designed to reflect energy issues;
- ICE surveys a sample of industries, but its coverage of the major energy-consuming industries is extensive enough to be a census for those industries;
- ICE includes data on non-purchased and atypical energy forms, including data on self-generated electricity, black liquor, and wood waste; and
- ICE lacks disaggregate provincial data and – while expanded in 2001 – only a limited number of industries are covered at the six-digit NAICS level;
    - all three-digit level industry groups are included; and
    - this level of aggregation has, however, provided a broad picture of energy consumption in Canada and, as a result, ICE data have been used as the primary input to STC's publication *Report on Energy Supply and Demand* (RESD).

The RESD data are disaggregated by province, but industry disaggregations are not nearly as detailed as NAICS allows or as ICE provides.[3] RESD data are used in this report because it is a balanced energy database - it attributes all energy produced and consumed to the various sectors in British Columbia and the other provinces.

GHG Emissions Data

Environment Canada (EC) publishes its *National Inventory Report* (EC 2010) annually, some 17 months after the year. This publication provides data on process emissions, as well as coefficients that can be used to determine CO_2, CH_4 and N_2O emissions based on fuels consumed. The coefficients are defined in units of emissions per physical unit of energy; in this analysis, physical units of energy are multiplied by these coefficients to determine the emissions generated in the use of the fuel.

There are a number of issues related to the analysis of GHG emissions. These include the definition / handling of process vs. fuel-based GHG emissions, the degree to which the energy (and thus estimated GHG) data are considered confidential, indirect emissions from the purchase of steam or electricity,[4] the role of electricity production in the industry and the difference in levels of energy consumption. Some of these are addressed below.

Production Data

The Canadian Socio-economic Information Management system (CANSIM) is a computerized database and information retrieval system updated weekly by STC. The database contains nearly 600,000 time series of data covering a wide variety of social and economic aspects of Canadian

[3] ICE data are never released by province or any other region, only nationally.

[4] While one can calculate emissions per unit of electricity generated, determining the carbon content of imported energy and its role in the total energy picture increases the complexity of the calculation. Further, credit for exported electricity, if that is allowed to form part of the calculation, complicates the estimation even more.

life that can be viewed in a number of different dimensions including geographical regions. CANSIM Table 379-0025 contains Gross Domestic Product (GDP) in 2002 constant dollars, disaggregated by province, and organized according to the NAICS system[5]. Data that populate this database come from a survey annually circulated by STC. Constant dollar data is derived by multiplying current period quantities of production by their price in the base year.

This report includes information on industry output in monetary units, the contribution to gross domestic product (GDP). CIEEDAC performed no in-depth analysis on output of these measures, used by CIEEDAC to calculate intensity ratios.

Intensity ratios (energy over output, population over output) are most useful in illustrating general trends over time. Indicators based on physical rather than monetary units tend to be a better proxy for technological or process innovations because monetary units are affected by many factors not associated with energy, such as costs of labour or selling price of the final product.[6] However, monetary data are generally more available and provide a generic unit for estimating intensity of a combination of industries that have different physical units (i.e., tonnes of cement compared to numbers of cars). Although physical production values are available for some of the sectors, further research is required before more logical units become available. Measures of energy intensity provided in this report should be viewed with caution due to the fact that they are based on monetary measures of output.

1.2.2. Sectors and Industries Included in this Section

Table 1-1 gives a summary of all British Columbia sectors and industries for which energy consumption data are available and are included in this section of the report. From these data, once can calculate GHG emissions.

Table 1–1 British Columbia Sectors and Industries Included in Report

Sector / Industry	
Primary Production (Electricity)	
Total Industrial	*Total Manufacturing cont'd*
Total Mining, Oil and Gas Extraction	*Other Manufacturing*
Total Manufacturing	*Forestry*
Pulp and Paper	*Construction*
Smelting and Refining, Non-ferrous	*Transportation*
Cement	*Agricultural*
Petroleum Refining	*Residential*
Chemicals	*Commercial, Institutional, and Public Administration*

[5] The data are also available from Table 379-0025 of STC's CANSIM database.

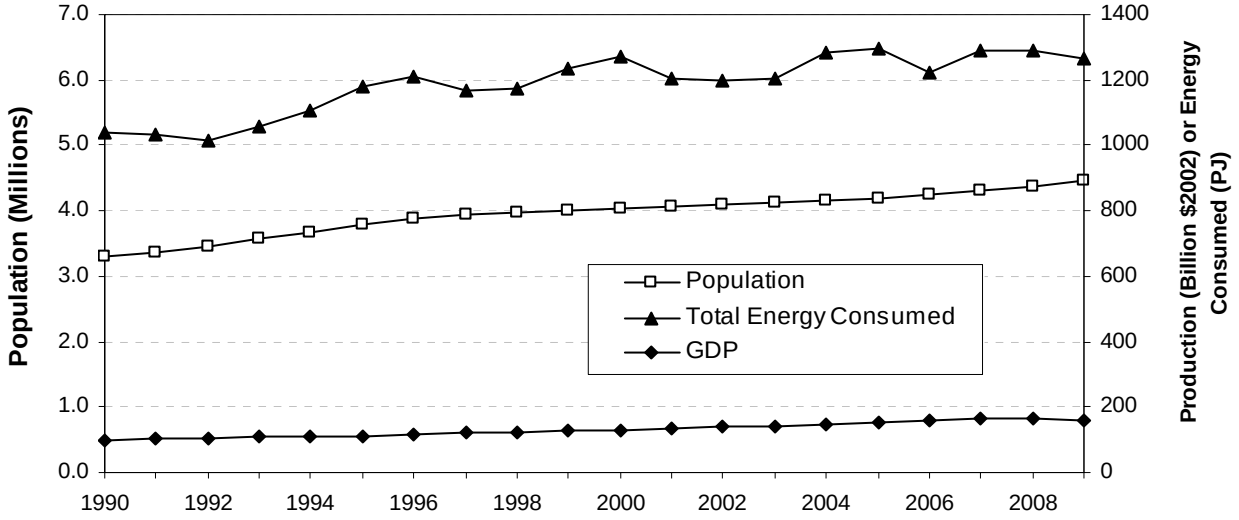
[6] See An Assessment of Data on Output for Industrial Sub-Sectors (CIEEDAC 1993) for more information on the issues of physical versus monetary units for calculating intensity indicators and on CIEEDAC's recommendations of appropriate units.

1.3. Energy Intensity, 1990 – 2009

The following section reports on changes in total energy consumption and GDP for British Columbia industries from 1990 to 2009. It also includes a brief discussion of population growth in relation to these changes. Appendix A contains detailed tables of the data used.

Figure 1-1 presents British Columbia's population growth (millions), energy consumption (PJ), and production (GDP in 2002 $billions) for 1990 to 2009. Total energy consumption includes confidential consumption, biomass consumed in the pulp and paper sector, and energy consumed to make secondary electricity.

Figure 1–1. Population, Energy Consumption, and GDP for BC

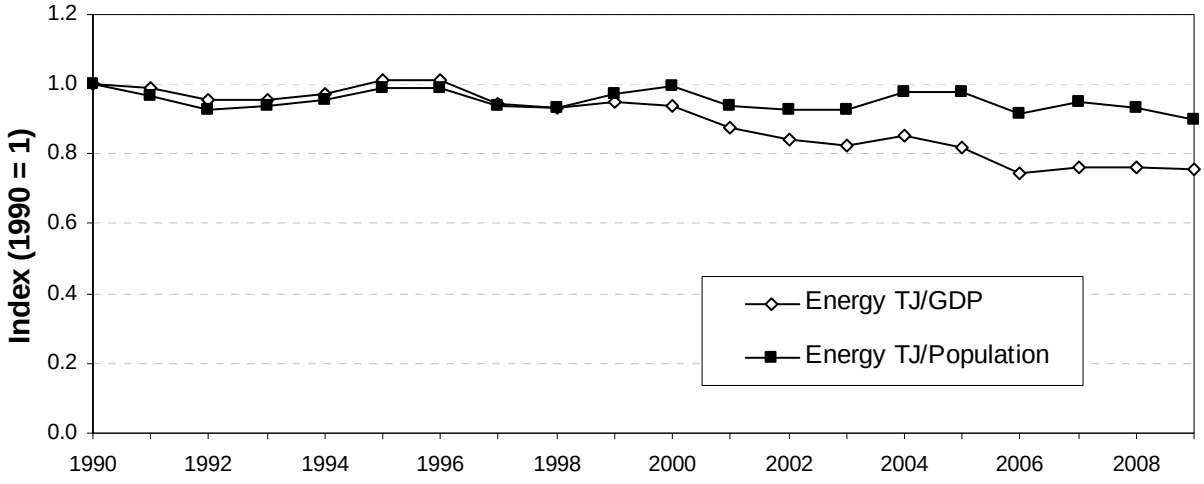


Sources: STC RESD; CANSIM Table 379-0025 and Table 051-0001.

Both population and GDP grow consistently over the study period, increasing by 35.5% and 60.5% since 1990, respectively. Both GDP and population increase continuously (see figure 1-1) with an average annual growth rate of just over 2.5% and 1.6% respectively between 1990 and 2009. The population grew 1.74% over 2009, but GDP fell by 1.3% from the previous year (2.3% in industrial sectors). Total energy consumption fluctuates over time, peaking in 2005 at 1,294 PJ, and finishes the period 21.6% above 1990 levels at 1,264 PJ, about 2% less than the amount of energy consumed in 2008.

We use GDP and population data to calculate the energy intensity indicators plotted in figure 1-2. These values are ratios of energy consumption per unit of GDP or population. Intensities are presented as indices, normalized to 1990, which help demonstrate changes from the base line. One can see that the indices show different rates of decline. Energy intensity based upon population decreased 10% and the indicator based on GDP decreased 24% between 1990 and 2009. From 2008 to 2009, the energy indicator based on population decreased nearly 4%, while intensity based on GDP diminished marginally. These indicators may suggest that, since 1990, there is a significant increase in energy efficiency but, while this may be true, other factors may also cause the change (e.g., changes in industry structure, changes in service economy vs. manufacturing economy, those things which changes value added but do not affect energy, etc.).

Figure 1–2. Energy Intensity Indicators for BC

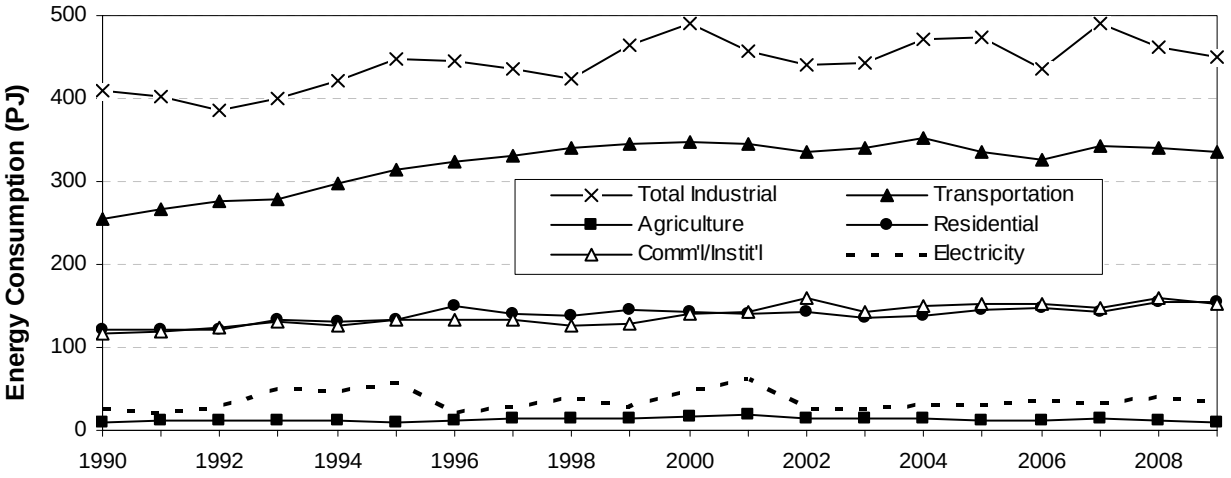


Sources: Calculated from STC RESD; CANSIM Table 379-0025 and Table 051-0001.

1.3.1. Energy Consumption by Sector

Figure 1-3 presents a comparison of energy consumption in British Columbia's major sectors. Each sector displays an increase in energy consumption between 1990 and 2009.

Figure 1–3. Comparison of Energy Consumption in the Major Sectors of BC



Source: STC RESD.

All sectors but agriculture showed an increase in consumption over the period although all of them dropped from the previous year. Transportation, Residential and Commercial / Institutional energy consumption show relatively significant increases at 32%, 27%, and 32% respectively over the period. Agriculture energy consumption decreased by 6% over the period but showed a 17% drop from last year and is also roughly half of what was consumed in 2001, its peak year.

Industry energy consumption increased by 10% since 1990 and has been relatively variant over the period. The Industrial sector, an amalgamation of construction, forestry, total manufacturing,

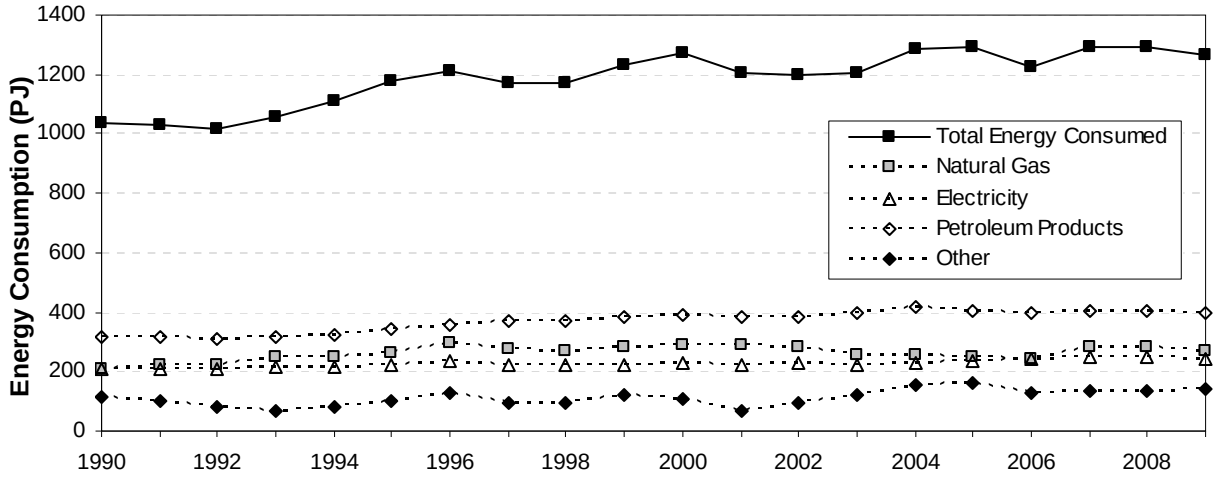
and mining and oil and gas extraction, decreased only 2.5% from 2008. Peak consumption occurred in 2000 and was nearly matched in 2007.

Energy consumption in the electricity sector fluctuates dramatically over time; the data shown in figure 1-3 represent the fuel consumption of secondary electricity (thermal generation).[7] Energy consumed to make electricity rose 31% over the period but dropped nearly 16% from 2008 and is just over half of what was consumed in 2001, the peak year. In 2009, 12% of BC's electricity came through thermal generation and use 83% more fuel than 1990.

1.3.2. Energy Consumption by Fuel

Figure 1-4 presents energy consumption by fuel type. Total energy consumption increases steadily until 2000 and then appears to level off somewhat. As noted, energy consumption in 2009, down about 2% from 2008, is 21.6% higher than 1990.

Figure 1–4. Energy Consumption by Fuel



Note: Other category includes all confidential consumption, as well as Coal, Coke, and Gas Plant NGLs.
Source: STC RESD.

Electricity demand decreased 2.3% from 2008 to 2009 and is now nearly 17% over 1990 levels. Coal consumption, although proportionally smaller than petroleum products and natural gas, showed the greatest increase (81%) by 2009 from 1990 but declined nearly 21% from last year. Coke consumption disappears. Natural gas consumption increased 26%, down nearly 5% from last year, while petroleum product consumption (still gas, motor gas, kerosene, diesel, light and heavy fuel oil, petroleum coke, aviation gasoline, and aviation turbo fuel) increased 24%.

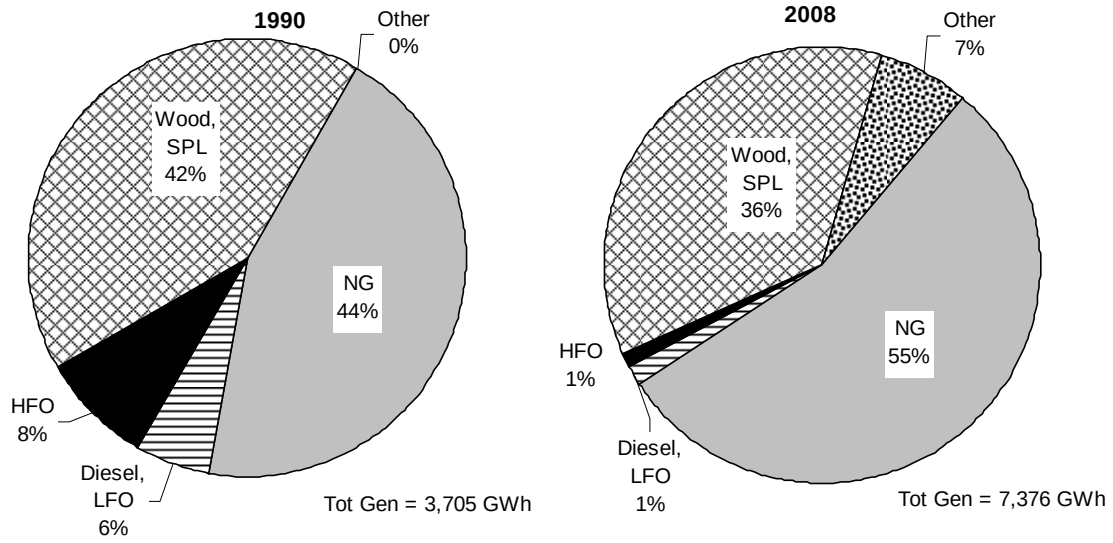
1.4. Primary Production of Electricity

Figure 1-5 compares the generation mix of thermal electric plants in BC between 1990 and 2008 (2009 data were not available from Stats Can at the time of writing). The market share of wood- and spent pulping liquor-fired electricity plants decreased from 45% in 2007 to 36% in 2008,

[7] We do include the electricity consumed by the industry during its production.

down slightly from 42% in 1990. In contrast, the market share of oil-fired electric plants decreased significantly. The market share of HFO-fired plants was only 1.36% and diesel / LFO-fired plants were only 1% in 2008, compared to 8% and 6%, respectively, in 1990. Natural gas-fired plants' share increased from 44% in 1990 to 55% in 2008, a higher share than in 2007.

Figure 1—5. Electricity Generation Mix by Fossil Fuels, 1990 and 2008



Source: STC RESD, supplemented by STC *Electricity Power Statistics.*

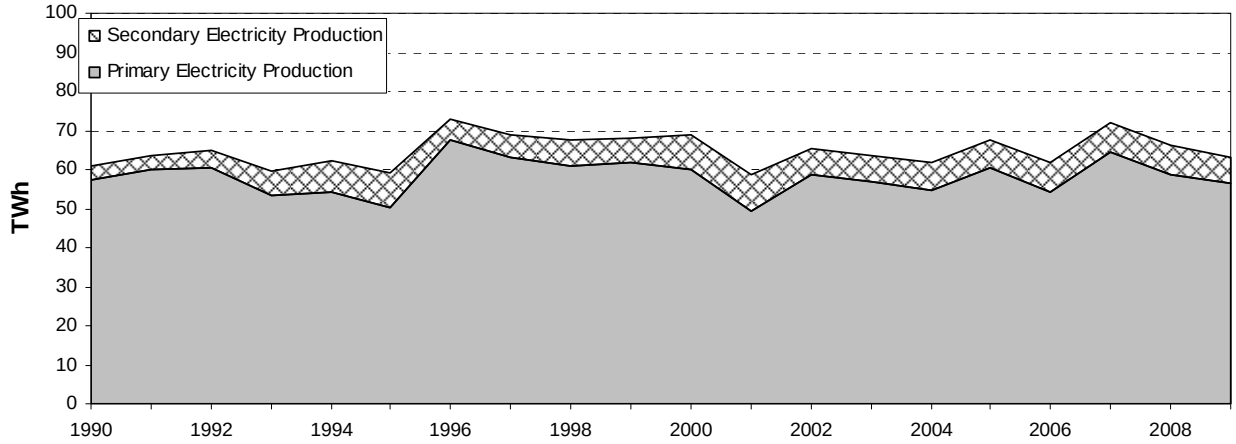
According to STC's RESD, BC's non-utility electricity generation by fossil fuel and wood fuels in 2009 was 4,513 GWh. This is roughly equivalent to what the CIEEDAC database on cogeneration estimates is generated by industry in cogeneration activities.

Figure 1-6 shows that primary electricity (hydro) dominates BC's generation market. Total electricity production fluctuated over time, and reached 63.2 TWh in 2009, a level 3.6% higher than in 1990. Between 2008 and 2009, primary electricity production decreased by 3.8%, and secondary production decreased by 8.3%.

Figure 1-7 shows annual production of electricity by utilities from 1990 to 2009. Utility production ranges from 74% to 82% of total grid-connected electricity generation in BC. Although utility production fluctuated over time, it increased from 47.7 TWh in 1990 to a peak in 2007 of 58.6TWh,[8] then decreased 49.9 TWh in 2009, a decrease of 5.5% from 2008. Hydroelectric generation dominates BC's utility generation mix; its share fluctuated between 89% and 98% during the study period. Between 2008 and 2009, total utility generation decreased 5.5%, and total hydro generation decreased 5% during this period.

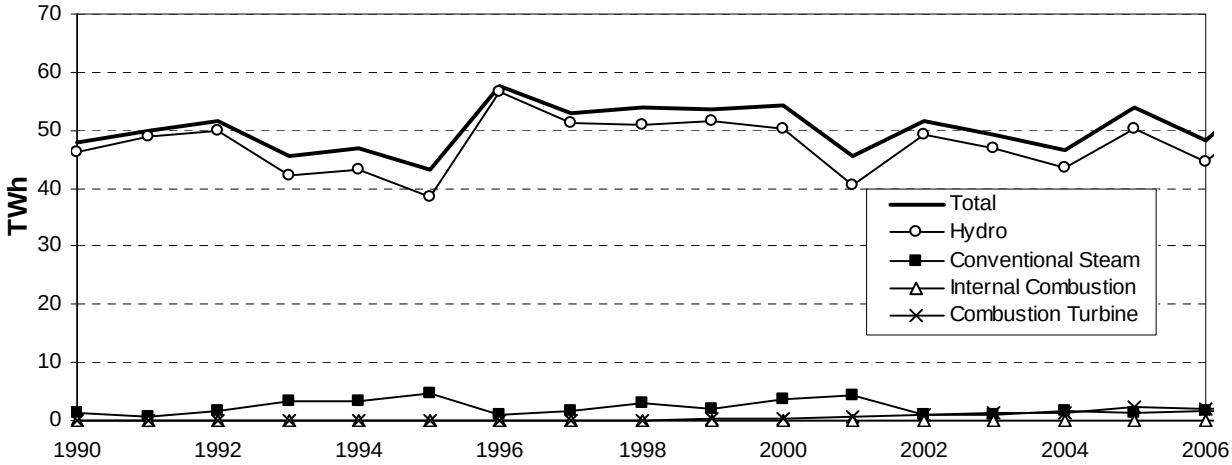
[8] Figure 1-6 and figure 1-7 are based on different STC publication series; data discrepancies may exist.

Figure 1–6. Primary and Secondary Electricity Production in BC



Source: STC RESD.

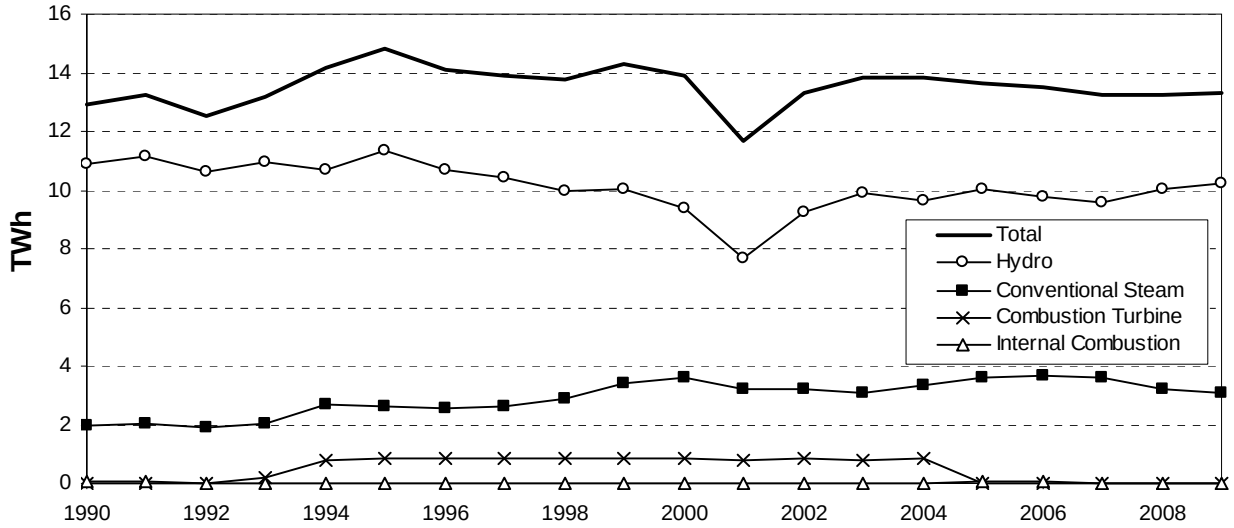
Figure 1–7. Utility Electricity Production, BC



Source: CANSIM Table 127-0007 - Electric power statistics, annual (Megawatt hour).

Figure 1-8 shows that non-utility production fluctuated over the study period, and reached its lowest level in 2001. In 2009, total non-utility production was 13.3 TWh, 3% higher than 1990. Between 2008 and 2009, total generation increased marginally. The dominance of hydro electricity diminished over time; the share of hydroelectricity decreased from 84% in 1990 to 77% in 2009 although it has been as low as 65% of production. Conventional steam plants increased in share over the study period and by 2009 provided 23% of total electricity.

Figure 1–8. Non-utility Electricity Production in BC

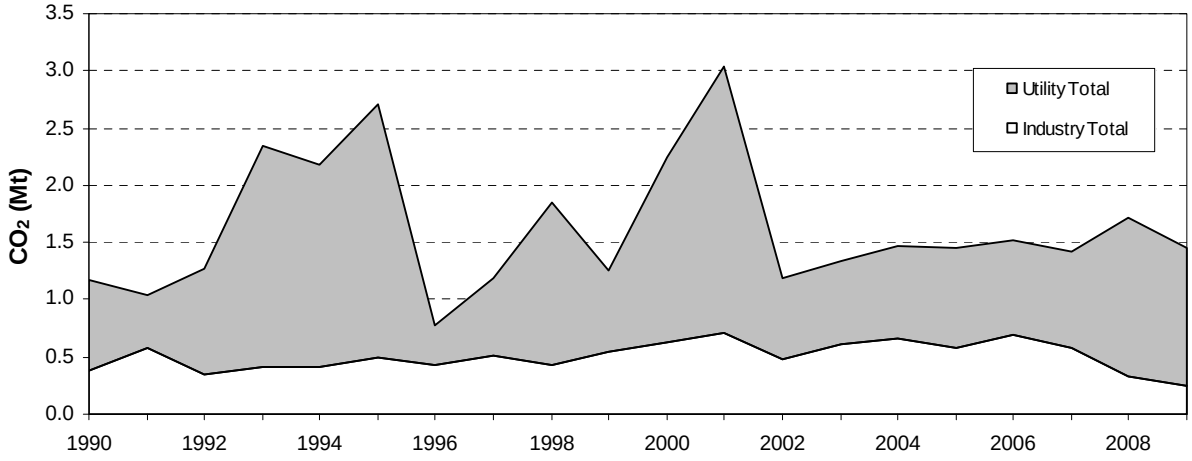


Source: CANSIM Table 127-0007 - Electric power statistics, annual (Megawatt hour).

1.4.1. GHG Emissions as a result of electricity generation

Figure 1.9 shows that GHG emissions resulting from the production of electricity have fluctuated much over the study period, primarily because of the changes in the fossil fuel consumption by the electricity utilities. Emissions peaked in 2001 at 3,039 kt, dropped in 2002 to near 1990 levels and increased relatively consistently from 2002 to the present where 2009 electricity GHG emissions are 23.5% above 1990 levels. Although there was a 12% decrease in intensity of GHG emissions per unit electricity generated between 2008 to 2009, the intensity is 19% higher than what it was in 1990.

Figure 1–9. GHG Emissions from Electricity Generation

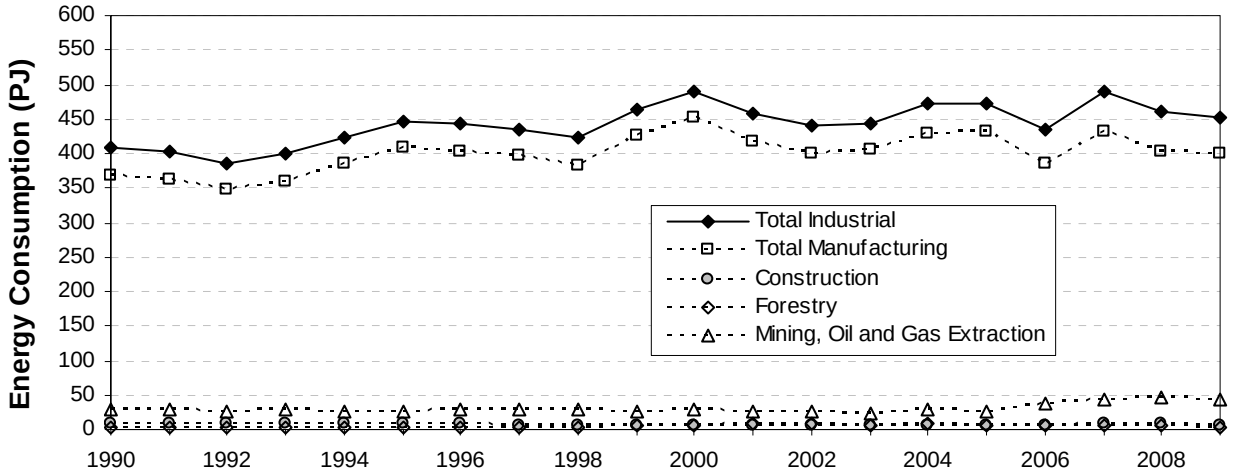


Source: CANSIM Table 127-0007 - Electric power statistics, annual (Megawatt hour), RESD energy consumed by fuel type converted to CO_2e using EC coefficients (EC, 2010)

1.5. Energy Consumption in Industry

Figure 1-10 presents the contributions of industrial sectors to total industrial energy consumption. Total Industrial consumption increased by 10 since 1990 but all of them dropped from 2008. Total Manufacturing, which includes Pulp and Paper, by far the largest consumer in the group, grew by 9% since 1990 decreasing by nearly 1% from last year. Forestry energy consumption has remained relatively flat between 2001 and 2006 and decline significantly in the last few years (35% from 2008 alone); even so, it is still 17% higher than 1990. The Mining / Oil and Gas Extraction industry, dropping 7% in from 2008, is still 45% higher than its 1990 level.

Figure 1–10. Energy Consumption by Industry, BC

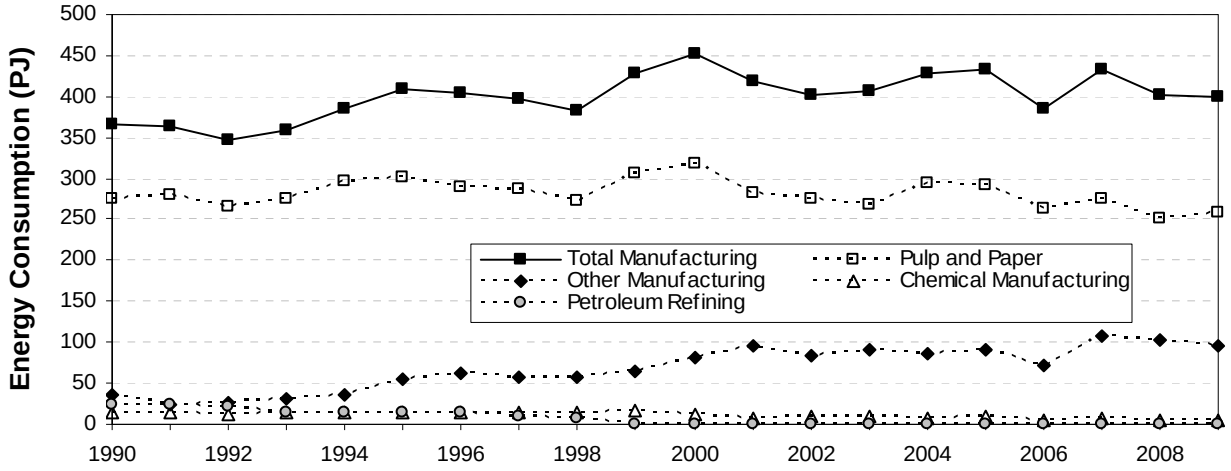


Source: STC RESD.

Figure 1-11 disaggregates consumption in Total Manufacturing by each manufacturing industry. All industry groups except Pulp and Paper showed decreasing energy demands in 2009 over 2008 and 2007. Even so, consumption is still about 90% higher than 1990 One major driving force behind the 24% rise in energy consumption in Total Manufacturing between 1990 and 2009 comes from the 169% increase in energy consumption in Other Manufacturing, which includes food, beverage, textile and electronics production industries. Pulp and Paper is the primary contributor to total manufacturing energy consumption consuming large amounts of biomass energy (spent pulping liquor and solid wood waste).[9] Over the study period, energy consumption in Pulp and Paper, which peaked in 2000, is currently 6% belown 1990 levels. Chemical manufacturing, some 66% below 1990 levels, dropped another 5% from 2008. Consumption in the petroleum refining industry are not available, due to confidentiality. Data are also not available for any year for cement or metal smelting and refining.

[9] There are some uncertainties regarding data for spent pulping liquor and solid wood waste for 1990 and 1991. Because of the impact on energy consumption levels, these data were extrapolated in order to present a more complete picture of energy consumption in British Columbia.

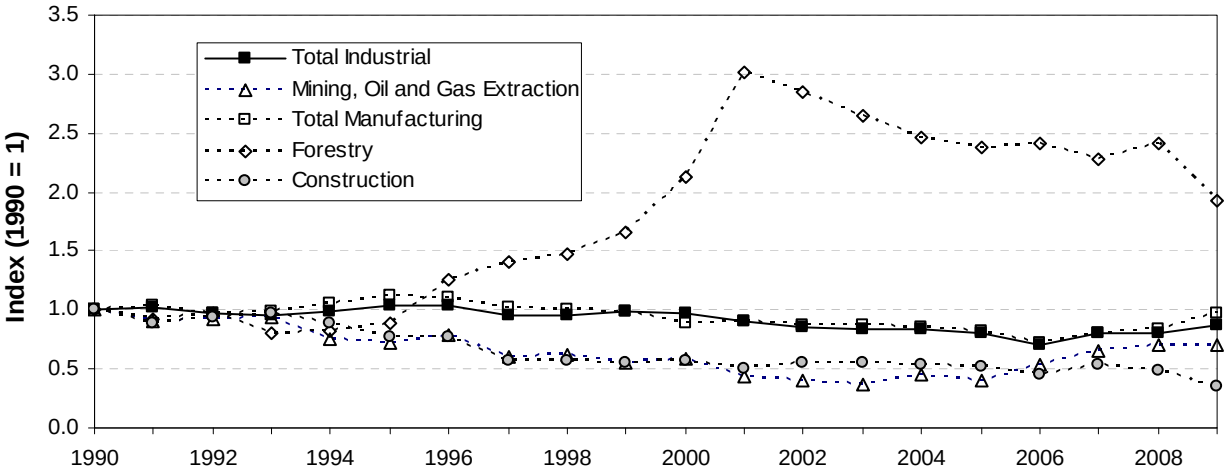
Figure 1–11. Energy Consumption in Manufacturing, BC



Source: STC RESD.

Figure 1-12 presents indicators of energy intensity based on GDP, indexed to 1990. With the exception of Forestry, energy intensities in all industries decrease, including Total Industry. Energy intensity in Forestry climbed dramatically between 1995 and 2001, but has since declined steadily[10].

Figure 1–12. Indices of Industrial Energy Intensity Based on GDP



Sources: STC RESD; CANSIM Table 379-0025 – Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS)

Between 1990 and 2009, energy intensity in Total Industrial, Total Manufacturing, Mining / Oil and Gas Extraction, and Construction decreased by 12%, 3%, 30% and 65%, respectively. However, as noted in the methodology section above, the intensity indicators provided here should be treated with caution as they are based on monetary measures of output. As such, they

[10] The increase in intensity in Forestry may be related to the softwood lumber dispute between the United States and Canada.

may not be a consequence of efficiency improvement but may be due to shifts, for example, in industry structure. CIEEDAC could not find a reason for the rapid changes in the forestry index, which shows a significant increase in intensity up to 2001 and then a general decline to a current level still 93% above 1990 levels.

1.6. Commercial and Residential sectors

To calculate energy intensity indicators, measures of production are necessary. However, no STC or NRCan series (i.e., 1990 to present) data on production aside from GDP could be found for the commercial and residential sectors of BC.[11] BC MEMPR provided information containing housing and commercial floor space data based on BC Hydro billing statistics to provide a single point estimation of intensity for the commercial and residential sectors based on floor space and number of housing units, respectively. In 2001, the energy intensity levels for the commercial sector, based on 51.94 million m^2 of commercial floor space and 134 PJ consumed, was 2.58 GJ/m^2. The first *Commercial and Institutional Building Energy Use Survey* (CIBEUS) of 2001, providing 2000 data, shows significantly lower floor space in the commercial sector and lower energy consumption; thus it shows a significantly lower energy intensity. CIEEDAC is investigating the definition of both the floor space and the energy consumption in this sector.[12]

For the residential sector, energy intensity levels in 2001 based on 1.47 million residential units and 141 PJ consumed was 95.86 GJ/unit.

Energy consumption levels in these two sectors can be seen in fig. 1.3 above.

1.7. Greenhouse Gas Emissions, 1990 – 2009

The following section reports on changes in total greenhouse gas emissions and GDP for British Columbia sectors from 1990 to 2009. It also includes a brief discussion of population growth in relation to these changes. Appendix A contains detailed tables of the data used.

CIEEDAC compared data calculated using RESD values and the value provided by Environment Canada in their *National Inventory Report*. The values differ a average of about 2.7% with a range of 0 to 9%.

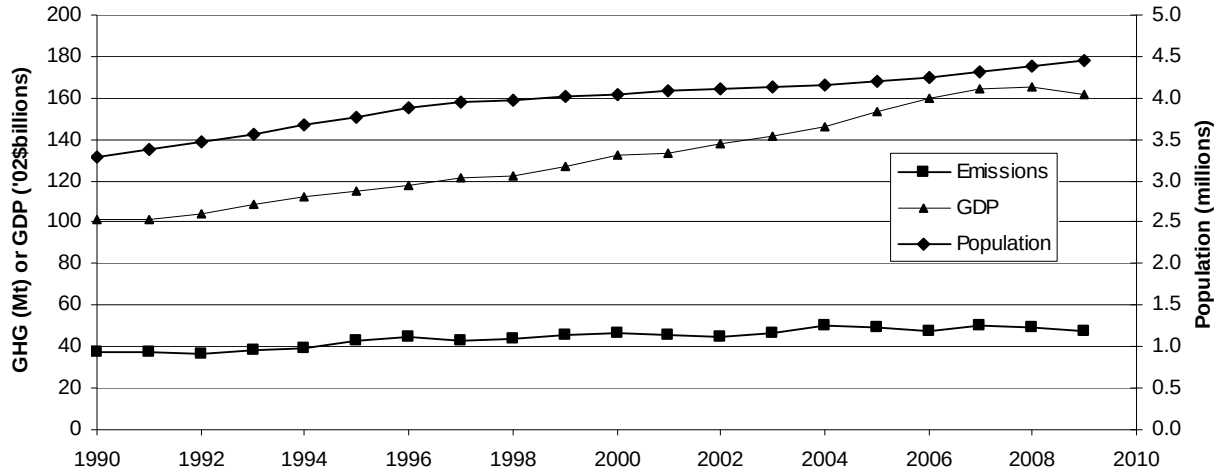
Figure 1-13 compares British Columbia's population growth (millions), GHG emissions (Mt), and production (GDP in 2002 $billions) for 1990 to 2009. Total energy consumption from which the emissions are calculated includes estimates of confidential consumption, biomass consumed in the pulp and paper sector,[13] and energy consumed to make secondary electricity.

As we noted earlier, population and GDP grow consistently over the study period, increasing by 35.5% (1.7%/a) and 76.5% (3.1%/a) since 1990, respectively. GHG emissions fluctuate over time, peaking in 2004 at 46.8 Mt, and finishes the period 22% above 1990 levels at 44.5 Mt, about 4.6% less than in 2008. We use GDP and population data to calculate the GHG emission indicators plotted as an index in Figure 1-14. These values are an index of the ratios of emissions

[11] STC does have data on number of mortgages approved by month by region on existing and new homes.
[12] CIEBUS lists about 27 million m^2 of floor space, consuming about 45 PJ
[13] Biomass data are used to calculate non-CO_2 GHG emissions. CO_2 emissions from biomass are not included because they are considered neutral by convention.

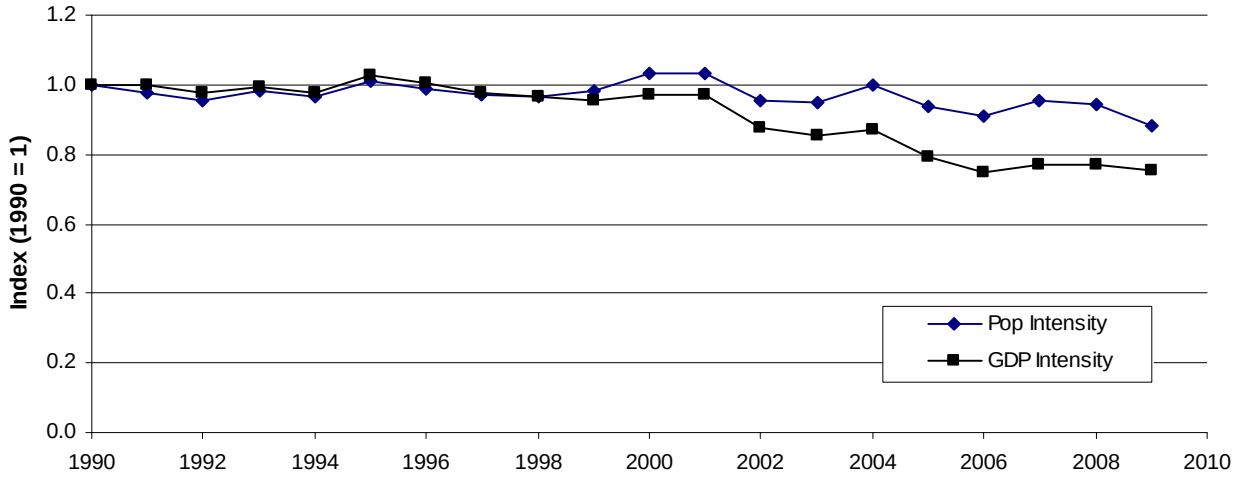
generated per capita or unit of GDP and help to demonstrate changes from the base line. One can see that the indices show different rates of decline. GHG emissions based upon population decreased 10% and the indicator based on GDP decreased 24% between 1990 and 2009. From 2008 to 2009, GHG emissions based on population decreased 6%, while intensity based on GDP decreased about 3%. These data suggest that, while considerably less GHGs are generated per unit value added, emissions per person do not change as much. It is difficult to speculate to the reasons for these changes; the link between energy and GHG emissions is not always straight forward.

Figure 1–13. GHG Emissions, Population and GDP for BC



Sources: STC RESD energy data converted to GHGs using EC coefficients (EC 2010); CANSIM Table 379-0025 and 051-0001.

Figure 1–14 GHG Intensity Indices for BC



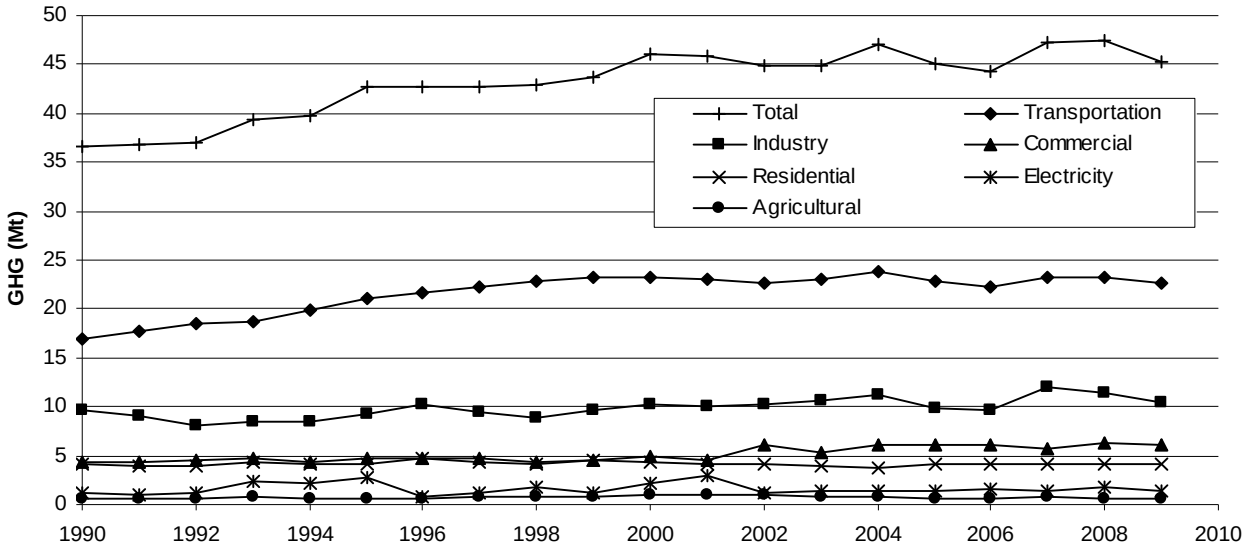
Sources: STC RESD; CANSIM Table 379-0025 and Table 051-0001.

1.7.1. GHG Emissions by Sector

Figure 1-15 compares GHG emissions in British Columbia's major sectors. Most sectors display an increase in energy consumption and, thus, emissions between 1990 and 2009. Transportation, Commercial / Institutional and Electricity sectors show relatively significant increases at 34%, 41% and 24% respectively. Residential and Industry GHG emissions increases more modestly at 1.5% and 8%, respectively by 1990.

Most sectors declined from last year in terms of emissions. The Industrial sector, (construction, forestry, all manufacturing, mining and oil and gas extraction) declined nearly 10% while Agriculture decreased 20% to a point 6% below 1990 levels. Commercial / institutional sectors decreased 5% respectively while Transportation decreased 2%. Electrical generation decreased significantly, nearly 16%. Residential rose marginally.

Figure 1–15. Comparison of GHG emissions in the Major Sectors of BC

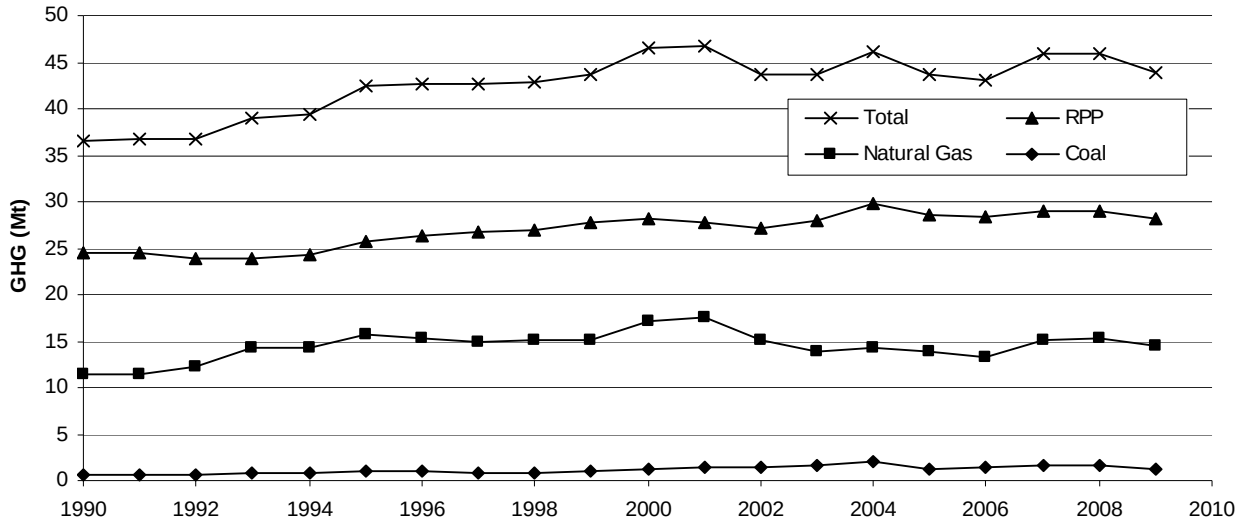


Source: STC RESD energy data converted to GHG emissions using EC coefficients (EC, 2010).

1.7.2. GHG Emissions by Fuel

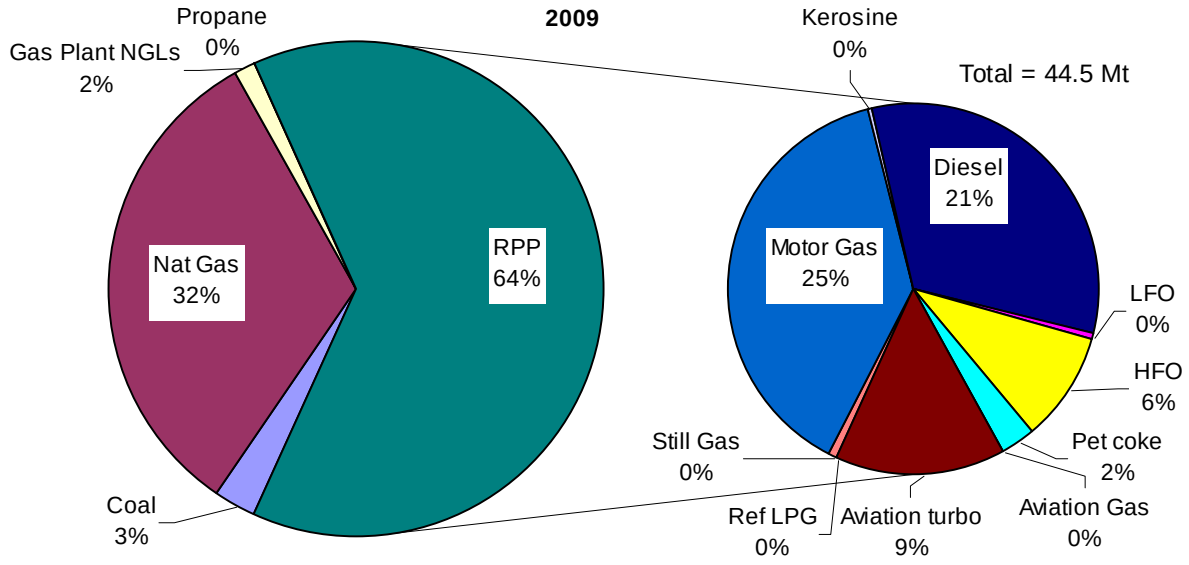
Figure 1-16 presents GHG emissions by fuel type. Coal emissions, although proportionally smaller than refined petroleum products (RPP) and natural gas (see Fig. 1.17) showed the greatest increase (106%) by 2009. Natural gas emissions increased 26%, 5.5% down from 2008, while petroleum product consumption increased 15%, with a 2.8% decrease from 2008.

Figure 1–16. GHG Emissions by Fuel



Source: STC RESD energy data converted to GHG emissions using EC coefficients (EC, 2010).

Figure 1-17. Proportions of Fuel Types contributing to GHG emissions in BC, 2007.



1.8. Conclusion and Summary

In 2009, British Columbia's total energy consumption (including energy consumed to make secondary electricity) reached 1,264 PJ, an increase of 21.6% above 1990. The rates of both population and GDP growth exceeded increases in energy consumption, resulting in energy intensity indicators decreasing by 10% and 31% in terms of energy consumption per population or GDP, respectively.

Consumption of all fuels declined in 2009 from 2008 but they are still considerably higher than they were in 1990. Natural gas, electricity and refined petroleum products are the major fuels of

the BC economy. Consumption of these major energy forms are 26% higher for natural gas, 16% for electricity and 24% for RPPS. Coal consumption, though representing a small portion of total energy consumption, increased the most – 81%.. Hydroelectricity continued to dominate electricity production, though the share of HFO-fired and diesel / LFO-fired plants declined significantly over the study period, and natural gas-fired plants' share increased.

Total Industrial energy consumption decreased 10% since 1990, decreasing 2.5% from 2008. Consumption in Total Manufacturing, up 9% from 1990, decreased 9% from 2008. Transportation, Residential and Commercial / Institutional energy consumption show relatively significant increases at 32%, 27%, and 32% respectively over the period; each declined from 2008 levels.

Total GHG emissions increase steadily before 2000 and then rise and fall with a peak in 2004 at 46.8 Mt. In 2009, emissions levels rose to a level 22% above 1990 but down from the peak; it was at about 44.5 Mt in 2009. Each of British Columbia's major sectors except for agriculture displays an increase in energy consumption between 1990 and 2009 and thus, each shows a higher level of GHG emissions except for agriculture. While Transportation, Commercial / Institutional and Electricity sectors show relatively significant increases at 34%, 41% and 24% respectively, Residential and Industry GHG emissions increases much more modestly at 1.5% and 8%, respectively. Coal consumption, again, showed the greatest increase (106%) by 2009 but plays a very minor role in total emissions generation. The bulk of the emissions come from the set of refined petroleum products, of which gasoline has the largest share. Among all the various petroleum products, natural gas, and coal, natural gas combustion generates the greatest amount of CO_2 in the province, about 32%. Natural gas emissions increased 26% since 1990 while petroleum product consumption increased 15%.

In the future, CIEEDAC will continue to update this section with the objective of improving and refining the accuracy of the data. Thus far, our analysis has only concerned itself with highly-aggregated economic sectors – the data are not available for more disaggregated analyses. This is especially true of industry, where it is clear from ICE data that further disaggregation might be possible. As with all reports published by CIEEDAC, we encourage and appreciate any feedback from our readers.

2. A Review of Cogeneration Facilities in British Columbia, 2009

CIEEDAC normally surveys cogeneration facilities for their data and was able to complete this task for 2009 through a unique contract with a consulting company asked to find such data for EC.

Cogeneration, also referred to as combined heat and power (CHP), is defined as the simultaneous generation of electricity (which includes direct drive power from steam turbines) and useful thermal energy from a single fuel. By making use of the waste from one process in the production of the other, substantial gains in energy efficiency are realized compared to the independent production of both products. The efficiency of cogeneration in converting primary energy into electrical and thermal energy places the technology at the forefront of many CO_2 emission reduction strategies. National and international commitments to reducing CO_2 emissions, has increased interest in cogeneration.

The thermal energy can be used in heating or cooling applications. Heating applications include generation of steam or hot water. Cooling applications require the use of absorption chillers that convert heat to cooling. A range of technologies can be used to achieve cogeneration, but the system must always include a power generator (either electric power or drive power) and a heat recovery system. The heat-to-power ratio, overall efficiency and the characteristics of the heat output are key attributes of cogeneration systems.

One classifies cogeneration systems by the type of prime mover used to drive the electrical generator. The five main types currently in use in Canada are steam turbines, gas turbines, reciprocating engines, microturbines and combined cycle gas turbines. New systems currently under development include fuel cells and stirling engines.

The attributes and prime movers referred to here and the information in the following sections (as well as a copy of the survey) are described in more detail in CIEEDAC's Report, *A Review of Existing Cogeneration Facilities in Canada (www.cieedac.sfu.ca).*

2.1. Objectives

CIEEDAC's Cogeneration Database aims to provide a comprehensive list of cogeneration projects in Canada's provinces and present unbiased data on the performance of cogeneration systems. To date, no other comprehensive list of Canadian cogeneration projects has been identified. This task is becoming increasingly challenging as cogeneration capacity expands rapidly under deregulation. Future updates of this report will continue to refine existing data and include new additions.

This report contains the following sections:

1. The methodology used to identify cogeneration projects in British Columbia.
2. A summary of cogeneration facilities in British Columbia by sector and system average performance characteristics.
3. Conclusions

2.2. Methodology

Beginning in 2004, CIEEDAC gathered data on Canadian cogeneration systems by means of a survey sent to all facilities listed in our database. Through this process, we identified several cogeneration systems across the country that are no longer operational, some sites that were never cogeneration facilities and some duplicate listings. In addition, CIEEDAC gathered new data on the performance characteristics of cogeneration systems operating in Canada's provinces and territories. The resulting database is more reliable and contains data that will enhance understanding of the opportunities for and limitations of cogeneration in Canada, and, for this report, British Columbia. In addition, we have identified new cogeneration systems through websites, industry contacts and utility personnel.

CIEEDAC considers the Canadian Cogeneration Database to be a comprehensive list of cogeneration systems operating in British Columbia. However, some systems may be missing because they are small or operate in remote locations; we hope to include them in future updates. Updating the database has been problematic because support for the survey is sporadic.

2.2.1. Data Sources

The key sources of data for this year's update of the Canadian Cogeneration Database are the completed questionnaires received from cogeneration facilities across Canada. New cogeneration systems were identified through websites and industry contacts. Historical sources of data include: the Canadian Gas Association (CGA), EC, consultants, independent associations, electric and gas utilities, STC, corporate and government websites, cogeneration manufacturer's brochures and industry journals.

2.3. Cogeneration Results, 2009

The following section summarizes the results of this year's cogeneration database survey for British Columbia. Table 2–1 presents BC's cogeneration capacity from 2000 to 2009 and compares BC's share in Canada. In 2009, with 16% of total operational electrical cogeneration capacity in Canada, the total cogeneration capacity in British Columbia reached 1,454 MW. Thermal capacity is 4,99 MW, about 65% of Canada's total. British Columbia is second in terms of installed cogeneration capacity after Ontario. We note that not all survey respondents provided all information – thermal capacity in BC may be underestimated.

Table 2–1 British Columbia's Cogeneration Capacity (MW)

Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Electrical Capacity										
British Columbia	1,373	1,408	1,408	1,408	1,408	1,468	1,468	1,468	1,468	1,454
Canada	4,525	5,267	6,352	6,743	6,789	6,936	7,007	7,007	7,007	9,075
% BC of total	30.3	26.7	22.2	20.9	20.7	21.2	21.0	21.0	21.0	16.0
Thermal Capacity										
British Columbia	4,156	4,433	4,433	4,433	4,433	4,433	4,433	4,433	4,433	4,999
Canada	27,200	27,846	28,937	29,063	29,127	29,159	29,473	29,473	29,473	32,065
% BC of total	15.3	15.9	15.3	15.3	15.2	15.2	15.0	15.0	15.0	16.0

Source: Canadian Cogeneration Database, CIEEDAC

2.3.1. Sector Results

In table 2–2, cogeneration capacity is allocated according to system operator / thermal host, and the facilities are coded using the NAICS system. The data are for 2009.

Table 2–2 British Columbia Cogeneration by System Operator / Thermal Host

Sector	*NAICS*	*Electricity Capacity (MW)*	*% of Total*	*Thermal Capacity (kW)*	*% of Total*
Oil and Gas Extraction	211	155	11%	0	0%
Utilities	221	398	27%	224	4.5%
Food Manufacturing	311	0	0%	0	0%
Wood Products Manufacturing	321	104	7.2%	364	7.3%
Paper Manufacturing	322	716	49%	4,336	87%
Pipeline Transportation	486	0	0%	0	0%
Waste Management and Remediation Services	562	23	1.6%	21	0.4%
Educational Services	611	0	0%	0	0%
Federal Government Public Administration	911	58	4.0%	54	1.1%
British Columbia Total		**1,454**		**4,999**	

*The Greater Vancouver Regional District water treatment facility on Iona Island is listed as providing district energy.
Source: Canadian Cogeneration Database, CIEEDAC

2.3.2. Cogeneration System Performance Characteristics

The data presented below are from the most recent cogeneration database and are based on data from 40 sites. We have data on average annual electricity generation from 26 sites, data on heat rate[14] from 11 sites, and data on heat to power ratio from 16 sites. The data on heat rate were not found to be reliable and are under review. Forthcoming editions of this report may contain more data on heat rate

Table 2–3 displays the average performance characteristics of cogeneration systems currently in operation in British Columbia. The average amount of electricity generated per kW_e of installed capacity is 5,206 kWh/kW/yr. The highest rate of electricity production, 8,750 kWh/kW/yr occurs in the education sector.[15] These levels of output give an indication of capacity utilization in the sectors.

The average heat to power ratio of systems operating in BC is 6.99. This means that for every kWh of electricity that could be produced by cogeneration systems, about 7 kWhs of useful thermal energy would be produced (i.e., these are not based on actual production figures but on system design). Table 2–3 shows that the paper manufacturing sector has the highest average heat to power ratio of all sectors. The wood manufacturing sector has the second highest ratio. This industry demands high quality thermal energy leaving less energy available to produce

[14] In this study, heat rate is defined as the energy content of fuel consumed in KJs, divided by the sum of the electricity output in kWhs and the thermal output in kWhs.
[15] These data are under review as this value is very close to the absolute limit of 8,760 kwh / kw installed per year.

electricity. The utilities and food manufacturing sectors have low heat to power ratios. Utilities have low heat to power ratios because their systems are designed to maximize electrical output.

Table 2–3 British Columbia Cogeneration System Performance Characteristics

Sector	*Electricity Generation (kWh/kW per year)*	*Average Efficiency*	*Heat to Power Ratio*
Oil and Gas Extraction			
Utilities	5,576	61.1%	0.75
Food Manufacturing		13.3%	1.26
Wood Products Manufacturing	4,242	66.0%	7.32
Paper Manufacturing	5,365	72.2%	9.37
Pipeline Transportation	-		
Waste Management and Remediation Services	3,485		
Educational Services	8,750		
Federal Government Public Administration	6,034		
Average	**5,206**	**64.8%**	**6.99**

Source: Canadian Cogeneration Database, CIEEDAC

Table 2–4 presents known and estimated annual cogenerated electricity generation by sector. The values shown for known electricity generation include only those data reported by the system operator. Using these data, one can derive average capacity utilization factor. Applying this factor, we estimated the electricity generation for all cogenerators. With the estimated values included, the hierarchy of total electricity generation has pulp and paper exceeding non-utility generation. Given a total electricity generation in 2009 in BC of 63,211 GWh, cogeneration may have contributed (based on our estimate) about 20% of BC's electricity generation in 2009. This appears far too high (it is about 96% of known industrial generation, of which most is reported to be hydro); it may indicate that there is an error in total generation data (i.e., generation not reported on Stats Can surveys) or there are errors in assessments provided by those surveyed related to the amount of electricity generated.

Table 2–4 British Columbia Cogenerated Electricity Generation for 2009

Sector	*Known Electricity Generation (MWh/year)*	*Estimated Electricity Generation (MWh/ year)*
Oil and Gas Extraction	-	1,357,800
Utilities	2,414,403	3,485,166
Food Manufacturing	-	2,190
Wood Products Manufacturing	362,415	912,792
Paper Manufacturing	2,702,950	6,268,919
Pipeline Transportation	-	-
Waste Management and Remediation Services	49,183	201,042
Educational Services	525	526
Federal Government Public Administration	350,000	508,080
British Columbia	**5,879,476**	**12,736,514**

Source: Canadian Cogeneration Database, CIEEDAC

Table 2–5 shows the average system efficiency for each type of cogeneration system. It shows that condensing turbine systems have the highest average efficiency (80.9%) while back pressure extraction turbine systems have the lowest (59.4%). However, for all system types the range of

efficiencies is large or the sample size is small. These data are indicative but should not be considered definitive; we suggest caution in using these data.

Table 2–5 British Columbia Cogeneration System Efficiency

System Type	*Average Efficiency*	*Range*	*Number of Units*
Steam Turbines Average	64.4	18.2% - 99.4%	38
Steam Turbines (ST)	70.8%		3
Back Pressure (BPST)	78.3%	70.8% to 85.8%	9
Back Pressure Extraction (BPEST)	62.4%	18.2% to 99.4%	13
Extraction (ECST)	64.9%	58.2% to 71.6%	7
Condensing (CST)	80.9%		6
Combined Cycle Gas Turbine (CCGT)			1
Gas Turbines (GT)			7
Spark Ignition (SI / IC)			5
Average for British Columbia	**71.6%**	**18.2% to 99.4%**	**51**

Source: Canadian Cogeneration Database, CIEEDAC

2.4. Conclusion and Summary

In CIEEDAC's *A Review of Existing Cogeneration Facilities in Canada*, cogeneration is defined as the simultaneous production of electrical and useful thermal energy from a single fuel. By making use of the waste from one process in the production of the other, substantial gains in energy efficiency can realized compared to the independent production of both products. The thermal energy can be used in heating or cooling applications. A range of technologies can be used to achieve cogeneration, but the system must always include a power generator (either electric power or drive power) and a heat recovery system.

CIEEDAC has completed seven annual reviews of cogeneration in Canada. The database currently contains information on 9.1 GW_e of cogeneration capacity in Canada.

Currently, British Columbia has the third largest electrical cogeneration capacity, 1.45 GW_e, after Ontario and Alberta. Alone, British Columbia accounts for 16% of total capacity in Canada. When classified by system operator, the pulp and paper sector has the most cogeneration, 0.72 GW_e, or almost 49% of total operational capacity in British Columbia. The utilities sector has the next highest cogeneration capacity of 0.40 GW_e, which represents about 27% of operating capacity.

The performance of cogeneration systems in British Columbia varies from a low of 18% to a high of 99%. On average, condensing turbine systems are the most efficient (81%) and back pressure extraction turbine systems are the least efficient (56%). Because the data set for this calculation is minimal, values appear to be out of a reasonable range.

CIEEDAC will continue to track and update this database with the objective of improving and refining the accuracy of the data. A revised report will be released annually. As with all reports published by CIEEDAC, we encourage and appreciate any feedback from our readers.

3. A Review of Renewable Energy in British Columbia, 2009

The discussion in the following section has not been updated to include data for 2009. CIEEDAC normally surveys renewable energy facilities for their data and was able to complete this task for 2009 through a unique contract with a consulting company asked to find such data for EC.

Renewable energy resources are derived from naturally regenerating energy resources such as the sun, wind, moving water, earth energy, and biomass (i.e., hog fuel, wood waste, black liquor, etc.). The majority of renewable energy forms are ultimately derived from the sun with an exception of geothermal and tidal energy.[16]

These resources can be used for electricity generation, heating and cooling services. Both low and high temperature thermal energy can be produced, depending on the resource. Some technologies can be used for cogeneration. In addition, water electrolysis technologies are being used to generate hydrogen from renewable power, with the potential for using that hydrogen currency as a mobile (i.e., transportation) or stationary fuel through fuel cells or direct combustion. Finally, renewable energy resources can be used to produce liquid bio-fuels such as ethanol or bio-diesel, both of which can be utilized as mobile or stationary fuels.

3.1. Objectives

This section of the report considers those resources and technologies used for power generation or cogeneration, renewable energy heating systems, hydrogen generation, and transportation fuels.

The purpose of this portion of the report is to achieve the following:

- Provide a comprehensive database of renewable energy facilities in British Columbia.
- Provide summary information on the mix of renewables by resource / technology type, by scale (capacity and annual generation), by owner / operator, by green certification status, and by vintage. It is also presents survey results for a series of questions about policy.

3.2. Background on Renewable Energy Technologies

Renewable energy technologies convert those naturally regenerating resources into useful energy currencies such as electricity, thermal energy, hydrogen or bio-fuels. These currencies can then be used to produce energy services. This section provides an overview of renewable power generating technologies.

Renewable energy technologies are found at a variety of scales, from a household level for supplying a proportion of a household load to power plants that can supply a large proportion of an electrical grid's power.

Several renewable energy technologies are technically mature and have been extensively commercialised, having been used in industrial and pre-industrial societies for hundreds of years. Many Canadian electricity companies started with hydroelectricity plants at the turn of the 20th

[16] Tides are somewhat associated with the sun in that they are the result of an interaction between solar and lunar gravity.

century, generating electricity from moving water in rivers. Some other technologies are in early stages of commercialisation with cost levels being higher than competing sources of energy.

3.2.1. Hydroelectricity

Hydroelectric technologies generate electricity from moving water in a river, stream or from a lake that is transferred through a pipeline to a lower elevation and through a turbine and generator to produce power. The water flows upstream of the project could be free flowing (i.e., run-of-river hydro) or stored behind a dam in a reservoir (i.e., storage hydro) to permit flexibility to meet varying electrical loads. Hydroelectricity projects are located in areas with large volumes of water available, in mountainous areas and / or where there is abundant rainfall. Storage hydroelectricity facilities are fully dispatchable, meaning that they can provide power consistently for 8,760 hours of the year, following loads with great precision, if the reservoir is large enough and full enough. Run-of-river facilities, where water is used at a rate no greater than that which runs down the river, are also dispatchable at times of year when water flows are sufficient.

In our report, we have distinguished between "standard" hydro, standard hydro "storage" and "low impact" hydro. Standard hydro and standard hydro storage are often associated with environmental impacts such as disturbance of fish habitat, whereas "low impact" hydro is not.

"Hydro storage" are facilities that use reservoirs to store surplus water in high flow periods allowing generation during low flow periods, or pumped storage facilities, which move water between an upper reservoir and a lower reservoir. During periods when electrical demand is high, water flows from the upper reservoir to produce extra electricity. When demand is low, the pumped storage plant lifts water from the lower reservoir to the upper reservoir, consuming electricity from other electricity plants[17].

Low impact hydro facilities are those that either: (a) have identified themselves as run-of-river hydro or microhydro, (b) have been certified by the Environmental Choice Program as Renewable Low-Impact Electricity, or (c) have met BC Hydro's Green Power Generation Green Criteria and have an Electricity Purchase Agreement with that utility. Criteria for the Environmental Choice Program and for BC Hydro's Green Power Generation can be found online at www.environmentalchoice.ca and www.bchydro.com respectively.

Standard hydro refers to sites that have only partially developed facilities, where an intake is situated on a river bank instead of on a dam and could only use a portion of the river flow, or any other hydro facility which could not be categorized as either hydro storage or low impact hydro.

3.2.2. Wind Power

Wind power is the generation of electricity from the kinetic energy of winds. Wind passes through wind turbine blades that turn a shaft connected to an electricity generator. Wind energy facilities are common in areas with consistent winds demonstrating high average wind speeds or areas with substantial gusts of wind on a predictable basis. They tend to be located in coastal areas, at high elevations, or in valleys or plains near mountainous areas. Wind power facilities

[17] www.canren.gc.ca/tech_appl/index.asp?CaId=4&PgId=26

are not readily dispatchable, although their output is often predictable based on daily wind patterns. They require back up through electrical grids with dispatchable supplies on-line or energy storage devices such as batteries.

3.2.3. Biomass and Biogas

Biomass energy is derived through the combustion of organic matter such as the waste products from a forestry operation or other plant matter. Biomass can be combusted in a boiler to produce steam for turbines to produce power. In cogeneration applications, the residual heat (thermal energy) is used as energy for other end-uses. Biomass power generation is primarily connected to the pulp, paper, and wood products manufacturing sectors through the combustion of wood residue products from those industries. Biomass power plants are fully dispatchable provided that wood resources are available, although there is a lagged start up time (it is not "instant" as we find with hydro power). The burning of biomass may be associated with air pollution, but there are technologies that minimize the particulate matter released.

Biogas energy is derived from biomass but is combusted as a gas comprised primarily of methane, the most common constituent of natural gas. Biogas is commonly generated from biomass waste products at sewage treatment plants, solid waste landfills, through forest sector activities, and agricultural operations. Biogas can be produced through a biological process that "digests" the biomass in a chamber with no oxygen, through a chemical process, or through heating in the absence of oxygen (destructive distillation). The biomass products are converted to a gaseous fuel. Biogas is then combusted in a boiler to produce steam for power generation through a steam turbine or through a combustion turbine directly. In both instances, under cogeneration applications, the residual heat is used as energy for other applications (thermal energy). Biogas generators are fully dispatchable provided that resources are available.

3.2.4. Solar Photovoltaic

Solar photovoltaic (PV) technologies generate electricity through semiconductor devices directly from solar radiation. They produce direct current electricity that can be converted to alternating current through inverters. Solar PV is utilized throughout Canada on many different types of buildings. Solar modules are installed as attachments on rooftops or through "building-integrated" configurations. Their output is not dispatchable, thus requiring a connection to an electrical grid with dispatchable supplies on-line or energy storage devices such as batteries to back them up. Solar electricity is only available during daylight hours and is reduced under cloudy conditions.

3.2.5. Geothermal and Earth Energy

The earth is naturally heated by the decay of radioactive particles in the earth's mantle. Geothermal energy and earth energy make use of this heat source. The renewable database uses 'geothermal' to define operations that use steam or hot water in the earth's crust (either from drilled wells or natural fissures) to power turbines, thus creating electricity. This is only possible where there is high temperature gradient, generally in areas with recent volcanic activity such as the BC coast. Earth energy installations, on the other hand, use the earth to *directly* heat or cool

(such as for hot water, or space heating). A medium or low temperature gradient is adequate for earth energy.

3.2.6. Others

Other technologies and resources not currently seen in British Columbia but existing or under development in Canada include:

- Tidal Energy: Converts moving water to electricity. Tidal energy is abundant in coastal areas, particularly on the BC coast when there are narrow passages with large volumes of water.
- Wave Power: Converts the kinetic energy of ocean waves into electricity.
- Solar Thermal: Uses the sun's energy to directly heat water or air. This technology is well established. There are installations in BC but these are not yet recorded in the renewables database.
- Municipal Solid Waste: The incineration of garbage to produce energy.
- Bio-diesel Fuel: A diesel derived from renewable sources such as vegetable oil.
- Ethanol Fuel: An alcohol fuel that can be mixed with or used instead of gasoline. It is made by distilling fermented sugars derived from vegetable sources such as corn or wheat.
- Hydrogen fuels and fuel cell systems: Hydrogen fuel is only renewable when the electricity used to cause electrolysis is from a renewable source. Renewable hydrogen generation is being proposed at several locations in Canada.

Certain types of renewable energy technologies that produce few environmental and social impacts are often categorized as "green energy" sources. These supplies are being used to meet regulatory requirements connected with environmental policy goals or sold to consumers as a premium product for a higher price than default energy supplies. Green energy is typically defined through facility certification standards such as those applied by the federal government sanctioned Environmental Choice "Eco-Logo" Program[18], BC Hydro[19], and the Canadian Electricity Association[20]. In BC, a new set of guidelines are currently being used to define clean energy. More information is available from the BC Ministry of Energy and Mines in a document entitled *BC Clean Electricity Guidelines*, released in September, 2005.

3.3. Methodology

This section provides an overview of the methodology pursued for the development of the data on BC's renewable energy. The BC data are part of a larger database containing information on renewable energy facilities throughout Canada. This database aims to bring together information

[18] See http://www.terrachoice.com and the "Renewable Low-Impact Electricity" label
[19] BC Hydro Green Criteria. See http://www.bchydro/com/greenipp
[20] CEA's Environmentally Preferable Electricity Portfolio certification system based on the methodology developed by the Oakland, California–based Scientific Certification Systems (SCS).

on all renewable power operations in Canada over a scale of 100 kilowatts (kW) of rated capacity. In the case of run-of-river hydro, earth, wind and solar power, smaller applications have also been included, provided they are connected to a regional or community electrical grid or connected with an industrial load. There are 1,063 records for renewable energy facilities in Canada, 163 of which are in British Columbia.

The following information is provided in the database for each facility: renewable resource type (i.e., wind, hydro, biomass); capacity (electrical, thermal, litre production, etc); number of generating / production units; average annual electricity or thermal heat generation if applicable; start year and capacity upgrades; grid connection; green certification status; conversion technology; market; installation and operating costs; employment; annual revenue; government incentives used; tax payments; and responses to questions on energy policy.

3.3.1. Data Sources

The original data were collected from a number of sources, including the following:

- Renewable energy industry association publications and statistics (i.e., Canadian Wind Energy Association, Canadian Hydropower Association, Canadian Bioenergy Association, Independent Power Producers of Ontario).
- Renewable energy publications from government and institutional sources
- Statistics Canada report, “Electric Power Generating Stations: 2000” – catalogue number 57-206-XIB. This provided by far the bulk of the initial data on specific sites.
- Communications with and materials from power plant owners and developers.
- Electric utility and retailer information sources.
- Personal knowledge of the authors of this report on power plants in Canada.

This year, the survey was conducted online at CIEEDAC’s website for more convenient access. The information was automatically entered into a Microsoft Access database. A report generator prints the information in the database in table found in Appendix C of this report.

Several limitations and sources of error in the database include the following:

- Despite a concerted effort to be comprehensive, several power plants may be missing, in particular, hydroelectricity, biomass, and biogas plants built after the year 2000, given that the STC source included information up to that year and the industry associations for those sources of energy do not publish a power plant listing. In contrast, the wind energy industry association and the federal government publish a directory of wind and solar power plants respectively.
- Distributed energy sources such as solar photovoltaics, solar thermal, and geothermal are by nature small and difficult to track. The database currently does not accurately reflect their contribution to renewable energy generation in BC. In the future, efforts will be made to obtain records from those selling and installing these systems.
- Annual electricity generation data is incomplete, as many companies chose not to reveal this information. The response rate will likely improve as a level of trust is built with survey respondents.

- For those biomass and biogas facilities that mix renewable fuels (e.g., spent pulping liquor) with non-renewable fuels (e.g., natural gas), renewable capacity and annual generation were generated by simply multiplying the total energy or power by the proportion of fuel that is renewable. For example, a 10 MW total capacity with 60% of the combusted fuel from renewable spent pulping liquor and 40% from natural gas would be recorded as 6 MW of renewable capacity. This simplification disregards differences in boiler types and efficiencies and any interdependencies between the fuel sources.

The tables and figures in the remainder of this section are generated directly from the data contained in the CIEEDAC Renewable Energy Database as described above.

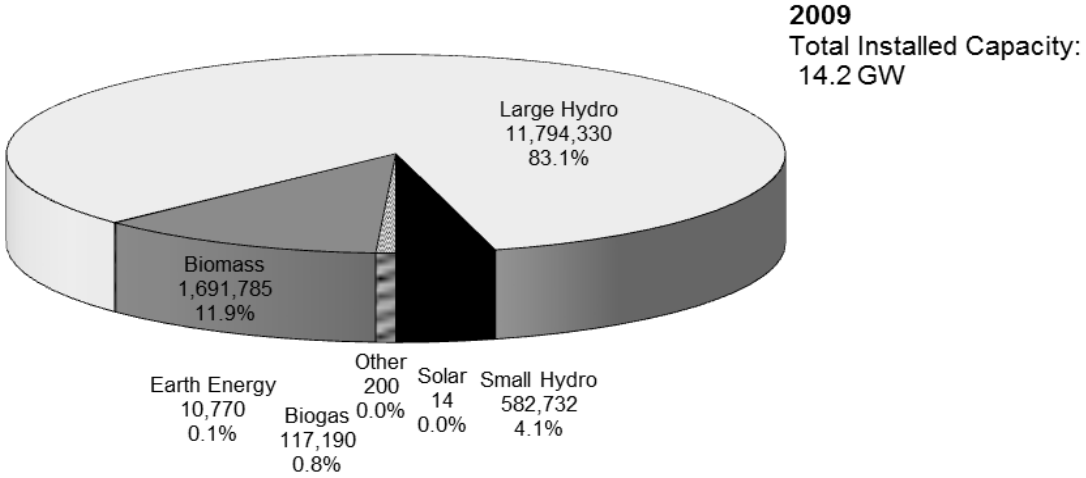
3.4. Renewable Energy Results, 1990 - 2009

3.4.1. Capacity

BC currently has an installed *renewable* capacity to produce *heat and electricity* of 14.1 GW. About 88% of renewable energy capacity is an electrical capacity with the remainder as thermal capacity (12%). Although we also collect information on generators of renewable liquid fuels, the database does not list any for BC.

Figure 3-1 below divides renewable energy capacity by resource types. In the figure, we see that hydroelectricity dominates BC's renewable energy power market, with large hydro and small hydro, for about 83% and 4.1% of BC's renewable energy power capacity, respectively. About 12% of renewable energy power capacity is derived from biomass wood residue sources (both electrical and thermal), and about 1% is from biogas, municipal solid waste and solar (both electrical and thermal). Renewable energy sources provide about 87% of BC's total installed electrical capacity of 14.9 GW.

Figure 3–1 Total Renewable Energy Capacity (kW) by Resource Type, BC

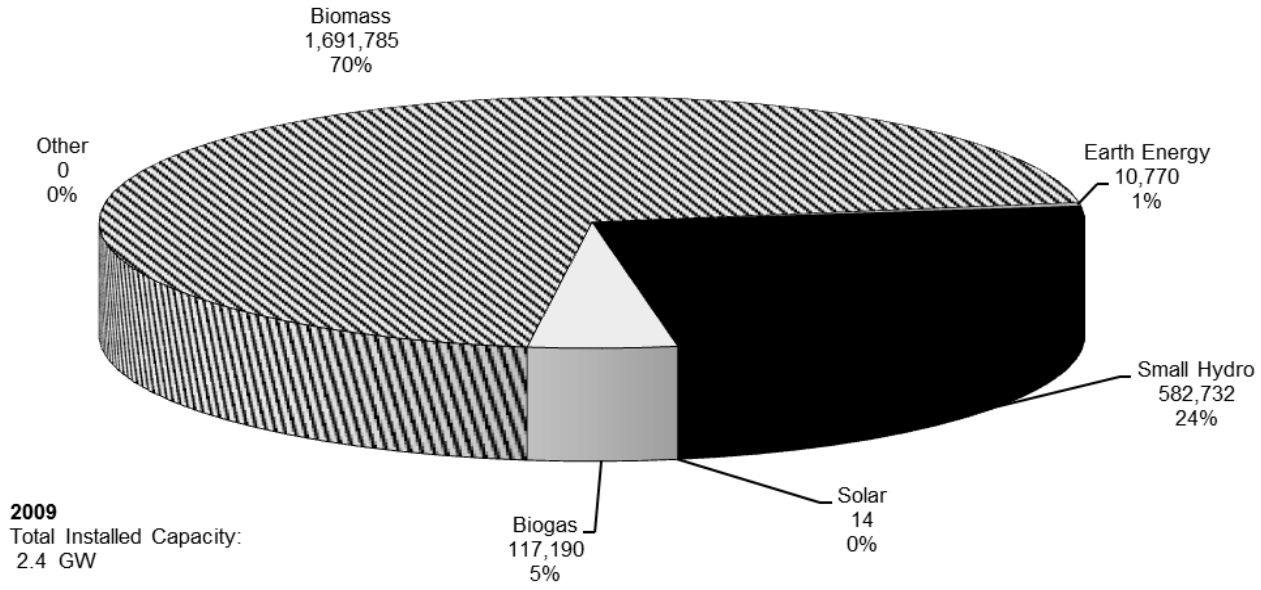


Source: CIEEDAC Renewable Energy Database, 2010

It is worthwhile also to look more carefully at those resources considered lower impact. Figure 3–2 illustrates the capacity share when excluding standard hydroelectric facilities. We note that

there are facilities using earth energy and landfill gas, but no information on capacity was available. They are assumed to make up a very small proportion of renewable energy capacity.

Figure 3.4–2 Total Renewable Energy Capacity (kW) by Resource Type, Excluding Standard Hydro and Standard Hydro Storage, BC



Source: CIEEDAC Renewable Energy Database, 2010

Figure 3–3 illustrates the total quantity of new electrical generating capacity added in BC during each decade of the last century, broken down by renewable resource type. Each decade up to 1980 saw increasing levels of capacity expansion (except during the Depression in the 30s). Since then, capacity additions have dropped off dramatically. Since 1991, new capacity has come almost exclusively from sources such as biomass and "low impact" hydro.

It should be noted that the composite chart includes only one entry for each power plant based on the original year of operation. It therefore allocates upgraded capacity to the start year. Nevertheless, it provides us with a useful overview of installation activity.

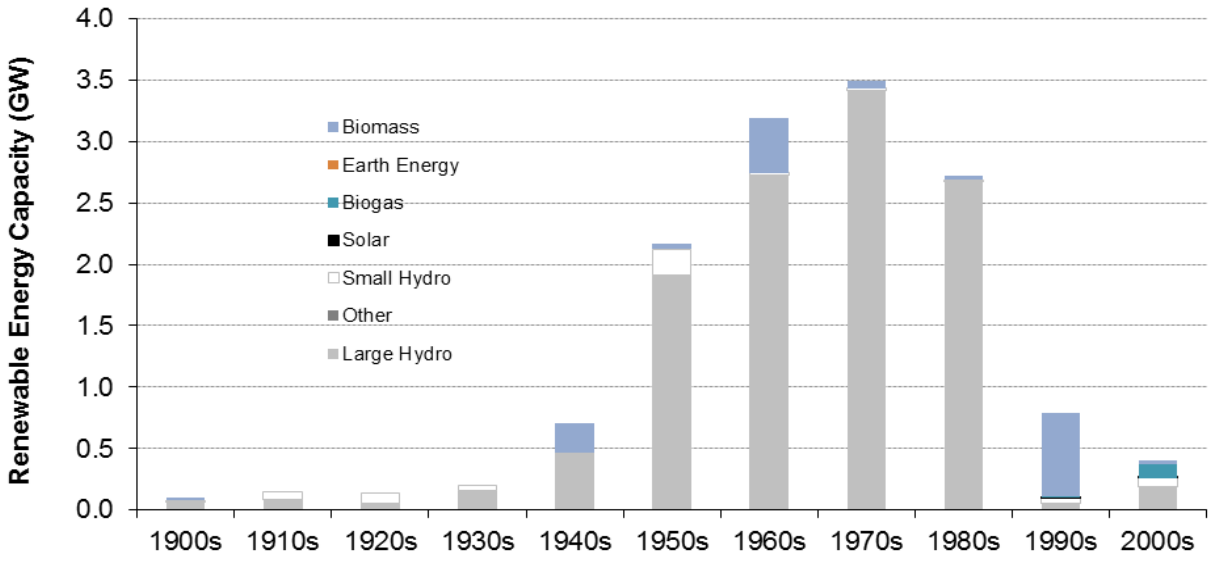
Figure 3–4 presents the number of facilities built rather than their capacity. It highlights recent efforts to add lower impact energy facilities. The Other category consists primarily of solar and earth energy. Many of these new facilities are small but, as the numbers increase, the impact can be quite significant.

3.4.2. Annual Generation of Energy

The survey asked facility operators to report their annual energy generation. The sums of these figures are listed in the first column of Table 3-1 below (in GWh). However, some facilities report only their rated capacity and not their annual energy generation. Thus, data from 39.5% of the facilities in the database that provide information on both their rated capacity and annual energy generation are used to calculate capacity factors for each renewable resource type. These

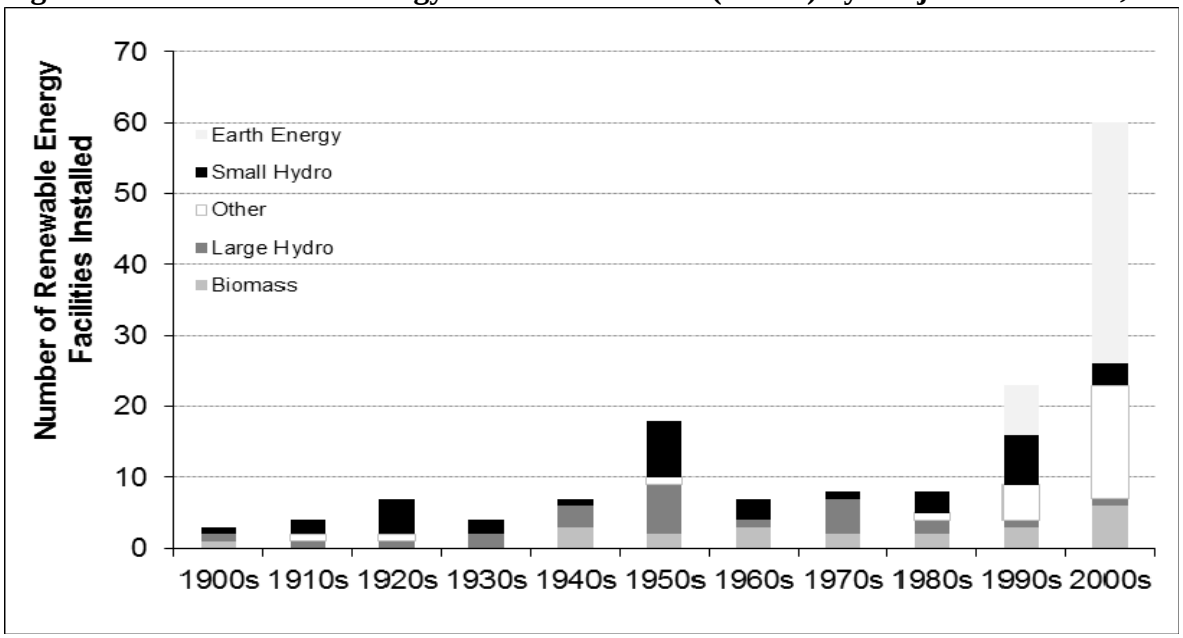
capacity factors are then applied to all of the facilities in the database that have reported their capacity to generate the second column in Table 3-1.

Figure 3–3 New Renewable Energy Capacity by Project Start Year, BC



Source: CIEEDAC Renewable Energy Database, 2010

Figure 3.4–4. Renewable Energy Facilities Installed (Count) by Project Start Year, BC



Source: CIEEDAC Renewable Energy Database, 2010

The 2009 renewable energy survey for BC reveals that 19% of the energy produced in BC is from renewable resources and estimates show it may be as high as 21%.[21].

Table 3–1 Annual Renewable Energy Generation (GWh) and Avoided Greenhouse Gas Emissions (1000 tonnes CO_2 equivalent), BC

Fuel Type	*Known Energy Generation*	*Estimated Energy Generation*	*Potential Total Energy Generation*	*Confirmed GHG Emissions Avoided*	*Estimated GHG Emissions Avoided*	*Potential Total GHG Emissions Avoided*
Biogas	16	89	105	3	29	33
Biomass	4,997	1,980	6,976	1,415	636	2,051
Large Hydro	60,090	2,022	62,112	26,440	890	27,329
Small Hydro	3,058	137	3,195	1,345	60	1,406
Solar	0	0	0	0	0	0
Other	1	43	44	1	19	19
Total	**68,161**	**4,271**	**72,432**	**29,204**	**1,634**	**30,838**

Source: CIEEDAC Renewable Energy Database, 2010

The associated quantities of greenhouse gas emissions avoided are also listed in Table 3-1 (in CO_2 equivalent). These calculations assume that the alternative to renewable electricity generation would be combine-cycle gas turbines, and that the alternative to burning wood residue for thermal energy would be burning natural gas in a boiler. As the estimated figures below might deviate significant from "real" energy generation and GHG emissions avoided in 2009, they should be cited with caution.

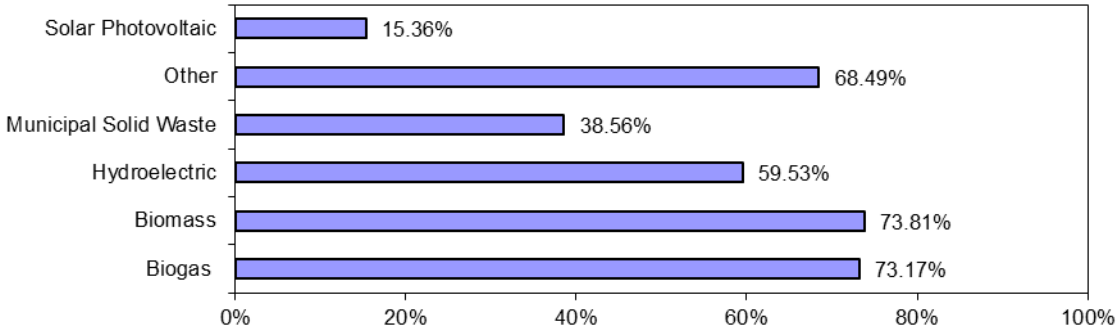
Due to the high proportion of renewable electricity generation, BC emitted only 902 kt of greenhouse gases from the production of electricity in 2005.[22] If these were replaced with combined cycle gas turbines, greenhouse gas emissions from electricity would be as high as 23.8 million tonnes of greenhouse gases.[23]

3.4.3. Capacity Utilization

By obtaining both capacity and annual generation we were able to estimate the average capacity utilization of each resource type, presented in Figure 3-5. Capacity utilization indicates the annual generation as a percentage of what could be generated if the plant ran constantly. Barriers to obtaining 100% capacity utilization could include an inconsistent supply of fuel (biomass), sunlight (solar), or water (hydro), planned down time for maintenance, mechanical failure, and a lack of demand during non-peak hours.

[21] Based on 2009 renewable energy generation and 2009 total primary energy production for BC from Statistics Canada's "Report on Energy Supply and Demand", taken from CANSIM.
[22] Based on an electricity GHG intensity of 0.017 kt CO_2e/GWh (Source: EC (2007))
[23] Assume greenhouse emissions intensity for marginal electricity production is 0.44 tCO_2e/MWh

Figure 3–5 Capacity Utilization by Resource Type, BC



Source: CIEEDAC Renewable Energy Database, 2010.

3.4.4. Characteristics of Electricity Generators

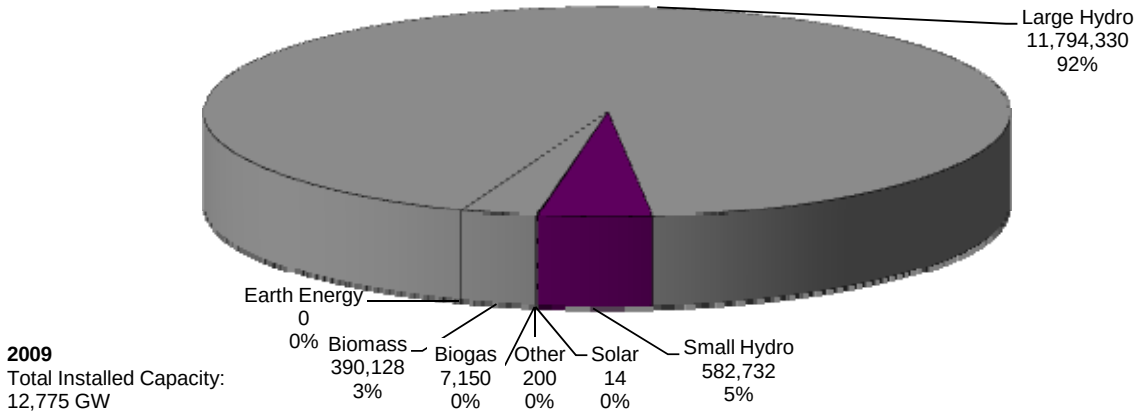
Figure 3–6 shows the breakdown of renewable electrical capacity by resource type. Hydroelectricity dominates BC's renewable generation market, with 92.3% and 4.6% of BC's electricity from renewables are generated by large hydro and small hydro facilities, respectively. The average facility capacities of these two types of hydro are 62MW and 3MW respectively. Large Hydro is the province's largest producer of renewable electricity. Hydroelectricity can also be broken into Hydro Storage, Hydro Run-of-River and Hydro Other. The dominant form of hydroelectricity is Hydro Storage, with a total capacity of 10.7 GW and an average facility capacity of 56.5 MW. Run-of-River is the second most common type of hydroelectricity in BC, with a total capacity of 1.2GW and an average facility capacity of 6.7MW. There are 62 hydro facilities including 32 hydro storage facilities in our database, which represent about 97% of installed renewable electricity capacity in British Columbia.

Figure 3–7 illustrates the electricity capacity share when excluding large hydro facilities.

Nine of the 62 hydro facilities in our database are certified 'green' by BC Hydro or the Environmental Choice EcoLogo program.

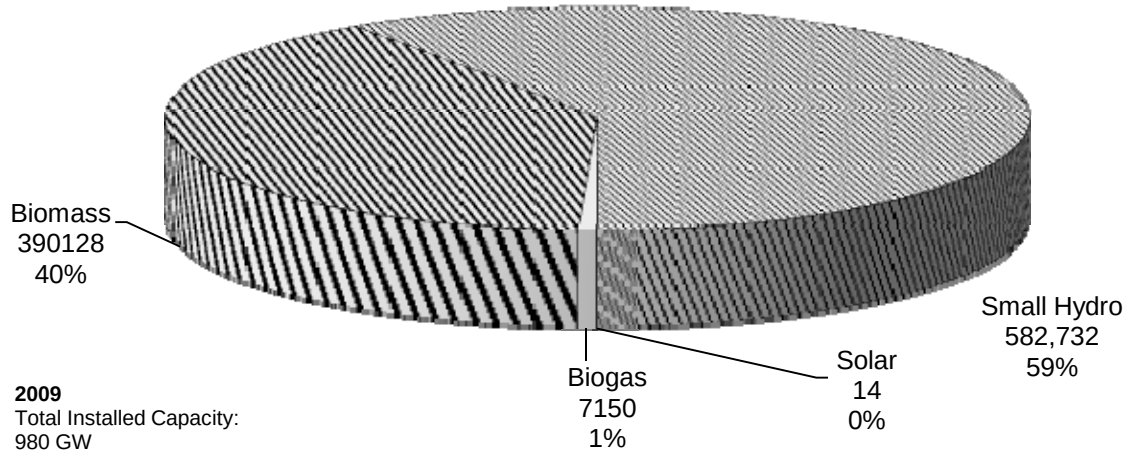
Although solar photovoltaics are shown here to represent a miniscule share of electrical capacity, this technology is likely under-represented in our database due to the difficulty of tracking down such a distributed energy source. Of the 10 installations listed, one is owned by a diversified electricity generator, one by a renewable electricity generator, one by a telecommunications firm, 1 by an academic research facility, and one by a private residence. None of them sell electricity to the grid. Eight of them were installed in the last 5 years.

Figure 3–6 Renewable Electrical Capacity (kW) by Resource Type, BC



Source: CIEEDAC Renewable Energy Database, 2010.

Figure 3–7 Renewable Electrical Capacity (kW) by Resource Type, Excluding Standard Hydro and Standard Hydro Storage, BC



Source: CIEEDAC Renewable Energy Database, 2010

3.4.5. Characteristics of Thermal Energy Generators

In 2009, fifty-nine facilities reported production of renewable thermal energy, with a total of 1,422 MW of capacity. Of this total thermal capacity, 83% is derived from wood waste in pulp and paper establishments. The remainder comes from landfill gas used by the utilities (7.0%), wood waste in wood manufacturing establishments (5.6%), biomass from the oil and gas industry (3%) and earth energy (0.8%).

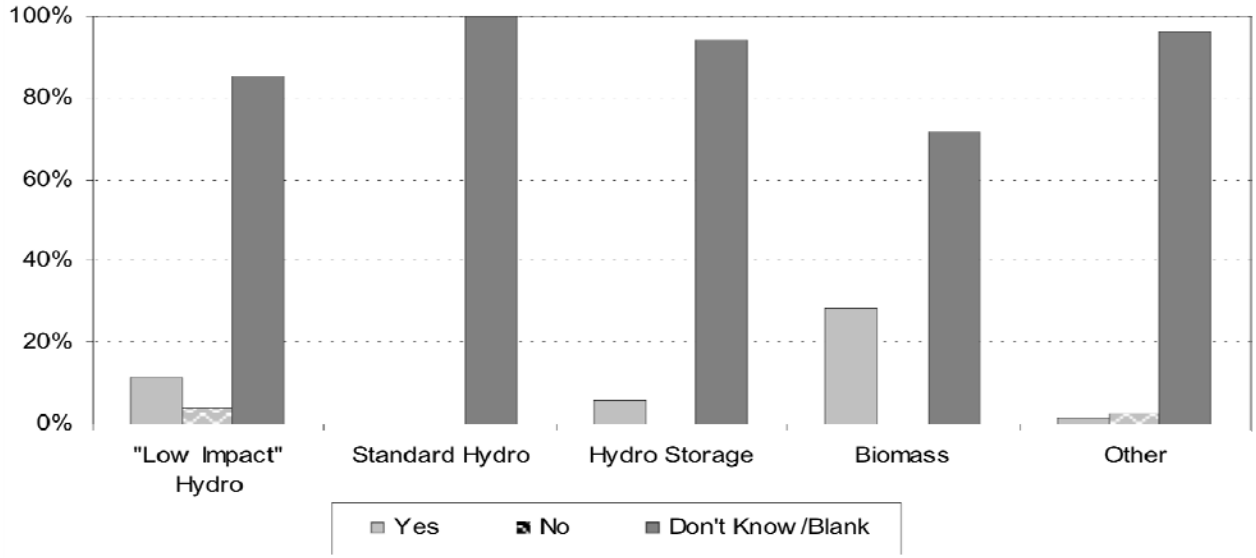
Nine thermal energy producers also report generating their own electricity but only five facilities reported selling electricity to the grid. Five of these 9 thermal energy producers report that they purchase electricity from the grid. In general, these facilities produce a relatively small amount of electricity compared to thermal energy with an average of only 13 kW of electrical capacity per 100 kW of thermal installed capacity with a total installed electric capacity of 163 MW.

There are 52 earth energy facilities listed in the database. Thirty two of these facilities have an average capacity of 337 kW comprising a total of 10.7 MW. The largest and smallest facilities are 2,321 kW and 18 kW, respectively.

3.5. Finances and Policy Survey, Implications for BC

Survey respondents were asked to provide financial information, and answer several questions about renewable energy policy. Confidentiality and a lack of response prevent the reporting of any financial statistics here. However, of 167 respondents, none indicated that they had received a financial incentive from the government, and 4 indicated that they'd received an incentive from another source (such as BC Hydro's Green Power Purchase Agreement or a grant from the Federation of Canadian Municipalities). The results presented here are not meant to be statistically accurate or representative of all facilities but merely report the responses received.

<u>Question 1</u>: Do any currently existing government or electric utility regulations hinder the wider adoption of new renewable energy in Canada?



Source: CIEEDAC Renewable Energy Database, 2008.

The following comments were also provided in response to the question "If so, which ones?".

Biomass and Biogas:

- *Various regulations around air permitting for renewable energy. Constrains ability to burn fuels."*
- *"Local utility charges more for hydro electric power than they pay us for exporting surplus renewal electricity into their grid Need utilities to pay a premium for renewal 'wood waste to energy'."*
- *"GVRD has restricted the development and use of biomass in the Lower Mainland."*
- *"Permitting, regulatory compliance, etc was a very high cost relative to revenues at this scale of operations."*

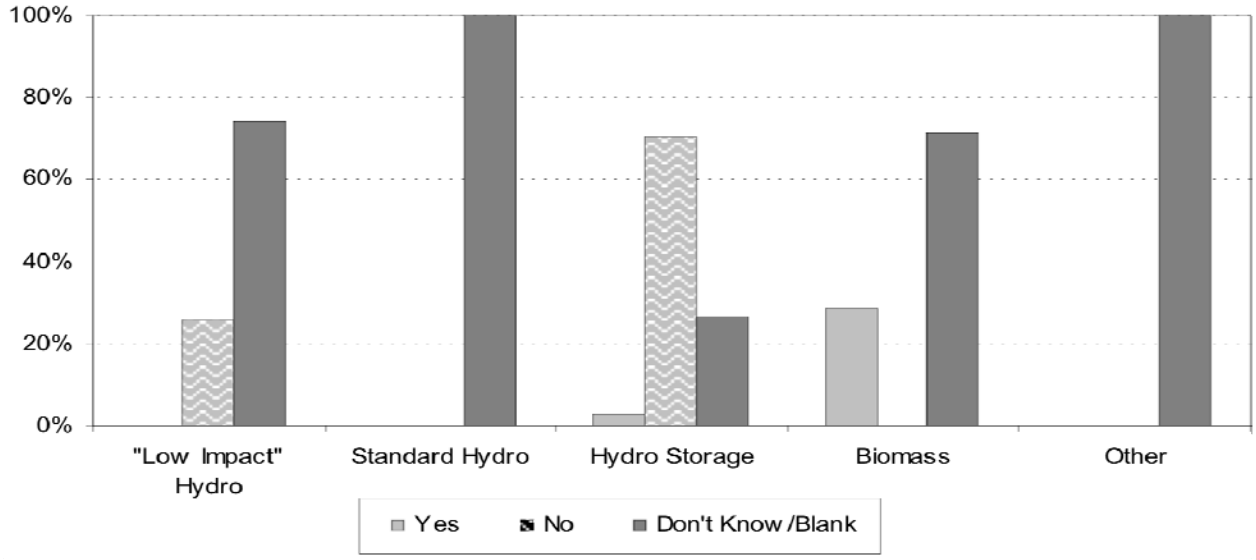
Hydro:

- **"***BC Hydro requires too much liability insurance. The property tax assessments are based on a legislated assessment rate that is not fair to producers that build cheaply. We are also taxed using a cap rate as a utility when we can't raise our rates like a utility. Streams that contain fish are almost impossible to permit due to the federal no net loss policy and now all streams in our area are considered as food sources to fish down stream and are protected that much more, even if they don't contain fish."*
- *"Navigable Water Protection Act is unreasonably applied."*
- *"Property taxes in BC excessive, navigable water protection act is unreasonably applied."*
- *"DFO, Environmental Assessment, IRIA, Navigable Waters Protection and other requirements do add significant regulatory costs / burden to any energy project."*
- *"Conflicts between the federal and provincial environmental assessment processes cause conflict and delays."*
- *"Stakeholder involvement on municipal, provincial, and fed levels cause great concern - everyone wants buy-in, which makes achieving it very difficult."*

Other:

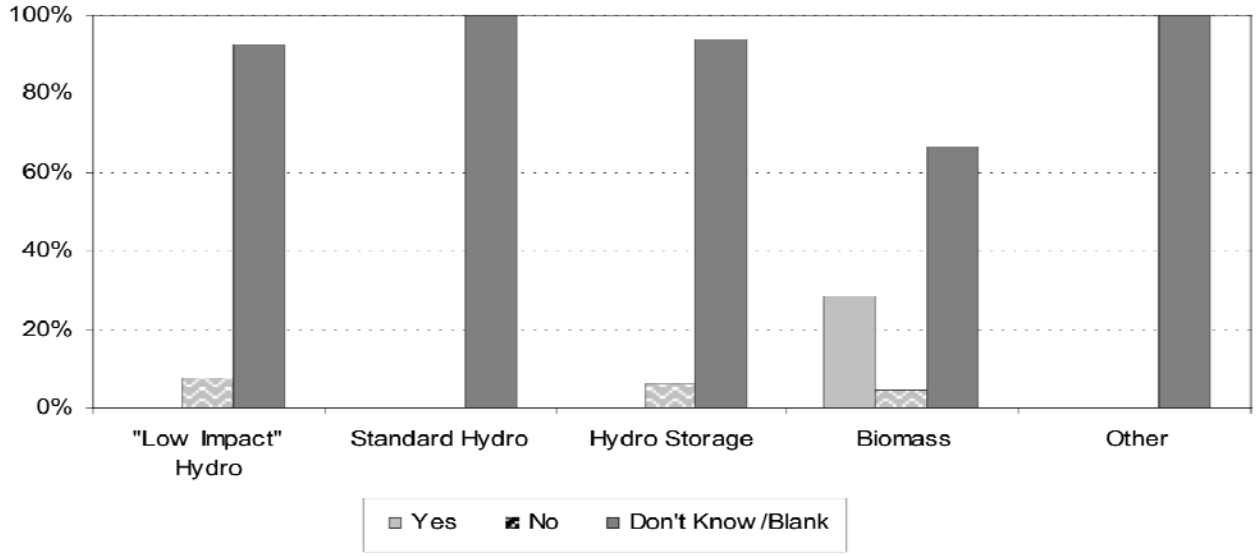
- *"No analog kWh meters certified for net metering (bi-directional)."*
- *"Property taxes in BC excessive."*
- *"Unable to wheel power to customers."*

<u>Question 2</u>: Would more facilities in Canada generate renewable energy if they were better informed about it?



Source: CIEEDAC Renewable Energy Database, 2008.

<u>Question 3</u>: Would the provision of information by the Government of Canada on renewable energy stimulate increased penetration of renewable energy in Canada? What sort of information would be particularly critical to provide?



Source: CIEEDAC Renewable Energy Database, 2008.

The following comments were provided in response to the question "What sort of information would be particularly critical to provide?"

Biomass and Biogas:

- *"Funding opportunities for these projects as the cost/benefits are quite low. Also assistance with obtaining access to capital funds. The value of electricity is too low in BC to make energy systems profitable."*
- *"Cost based information—companies won't do anything until know how affects bottom line."*
- *"'How to apply for any subsidies"*
- *"Need provincial government to take a higher profile role by encouraging BC Utilities Commission to require utilities to purchase wood waste energy electricity at a price equivalent to new sources."*
- *"'How can these projects be made economic? Tax incentives, grants or subsidies."*
- *"Providing information to renewables enthusiast groups and associations."*

Hydro:

- *"'The Government of Canada could provide this information to tax assessors, BC Hydro, and fisheries, that we need more renewable projects so there will be someone to tax, have sufficient supply of energy and a clean atmosphere so the climate won't change and reduce fish habitat. The producers of energy don't need more information from the Government. I believe that all the Government does is put out information instead of directing the agencies responsible to acquire more green energy."*

- *"It depends on your target audience - if you're trying to build market demand, then perhaps yes, illustrating the pros/cons of each type of fuel may build consumer education which guides government policy direction and corporate planning & product and service options.*
- *If you're trying to invite utilities/companies to build more facilities, no, as its not necessarily information that assists these decisions, its more bound by the supply/demand balance of the operating area coupled with environmental and social considerations.*
- *It's not a providing information role that the Government of Canada needs to play - its action and leadership. Specifically, in the area of renewables, it translates to rules for emission reductions and emission caps that need to be developed to send a signal to business, industry, customers and the public about what is acceptable standards and what's required when these standards are surpassed, e.g. purchasing emission reduction credits, reducing emissions through newer technologies etc."*
- *"Success stories and the true benefit to both the environment and the economy to show that using these natural RENEWABLE resources provides long term investments in typically rural areas for tax revenue and infrastructure."*
- *"Cost of renewable energy and payback period."*

<u>Question 4</u>: For your region, how much of a subsidy (in $/kWh) would be required to make renewable energy cost-competitive with conventional electricity generation?

Biomass and Biogas:

- 4 facilities: $0.03/kW
- 1 facility: $0.03-0.05/kW
- 2 facilites: $0.07/kW
- 1 facility: $0.15-0.20/kW

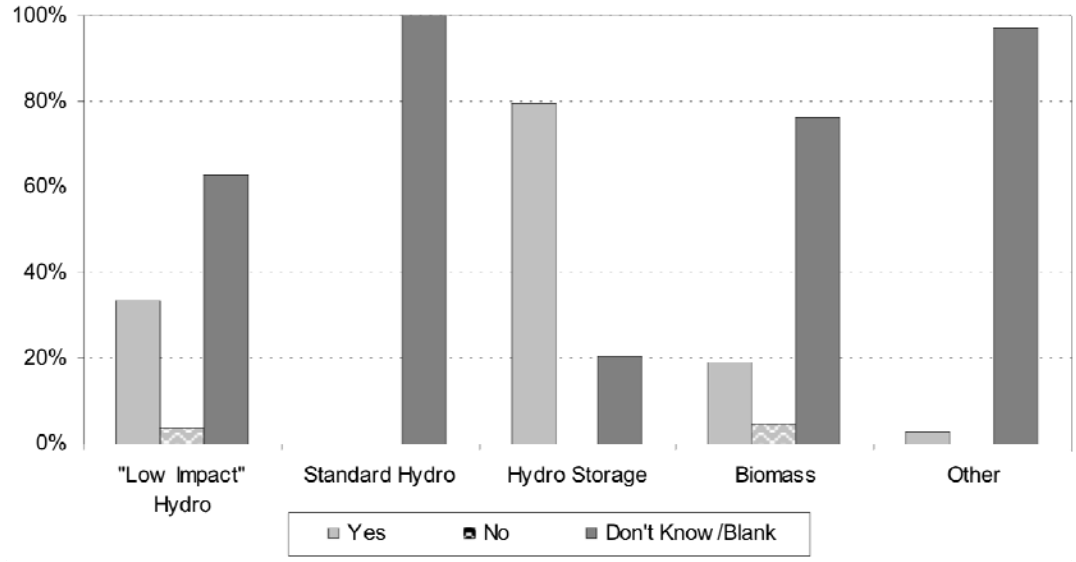
Hydro:

- 1 facility: $0.02/kw
- 1 facility: $0.03/kW
- 1 facility: $0.10-$0.15/kW
- 2 facilities: Probably $40/MWh would start to attract small hydro, for wind more like $50/MWh. Long term contracts (>15 YEARS) are critical to attract investment.

Other:

- 1 facility: $0.25 /kWh (solar photovoltaics)

<u>Question 5</u>: If you sell renewable energy to a third party, do you think that their decision to purchase from you is dependent on the fact that the energy you produce is considered "green"?



Source: CIEEDAC Renewable Energy Database, 2008.

<u>Question 6</u>: How big of a premium do you think your customers are willing to pay for "green" energy (in $/kWh)?

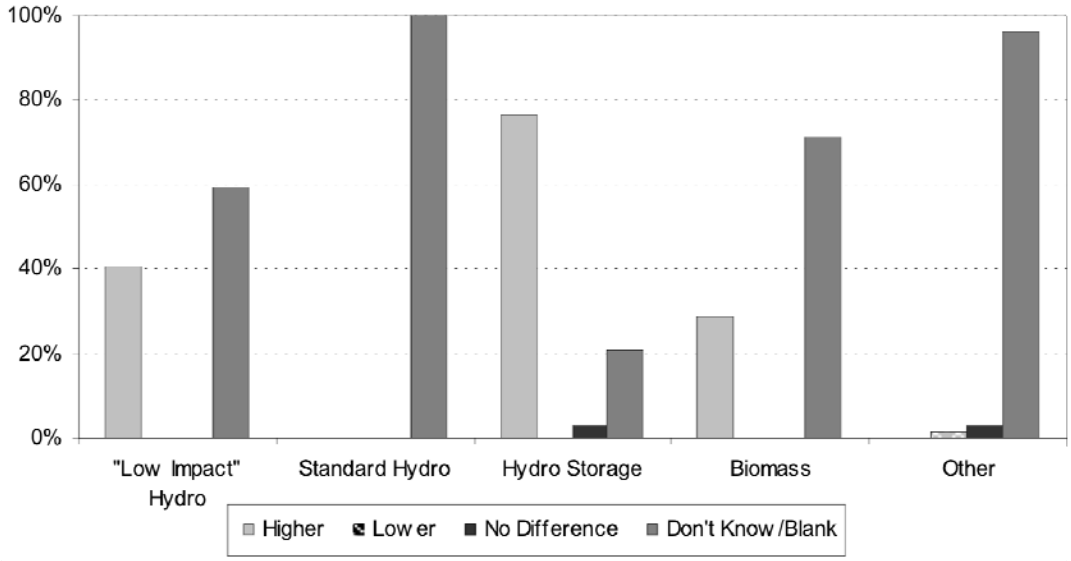
Biomass and Biogas**:**

- 4 facilities: $0.01/kW premium
- 1 facility: $0.10/kW premium
- 1 facility: Double the going rate

"Low impact" hydro**:**

- 1 facility: Not much

<u>Question 7</u>: If you were to start from scratch and re-install the same facility again starting today, would the cost be lower, either due to your previous experience or due to general cost trends for equipment? If so, how much lower?



Source: CIEEDAC Renewable Energy Database, 2008.

While many respondents were did not comment on whether government policy hindered the adoption of renewable energy in Canada, a number of hydro and biomass operators suggested that there was room for improvement. One theme that emerged was that the increasing involvement in renewable energy generation including environmental assessments and stakeholder involvement inhibited further penetration of renewable energy. For the government to increase renewable energy in Canada they should provide more information on the cost of producing renewable energy in Canada and provide some subsidy per kWh to make it competitive with conventional energy sources.

3.6. Comparison with the Rest of Canada

Table 15-2 below illustrates Canada's renewable electrical capacity and total electrical capacity in kilowatts in place in 2005 by province (data not available for thermal capacity)[24]. 49% of Canada's renewable power capacity is in Québec, while about 17% is in British Columbia.

Table 15-2 illustrates the percentage of total provincial and territorial installed capacity that is provided by renewable energy. Quebec has the highest proportion at 95%. BC ranks fourth for the renewables proportion, after Québec, Newfoundland & Labrador, and Manitoba.

[24] Based on 2005 renewable electrical capacity and 2004 total installed electrical capacity.

Table 15–2 Capacity (in kW) and Percentage of Provincial Supply from Renewable Energy

Province	Total Renewable Electrical Capacity	Total Installed Electrical Capacity	% of Provincial Electrical Capacity	% of Canadian Renewables
Alberta	1,405,099	11,396,860	12%	1.9%
British Columbia	12,794,488	14,558,909	88%	17.4%
Manitoba	5,014,623	5,532,173	91%	6.8%
New Brunswick	1,072,762	4,433,208	24%	1.5%
Newfoundland & Labrador	6,961,710	7,494,309	93%	9.5%
Nova Scotia	541,830	2,413,235	22%	0.7%
Nunavut & Northwest Territories	59,253	198,466	30%	0.1%
Ontario	8,520,514	32,930,188	26%	11.6%
Prince Edward Island	16,280	121,110	13%	0.0%
Québec	35,916,670	37,768,726	95%	49.0%
Saskatchewan	943,705	3,796,920	25%	1.3%
Yukon	77,815	122,260	64%	0.1%
Total	**73,324,749**	**120,766,364**	**60.7%**	**100%**

Source: CIEEDAC Renewable Energy Database, 2010; Stats Canada "Electric Power Generation, Transmission, and Distribution, special distribution to CIEEDAC from Stats Can.

3.7. Conclusion and Summary

Renewable energy resources could provide a significant amount of energy, contributing to goals of energy sustainability. With Canada's ratification of the Kyoto Protocol, interest in this area has expanded, especially in terms of the smaller, more distributed generation sites (e.g., less than 500kW installations). CIEEDAC believes that getting a focus on this area now will be important in future assessments of energy utilization.

Renewable energy was estimated to provide nearly 13% of energy produced in British Columbia in 2006. The installed renewable electricity facilities represent almost 90% of the province's total electricity capacity in that same year. The installed renewable electrical capacity of 12.79 GW is dominated by hydroelectricity and cogeneration from biomass wood residue, accounting for 96.6% and 3.3% of the total respectively, with biogas, and solar photovoltaic sources accounting for about 0.1% of BC's installed capacity.

Capacity was rapidly added throughout the century, but after 1970 new installations dropped off dramatically. There has been a focus since the 90s on lower impact, smaller scale operations. Capacity utilization is highest among biomass thermal operation, followed by biogas thermal generation and biomass electricity generation.

BC electricity generation emitted only 902 kilotonnes of greenhouse gases (CO_2e) in 2005 due to the high percentage of renewable sources. If these were replaced with combine-cycle gas turbines, greenhouse gas emissions from electricity would be as high as 23.8 million tonnes of greenhouse gases.

No BC respondents reported using any government incentive programs (however most respondents were not willing to provide such financial information). Responses to renewable energy policy questions called for greater "action and leadership" by government, and subsidies.

They also cited government and electric utility regulations as a hindrance to renewable energy development, and leading to higher costs.

In terms of the proportion of installed electrical capacity that is renewable, British Columbia ranks fourth after Quebec, Newfoundland and Labrador, and Manitoba.

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   NOTE: Data updating and review are not complete; data reflects previous assessments and do not reflect current systems.

Appendix A: Energy Consumption Data Tables

Table 1: Total Energy Consumption by Major Sector in British Columbia (TJ)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Energy Consumed	1,039	1,181	1,213	1,169	1,172	1,233	1,272	1,207	1,200	1,204	1,287	1,294	1,225	1,292	1,291	1,264
Total Industrial	409	447	445	436	424	464	491	458	440	443	472	473	436	490	462	451
Transportation	254	315	324	332	341	345	348	344	336	340	352	335	327	343	341	335
Agriculture	10	9.9	11.4	13.3	14.1	14.4	16.2	18.1	14.5	13.7	13.4	11.2	11.5	13.4	11.4	9.5
Residential	121	134	149	139	137	145	143	141	142	136	138	145	147	143	154	154
Comm., Instit. & Pub Admin	116	132	133	134	127	128	141	142	159	144	151	154	152	147	159	153
Electric Power Gen	21	53	14	23	36	25	44	60	23	26	29	29	30	28	35	30

Note: Total Energy Consumed includes all hidden and confidential values, as well as total energy consumed to make secondary electricity.
Source: STC RESD.

Table 2: Industrial Energy Consumption by Industry Sub-sector in British Columbia (TJ)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Industrial	409	447	445	436	424	464	491	458	440	443	472	473	436	490	462	451
Total Mining, Oil & Gas Extraction	29.5	26.3	29.2	28.0	30.4	26.7	28.8	26.7	25.6	23.3	28.0	26.9	36.8	42.8	46.0	42.9
Total Manufacturing	367	410	404	397	383	427	451	419	401	406	429	432	385	433	403	399
Pulp and Paper	276	302	289	287	273	307	317	282	274	268	294	292	264	274	250	259
Smelting and Refining	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Petroleum Refining	23.4	15.1	13.9	9.2	8.1	X	X	X	X	X	X	X	X	X	X	X
Chemical Manufacturing	15.2	14.3	14.0	15.4	14.4	16.9	12.7	7.9	8.7	8.9	7.8	8.5	5.7	7.5	5.5	5.2
Other Manufacturing	35.3	54.1	61.8	57.0	57.0	64.3	81.2	95.5	82.9	90.8	86.1	91.1	72.9	107.9	104.0	94.8
Forestry	3.0	2.9	3.8	4.1	4.3	4.5	5.5	7.8	7.6	7.2	7.6	7.2	7.2	6.2	5.4	3.5
Construction	9.8	8.0	8.1	6.5	5.8	5.5	5.7	5.1	5.8	6.5	6.9	7.0	7.0	8.2	7.9	5.3

Note: Total manufacturing includes the confidential and hidden values of the Smelting and Refining and Cement sub-sectors; Pulp and Paper consumption includes biomass fuels: spent pulping liquor and solid wood waste.
Source: STC RESD.

Table 3: Energy Consumed to Make Secondary Electricity (TJ)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal	0	0	0	0	0	0	0	0	0	0	0	23	29	114	20	0
Natural Gas	16,589	51,883	12,634	22,129	35,265	23,652	42,857	58,251	22,382	24,965	27,378	28,047	28,311	23,418	29,759	24,472
Petroleum Products	4,491	1,216	1,680	1,042	1,024	978	1,183	1,467	805	1,114	1,326	730	1,604	4,708	4,963	5,150
Diesel Fuel Oil	2,209	561	1,037	545	613	498	663	724	563	611	506	442	407	477	191	107
Light Fuel Oil	0	0	39	4	12	4	27	4	0	0	0	2	1	0	0	0
Heavy Fuel Oil	2,283	655	605	492	400	476	493	740	246	514	840	293	132	34	17	4
Total	21,080	53,099	14,314	23,170	36,289	24,630	44,039	59,718	23,187	26,079	28,704	28,800	29,944	28,240	34,742	29,622
Secondary Electricity Generated*	13,340	31,941	18,019	19,986	24,880	23,757	30,515	34,564	23,245	23,234	26,376	26,808	26,461	27,162	26,543	24,353

*Note: This electricity includes that generated from biomass but data on quantity of biomass consumed to make electricity are not available.
Source: STC RESD.

Table 4: Energy Consumed to Make Steam (TJ)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Natural Gas	-	8	2	-	-	205	289	188	36	36	7,537	187	187	187	187	187
Heavy Fuel Oil	-	-	-	-	-	262	207	353	5	11	20	8	9	10	11	12
Total	**-**	8	2	-	-	467	496	541	41	47	7557	195	196	197	198	199

Source: STC RESD.

Table 5: Population, GDP and Energy Intensity Indicators

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Population ('000)	3,292	3,777	3,874	3,949	3,983	4,011	4,039	4,076	4,098	4,122	4,155	4,197	4,244	4,310	4,384	4,460
Intensity (TJ/Pop)	0.316	0.313	0.313	0.296	0.294	0.307	0.315	0.296	0.293	0.292	0.310	0.308	0.289	0.300	0.295	0.283
Index (1990=1)	1.0	0.990	0.992	0.938	0.932	0.974	0.997	0.938	0.927	0.925	0.981	0.976	0.914	0.949	0.933	0.898
GDP(2002 $billion)	100.7	112.9	116.0	120.0	121.8	125.5	131.4	133.5	138.2	141.3	146.6	153.2	159.4	164.4	163.6	161.6
Intensity (TJ/$mil)	10.3	10.5	10.5	9.7	9.6	9.8	9.7	9.0	8.7	8.5	8.8	8.4	7.7	7.9	7.9	7.8
Index (1990=1)	1	1.014	1.013	0.944	0.932	0.952	0.938	0.876	0.841	0.826	0.851	0.818	0.744	0.761	0.764	0.758

Sources: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 6: Energy Consumption, Mining and Oil and Gas Extraction (TJ)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal												453	3,669	4,659	4,638	3,683
Natural Gas	3,755	2,010	8,004	6,032	5,135	2,737	3,937	2,703	3,730	1,137	3,751	2,513	11,455	16,240	22,000	23,058
Gas Plant NGLs	480	745	523	483	689	820	1,295	x	746	672	604	1,166	1,152	1,370	1,539	1,210
Electricity	13,619	13,165	10,826	9,575	11,447	9,363	10,806	11,953	11,377	9,718	9,333	9,362	7,803	8,960	6,992	6,946
Coke																
Coke Oven Gas																
Petroleum Products	11,690	10,406	9,846	11,913	13,114	13,813	12,721	11,199	9,729	11,799	11,759	13,646	12,741	11,613	10,838	8,008
Still Gas																
Motor Gas																
Kerosene	237	6	9	11	161	161	165	186	115	138	174	179	117	84	68	8
Diesel Fuel Oil	11,194	10,160	9,610	11,727	12,587	13,235	12,155	10,537	9,180	10,984	10,907	12,591	11,995	11,245	10,502	7,748
Light Fuel Oil	259	240	227	175	366	417	401	476	434	677	678	663	629	284	268	252
Heavy Fuel Oil												213				
Petroleum Coke																
Aviation Gasoline																
Aviation Turbo Fuel																
Total Energy	29,542	26,329	29,201	28,007	30,384	26,732	28,760	26,685	25,581	23,329	27,977	26,927	36,820	42,842	46,006	42,904

Source: STC RESD.

Table 7: Production (GDP) and Energy Intensity Indicators, Mining and Oil and Gas Extraction (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	2,015	2,484	2,551	3,137	3,324	3,329	3,344	4,252	4,383	4,298	4,270	4,643	4,619	4,484	4,511	4,170
Intensity (Energy TJ/GDP)	14.7	10.6	11.4	8.9	9.1	8.0	8.6	6.3	5.8	5.4	6.6	5.8	8.0	9.6	10.2	10.3
Index (1990=1)	1	0.723	0.781	0.609	0.623	0.548	0.587	0.428	0.398	0.370	0.447	0.396	0.544	0.652	0.696	0.702

Source: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 8: Energy Consumption, Pulp and Paper (TJ)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal									x	x	x	x	x	x	x	x
Natural Gas	28,040	42,547	44,809	42,994	39,809	42,224	40,151	31,937	32,233	25,133	26,604	19,041	19,476	22,105	15,243	16,729
Gas Plant NGLs																
Electricity	47,835	53,471	51,218	48,723	49,702	53,026	52,439	48,012	46,578	48,226	52,547	54,735	56,421	56,231	45,119	47,841
Coke									201	297	2031	1978	1807	2241	2070	1784
Coke Oven Gas																
Petroleum Products	30,948	8,576	10,870	11,311	8,041	7,273	7,749	9,487	4,312	5,722	4,953	2,433	2,219	1,853	635	1,153
Still Gas																
Motor Gas																
Kerosene		8	41						-	-	-	-	-	-	87	121
Diesel Fuel Oil	3,241	2,406	3,141	2,681	2,107	1,689	532	486	487	482	467	127	462	95	268	276
Light Fuel Oil	77	77	50	39	62	93	140	4	5	42	2	0	1	0	0	0
Heavy Fuel Oil	27,629	8,379	8,079	5,321	5,104	5,967	8,815	3,829	3,820	5,198	4,484	2,306	1,756	1,758	281	757
Petroleum Coke																
Aviation Gasoline																
Aviation Turbo Fuel																
Solid Wood Waste	42,152	57,872	46,764	46,728	51,336	55,170	63,612	57,456	61,138	68,287	80,621	89,182	86,310	83,646	82,476	82,483
Spent Pulping Liquor	126,673	139,959	134,848	137,060	124,292	146,034	150,430	132,454	129,727	120,213	127,140	124,669	97,174	107,534	104,275	108,766
Total	275,649	302,424	288,508	286,818	273,184	303,865	314,382	279,333	274,309	268,491	294,458	292,378	263,756	274,100	250,154	258,792

Source: STC RESD.

Table 9: Production (GDP) and Energy Intensity Indicators, Pulp and Paper (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	1,510	1,488	1,506	1,266	1,049	1,528	1,484	1,241	1,316	1,334	1,411	1,527	1,517	1,483	1,305	1,077
Intensity (Energy TJ/GDP)	182.5	203.3	191.5	226.5	260.5	200.7	213.8	227.3	208.5	201.3	208.6	191.4	173.9	184.8	191.7	240.3
Index (1990=1)	1.00	1.114	1.049	1.241	1.427	1.100	1.171	1.245	1.142	1.103	1.143	1.049	0.953	1.012	1.050	1.316

Source: CANSIM Table 3790025 v3827717.

Table 10: Production (GDP), Non-ferrous Smelting and Refining (Million $2002)[1]

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2005	2007	2008	2009
GDP	959	1,044	1,058	1,285	x	x	x	x	1,509	1,523	1,678	1,718	1,772	1,864	1,729	1,456

Note: 1. Energy consumption, and thus intensity indicators are not available.
Source: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 11: Production (GDP), Cement (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2005	2007	2008	2009
GDP	X	X	x	287	263	236	240	213	239	281	311	319	350	455	423	291

Note: 1. Energy consumption, and thus intensity indicators are not available.
Source: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 12: Energy Consumption, Petroleum Refining (TJ)[1]

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007	2007
Coal						x	x	x	x	x	x	x	x	x	x	x
Natural Gas	4,466	304	522	576	1,031	x	x	x	x	x	x	x	x	x	x	x
Gas Plant NGLs						x	x	x	x	x	x	x	x	x	x	x
Electricity	1,331	817	719	901	582	x	x	x	x	x	x	x	x	x	x	x
Coke						x	x	x	x	x	x	x	x	x	x	x
Coke Oven Gas																
Petroleum Products	17,624	13,992	12,704	7,683	6,486	x	x	x	x	x	x	x	x	x	x	x
Still Gas	13,473	11,109	9,838	5,555	4,061	x	x	x	x	x	x	x	x	*x*	*x*	*x*
Motor Gas	10	7	7	3	4	x	x	x	x	x	x	x	x	x	x	x
Kerosene			8	4		x	x	x	x	x	x	x	x	x	x	x
Diesel Fuel Oil	170	93	93	104	77	x	x	x	x	x	x	x	x	x	x	x
Light Fuel Oil	8		15	8	8	x	x	x	x	x	x	x	x	x	x	x
Heavy Fuel Oil	405					x	x	x	x	x	x	x	x	x	x	x
Petroleum Coke	3,554	2,776	2,736	2,002	2,322	x	x	x	x	x	x	x	x	x	x	x
Aviation Gasoline						x	x	x	x	x	x	x	x	x	x	x
Aviation Turbo Fuel	4	7	7	7	15	x	x	x	x	x	x	x	x	x	x	x
Total	23,420	15,114	13,945	9,160	8,098	x	x	x	x	x	x	x	x	x	x	x

Note: 1. Energy consumption data confidential after 1998.
Source: STC RESD.

Table 13: Production (GDP) and Energy Intensity Indicators, Petroleum Refining (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	x	x	149	76	75	x	x	x	75	77	74	x	x	x	x	x
Intensity (Energy TJ/GDP)	-	-	93.8	120.2	108.3	-	-	-	0.0	0.0	0.0	-	-	-	-	-

Source: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 14: Energy Consumption, Chemical Manufacturing (TJ)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal								X	x	x	x	x	x	x	x	x
Natural Gas	8,731	8,053	7,917	8,874	7,993	10,265	6,033	2,007	2,335	2,349	1,689	2,215	385	327	341	311
Gas Plant NGLs														-	-	-
Electricity	6,387	6,175	5,923	6,512	6,353	6,352	6,657	5,917	6,398	6,546	6,081	6,193	5,259	7,142	5,078	4,811
Coke									x	x	x	x	x	x	x	x
Coke Oven Gas																
Petroleum Products	105.75	61.89	127.64	61.89	11.49	296.24	38.25					9	9	7	4	4
Still Gas																
Motor Gas																
Kerosene																
Diesel Fuel Oil	35	62	128	62	11	11			x	x	x	x	x	x	x	x
Light Fuel Oil									x	x	x	x	x	x	x	x
Heavy Fuel Oil	71					285	38		x	x	x	x	x	x	x	x
Petroleum Coke																
Aviation Gasoline																
Aviation Turbo Fuel																
Total	15,224	14,290	13,968	15,448	14,358	16,913	12,728	7,924	8,733	8,895	7,769	8,487	5,721	7,531	5,477	5,163

Source: STC RESD.

Table 15: Production (GDP) and Energy Intensity Indicators, Chemical Manufacturing (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	139	x	197	x	116	102	170	181	225	x	220	236	156	145	148	128
Intensity (Energy TJ/GDP)	109.4	-	70.9	-	123.8	165.8	74.9	43.8	38.8	-	35.3	36.0	36.7	52.0	37.0	40.4
Index (1990=1)	1.00	-	0.647	-	1.131	1.515	0.684	0.400	0.355	-	0.323	0.329	0.335	0.475	0.338	0.369

Source: CANSIM Table 3790025.

Table 16: Energy Consumption, Other Manufacturing (TJ)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal		254	241	319	171	73	271	x	x	x	x	x	x	x	x	x
Natural Gas	26,722	42,654	49,961	45,893	46,663	52,448	66,346	77,894	63,824	70,874	67,090	70,661	52,290	86,559	80,074	71,753
Gas Plant NGLs	449	1,070	761	730	711	484	952	1,394	x	x	x	x	x	x	x	x
Electricity	6,760	7,298	7,486	7,647	8,169	9,737	11,431	13,534	14,405	14,839	14,306	14,597	15,022	14,800	16,646	15,986
Coke									x	x	x	x	x	x		
Coke Oven Gas																
Petroleum Products	1,387	2,831	3,312	2,414	1,273	1,597	2,190	1,998	2,330	2,963	2,793	2,440	2,208	2,638	2,965	3,598
Still Gas																
Motor Gas																
Kerosene	45	294	177	41		57	8				1	1	0	1	0	0
Diesel Fuel Oil	940	1,659	2,050	1,783	1,000	1,287	1,708	1,674	x	x	x	x	x	x	x	x
Light Fuel Oil	147	855	894	255	120	147	256	140	140	124	126	38	113	109	85	27
Heavy Fuel Oil	255	(4)		134			43	115		210	0	0	0	1	0	17
Petroleum Coke		27	191	200	153	107	176	70	x	x	x	x	x	x	x	x
Aviation Gasoline																
Aviation Turbo Fuel																
Total	35,318	54,107	61,763	57,003	56,988	64,343	81,194	95,460	82,908	90,773	86,079	91,089	72,886	107,904	103,999	94,843

Source: STC RESD.

Table 17: Production (GDP) and Energy Intensity Indicator, Other Manufacturing (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	7,473	6,352	6,726	6,957	6,576	7,361	8,553	7,896	8,881	7,214	9,696	10,115	10,919	10,950	9,679	8,231
Intensity (Energy TJ/GDP)	4.7	8.5	9.2	8.2	8.7	8.7	9.5	12.1	9.3	12.6	8.9	9.0	6.7	9.9	10.7	11.5
Index (1990=1)	1.00	1.802	1.943	1.733	1.833	1.849	2.008	2.558	1.975	2.662	1.878	1.905	1.412	2.085	2.273	2.438

Sources: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 18: Energy Consumption, Total Manufacturing (TJ)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal	3,283	6,468	6,299	6,125	5,508	6,528	9,069	9,538	10,754	11,243	11,750	10,380	10,072	10,822	9,249	7,495
Natural Gas	73,905	98,804	108,539	103,683	100,879	110,165	124,322	107,711	102,428	101,489	98,701	95,318	75,546	112,778	99,901	92,609
Gas Plant NGLs	449	1,070	761	730	711	484	952	1,394	1,823	1,714	1,540	2,971	2,934	3,491	3,918	3,085
Electricity	86,608	91,742	89,799	88,184	90,210	95,770	97,398	87,721	87,763	92,983	98,969	101,729	102,844	104,820	93,370	93,163
Coke	813	1,643	1,632	666	115	210	254	205	201	297	2,031	1,978	1,807	2,241	2,070	1,784
Coke Oven Gas									223	230			0	0	0	0
Petroleum Products	32,824	12,206	15,079	14,191	10,052	9,904	10,309	11,994	7,043	9,062	8,584	5,613	8,345	7,606	7,486	9,691
Still Gas																
Motor Gas																
Kerosene	45	433	381	260		57	8				1	1	0	1	90	121
Diesel Fuel Oil	4,375	4,027	4,723	5,075	3,799	3,570	3,474	2,248	2,531	2,941	2,815	2,359	2,572	2,436	3,037	3,719
Light Fuel Oil	236	901	982	337	171	217	349	283	144	168	128	39	114	109	85	31
Heavy Fuel Oil	27,963	6,351	8,379	8,212	5,330	5,393	6,052	8,925	3,820	5,408	4,484	9,005	1,756	1,758	281	774
Petroleum Coke	205	494	614	307	752	667	426	538	548	545	1,156	908	3,903	3,302	3,993	5,046
Aviation Gasoline																
Aviation Turbo Fuel																
Total	366,705	409,771	403,726	397,369	383,104	427,053	451,077	418,535	401,101	405,515	429,336	431,839	385,033	432,936	402,745	399,075

Note: Total includes Pulp and Paper, Smelting and Refining, Cement, Petroleum Refining, Chemicals, Other Manufacturing, and confidential/hidden consumption.
Source: STC RESD.

Table 19: Production (GDP) and Energy Intensity Indicators, Total Manufacturing (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	10,834	10,846	10,854	11,507	11,255	12,840	14,990	13,667	13,687	13,884	14,723	15,435	15,851	15,841	14,245	12,183
Intensity (Energy TJ/GDP)	33.8	37.8	37.2	34.5	34.0	33.3	30.1	30.6	29.3	29.2	29.2	28.0	24.3	27.3	28.3	32.8
Index (1990=1)	1.00	1.116	1.099	1.020	1.006	0.983	0.889	0.905	0.866	0.863	0.861	0.827	0.718	0.807	0.835	0.968

Source: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 20: Energy Consumption, Forestry (TJ)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal																
Natural Gas																
Gas Plant NGLs																
Electricity																
Coke																
Coke Oven Gas																
Petroleum Products	2,978	2,925	3,789	4,060	4,271	4,544	5,523	7,848	7,585	7,208	7,555	7,246	7,182	6,241	5,380	3,500
Still Gas																
Motor Gas																
Kerosene	26	19	15	79	15	11	8	4	4	5	7	3	3	3	4	4
Diesel Fuel Oil	2,696	2,766	3,504	3,853	3,960	4,305	5,373	7,733	7,511	7,105	7,359	7,010	6,970	6,087	5,259	3,409
Light Fuel Oil	147	124	178	66	58	23	23	81	50	32	190	166	162	151	113	74
Heavy Fuel Oil	108	17	92	63	238	204	119	30	20	66	0	67	47			
Petroleum Coke																
Aviation Gasoline																
Aviation Turbo Fuel																
Total	2,978	2,925	3,789	4,060	4,271	4,544	5,523	7,848	7,585	7206	7,555	7,246	7,182	6,241	5,379	3,499

Source: STC RESD.

Table 21: Production (GDP) and Energy Intensity Indicators, Forestry (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	3,030	3,375	3,062	2,935	2,952	2,789	2,638	2,647	2,713	2,761	3,129	3,102	3,037	2,778	2,275	1,848
Intensity (Energy TJ/GDP)	1.0	0.87	1.24	1.38	1.45	1.63	2.09	2.97	2.80	2.61	2.41	2.34	2.36	2.25	2.36	1.89
Index (1990=1)	1.00	0.881	1.259	1.406	1.471	1.656	2.129	3.015	2.842	2.653	2.454	2.375	2.404	2.284	2.403	1.925

Source: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 22: Energy Consumption, Construction (TJ)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal																
Natural Gas	4,258	3,117	3,368	1,784	1,416	1,216	1,109	1,006	1,136	1,379	1,735	1,829	1,916	2,058	1,810	853
Gas Plant NGLs	677	230	158	156	206	162	125	119	91	78	70	75	74	88	99	78
Electricity																
Coke																
Coke Oven Gas																
Petroleum Products	4,835	4,703	4,568	4,517	4,162	4,078	4,422	4,020	4,612	5,045	5,112	5,141	5,036	6,039	5,999	4,394
Still Gas																
Motor Gas																
Kerosene	15	8	11	19	8	4	4	4	3	4	4	3	3	2	0	0
Diesel Fuel Oil	4,158	4,305	4,174	4,131	3,926	3,864	4,251	3,845	4,458	4,935	4,982	4,990	4,899	5,927	5,952	4,232
Light Fuel Oil	654	391	383	367	229	210	167	171	151	106	126	148	134	110	47	43
Heavy Fuel Oil	8															
Petroleum Coke																
Aviation Gasoline																
Aviation Turbo Fuel																
Total	9,770	8,050	8,094	6,457	5,784	5,456	5,656	5,144	5,840	6501	6,917	7,045	7,026	8,185	7,907	5,325

Source: STC RESD.

Table 23: Production (GDP) and Energy Intensity Indicators, Construction (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	5,778	6,240	6,176	6,617	6,101	5,881	5,795	6,021	6,328	6,927	7,675	8,115	9,069	8,985	9,559	9,053
Intensity (Energy TJ/GDP)	1.7	1.3	1.3	1.0	0.9	0.9	1.0	0.9	0.9	0.9	0.9	0.9	0.8	0.9	0.8	0.6
Index (1990=1)	1.00	0.763	0.775	0.577	0.561	0.548	0.577	0.506	0.546	0.555	0.533	0.513	0.458	0.539	0.489	0.348

Source: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 24: Energy Consumption, Total Industry (TJ)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal	3,283	6,468	6,299	6,125	5,508	6,528	9,069	X	10,754	11,243	14,280	10,834	13,741	15,481	13,886	11,178
Natural Gas	81,918	103,934	119,912	111,501	107,433	113,993	130,150	111,398	107,296	104,005	104,187	99,659	88,918	131,076	123,710	116,520
Gas Plant NGLs	1,606	2,045	1,445	1,368	1,607	1,466	2,372	2,650	2,660	2,464	2,214	4,212	4,160	4,950	5,556	4,374
Electricity	100,227	104,907	100,626	97,760	101,657	105,134	108,203	99,399	99,139	102,701	108,302	111,091	110,647	113,780	100,362	100,109
Coke	813	1,643	1,632	666	115	210	254	205	201	297	2,031	1,978	1,807	2,241	2,070	1,784
Coke Oven Gas									223	230	0	0	0	0	0	0
Petroleum Products	52,323	30,239	33,283	34,689	31,597	32,335	32,980	35,060	28,969	33,112	33,009	31,431	33,305	31,499	29,701	25,587
Still Gas																
Motor Gas																
Kerosene	324	467	422	369	185	234	185	192	120	146	185	185	123	89	162	132
Diesel Fuel Oil	22,427	21,259	22,013	24,794	24,275	24,972	25,255	24,363	23,683	25,965	26,062	26,950	26,437	25,696	24,749	19,108
Light Fuel Oil	1,292	1,656	1,768	944	823	865	943	1,009	778	983	1,122	1,015	1,039	654	512	396
Heavy Fuel Oil	28,076	6,364	8,467	8,275	5,563	5,597	6,171	8,959	3,840	5,473	4,484	2,373	1,803	1,758	285	905
Petroleum Coke	205	494	614	307	752	667	426	538	548	545	1,156	908	3,903	3,302	3,993	5,046
Aviation Gasoline																
Aviation Turbo Fuel																
Total	408,996	447,074	444,816	435,893	423,545	463,780	491,015	458,216	440,106	442,550	450,159	473,057	436,062	490,204	462,036	450,799

Note: Total includes Forestry, Construction, Total Manufacturing, and confidential/hidden consumption.
Source: STC RESD.

Table 25: Production (GDP) and Energy Intensity Indicators, Total Industry (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	21,656	22,946	22,644	24,196	23,632	24,838	26,768	26,587	27,111	27,871	29,798	31,294	32,576	32,088	30,591	27,254
Intensity (Energy TJ/GDP)	18.9	19.5	19.6	18.0	17.9	18.7	18.3	17.2	16.2	15.9	15.8	15.1	13.4	15.3	15.1	16.5
Index (1990=1)	1.00	1.032	1.040	0.954	0.949	0.989	0.971	0.913	0.860	0.841	0.838	0.800	0.709	0.809	0.800	0.876

Source: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 26: Energy Consumption, Transportation (TJ)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal																
Natural Gas	16,846	27,388	29,695	28,502	31,055	27,698	32,360	36,521	26,370	20,639	21,954	19,234	15,029	18,093	17,420	16,998
Gas Plant NGLs	12,237	8,859	6,206	6,048	7,371	4,624	4,914	4,829	4,598	4,167	4,153	3,053	3,015	3,588	4,027	3,169
Electricity	557	745	863	849	767	618	619	607	718	751	698	712	616	750	678	828
Coke																
Coke Oven Gas																
Petroleum Products	223,952	277,817	286,959	296,212	302,265	311,656	310,403	302,514	304,170	314,221	325,345	312,327	308,030	320,339	318,952	313,856
Still Gas																
Motor Gas	115,283	138,141	140,706	147,298	154,984	154,189	152,436	150,042	149,568	152,190	161,961	153,387	151,470	152,433	148,929	152,800
Kerosene																
Diesel Fuel Oil	61,348	80,230	81,452	80,930	75,378	76,520	73,184	73,306	71,698	73,149	71,256	67,811	67,444	71,895	78,289	73,854
Light Fuel Oil																
Heavy Fuel Oil	16,561	20,886	17,668	16,354	19,733	22,185	23,120	29,784	26,620	38,125	38,118	37,042	34,966	42,096	34,735	31,760
Petroleum Coke																
Aviation Gasoline	446	248	204	94	181	194	144	168	169	176	143	179	151	211	158	154
Aviation Turbo Fuel	30,314	38,312	46,928	51,536	51,990	58,568	61,519	49,215	56,116	50,581	53,867	53,908	53,999	53,704	56,841	55,288
Total	253,592	314,815	323,722	331,618	341,457	344,525	348,256	344,180	335,857	339,777	352,149	335,327	326,691	342,833	341,076	334,850

Note: Total includes railways, airlines, marine, pipelines, road transport/urban transit and retail pump sales.
Source: STC RESD.

Table 27: Production (GDP) and Energy Intensity Indicators, Transportation (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	5,141	5,917	5,924	13,166	13,329	13,837	14,855	14,835	14,789	15,284	15,864	17,340	19,063	19,496	19,498	18,399
Intensity (Energy TJ/GDP)	49.3	53.2	54.6	25.2	25.6	24.9	23.4	23.2	22.7	22.2	22.2	19.3	17.1	17.6	17.5	18.2
Index (1990=1)	1.00	1.079	1.108	0.511	0.519	0.505	0.475	0.471	0.460	0.451	0.450	0.392	0.347	0.356	0.355	0.369

Source: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 28: Energy Consumption, Agriculture (TJ)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal																
Natural Gas	2,781	620	564	2,512	2,367	2,360	4,149	4,140	731	697	669	742	748	738	689	557
Gas Plant NGLs	449	115	79	74	104	96	190	256	163	152	150	144	143	170	190	149
Electricity	984	1,347	1,396	1,306	2,533	2,486	1,827	1,439	1,344	1,294	1,452	1,472	1,329	1,737	1,375	1,462
Coke																
Coke Oven Gas																
Petroleum Products	5,880	7,840	9,394	9,382	9,088	9,433	10,073	12,271	12,223	11,571	11,151	8,879	9,239	10,753	9,194	7,368
Still Gas																
Motor Gas	2,211	1,944	2,135	2,281	2,433	2,422	2,583	3,224	4,016	4,094	4,158	3,812	3,796	3,844	3,801	3,304
Kerosene	377	399	494	456	275	286	196	166	153	96	40	9	12	9	4	0
Diesel Fuel Oil	1,791	4,425	5,357	5,353	5,205	5,331	6,320	7,308	7,185	7,068	6,833	5,022	5,377	6,832	5,370	4,064
Light Fuel Oil	1,501	1,071	1,408	1,292	1,176	1,393	920	1,498	801	314	119	38	54	68	19	0
Heavy Fuel Oil							55	77	66							
Petroleum Coke																
Aviation Gasoline																
Aviation Turbo Fuel																
Total	10,093	9,922	11,433	13,274	14,091	14,375	16,238	18,106	14,461	13,713	13,421	11,238	11,459	13,398	11,447	9,536

Source: STC RESD.

Table 29: Production (GDP) and Energy Intensity Indicators, Agriculture (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	878	878	921	954	909	979	975	1,141	1,058	1,053	1,057	1,061	1,068	1,125	1,109	1,062
Intensity (Energy TJ/GDP)	11.3	11.3	12.4	13.9	15.5	14.7	16.7	15.9	13.7	13.0	12.7	10.6	10.7	11.9	10.3	9.0
Index (1990=1)	0.760	0.760	0.835	0.935	1.042	0.987	1.119	1.067	0.919	0.875	0.853	0.712	0.721	0.801	0.694	0.604

Source: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 30: Energy Consumption, Residential (TJ)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal	10	1		1	1			x				524	206	x	0	0
Natural Gas	63,285	75,188	85,721	77,948	76,748	82,323	78,579	76,085	79,284	75,220	72,592	79,057	81,451	80,177	80,220	81,022
Gas Plant NGLs	2,244	1,861	1,320	1,259	1,303	843	990	1,009	1,282	1,152	1,014	907	896	1,066	1,197	942
Electricity	45,280	52,557	57,242	55,424	54,344	56,326	58,328	58,226	60,042	59,164	63,115	63,413	63,783	60,881	71,924	70,916
Coke																
Coke Oven Gas																
Petroleum Products	10,281	4,365	4,989	4,850	4,617	5,140	5,584	5,809	1,059	951	1,238	899	896	957	910	825
Still Gas																
Motor Gas																
Kerosene	934	528	599	452	388	279	226	121	119	127	185	74	62	102	64	60
Diesel Fuel Oil																
Light Fuel Oil	9,310	3,837	4,390	4,398	4,229	4,862	5,358	5,688	940	826	1,053	826	833	855	846	764
Heavy Fuel Oil	38															
Petroleum Coke																
Total	121,100	133,969	149,274	139,478	137,014	144,631	143,458	141,196	141,668	136,487	137,960	144,800	147,231	143,082	154,251	153,705

Source: STC RESD.

Table 31: Production (GDP) and Energy Intensity Indicators, Residential (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	7,875	10,421	10,766	11,388	11,754	12,070	12,341	12,621	13,212	13,629	14,144	14,946	15,669	16,392	17,203	18,017
Intensity (Energy TJ/GDP)	15.4	12.9	13.9	12.2	11.7	12.0	11.6	11.2	10.7	10.0	9.8	9.7	9.4	8.7	9.0	8.5
Index (1990=1)	1.00	0.836	0.902	0.796	0.758	0.779	0.756	0.727	0.697	0.651	0.634	0.630	0.611	0.568	0.583	0.555

Source: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 32: Energy Consumption, Commercial and Institutional (TJ)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal		21			10		735	278								
Natural Gas	46,942	58,616	60,636	58,156	51,533	53,405	54,816	52,298	68,768	55,579	54,313	53,114	53,161	52,362	57,497	51,773
Gas Plant NGLs	1,466	3,927	2,803	2,734	2,450	1,957	2,885	3,119	3,194	2,908	2,613	1,747	1,726	2,053	2,303	1,815
Electricity	41,265	46,308	47,430	47,732	47,823	47,786	50,458	51,764	51,708	50,725	48,528	49,384	50,090	50,086	51,347	50,870
Coke																
Coke Oven Gas																
Petroleum Products	26,259	23,499	22,591	24,938	24,880	25,303	28,304	26,335	35,096	34,408	45,705	49,325	46,916	42,546	48,147	48,262
Still Gas																
Motor Gas	6,142	5,095	5,348	6,194	6,741	6,769	6,829	5,457	5,212	5,325	5,117	5,134	4,995	5,538	5,817	6,167
Kerosene	268	181	219	245	170	177	339	388	430	408	435	384	287	328	219	154
Diesel Fuel Oil	10,710	10,142	10,641	11,991	12,601	12,700	15,217	15,002	19,837	18,895	28,376	31,932	30,344	26,411	34,355	34,611
Light Fuel Oil	3,980	2,035	2,085	1,977	1,102	1,319	2,118	1,560	5,698	5,653	5,711	5,711	5,337	4,410	1,932	1,734
Heavy Fuel Oil	718	455	526	755	897	995	616	956	816	659	2,573	2,550	2,395	2,960	2,516	2,644
Petroleum Coke									-	-	-		-		-	
Aviation Gasoline	637	493	499	577	446	359	402	335	361	310	345	282	265	215	204	188
Aviation Turbo Fuel	3,804	5,099	3,273	3,201	2,925	2,985	2,783	2,637	2,742	3,158	3,148	3,332	3,293	2,684	3,104	2,764
Total	115,932	132,373	133,460	133,565	126,695	128,376	137,200	130,675	158,768	143,622	151,158	153,569	151,892	146,987	159,294	152,720

Note: This sector includes Public Administration.
Source: STC RESD

Table 33: Production (GDP) and Energy Intensity Indicators, Commercial and Institutional (Million $2002)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP	44,755	54,821	56,960	70,840	72,511	74,245	76,948	79,209	82,302	84,785	85,427	86,705	92,496	96,330	97,431	97,216
Intensity (Energy TJ/GDP)	2.6	2.4	2.3	1.9	1.7	1.7	1.8	1.8	1.8	1.5	1.8	1.8	1.6	1.5	1.6	1.6
Index (1990=1)	1.00	0.932	0.905	0.728	0.675	0.668	0.709	0.691	0.689	0.598	0.683	0.684	0.634	0.589	0.631	0.606

Note: This sector includes Public Administration.
Source: CANSIM Table 379-0025 - Gross Domestic Product (GDP) at basic prices, by North American Industry Classification System (NAICS) and province, annual (dollars).

Table 34: Electricity Generation, Net Supply and Producer Consumption of British Columbia (GWh)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Electricity Production	61,014	59,054	72,674	68,883	67,770	68,181	68,685	58,764	65,335	63,383	61,979	67,774	61,598	71,832	66,072	63,211
Primary Electricity	57,308	50,181	67,668	63,332	60,859	61,582	60,208	49,163	58,878	56,929	54,652	60,327	54,247	64,287	58,699	56,447
Secondary Electricity	3,706	8,872	5,005	5,552	6,911	6,599	8,476	9,601	6,457	6,454	7,327	7,447	7,350	7,545	7,373	6,765
Total Net Supply	57,514	61,464	65,437	61,065	62,100	62,336	64,054	61,542	62,895	60,837	63,450	65,732	68,151	69,024	68,546	66,976
Primary Electricity	53,809	52,592	60,432	55,513	55,189	55,737	55,577	51,941	56,438	54,383	56,123	58,285	60,801	61,479	61,173	60,211
Secondary Electricity	3,706	8,872	5,005	5,552	6,911	6,599	8,476	9,601	6,457	6,454	7,327	7,447	7,350	7,545	7,373	6,765
Producer Consumption (Primary)	5,205	4,280	7,782	4,656	4,565	3,355	3,112	2,778	3,742	1,216	1,756	2,934	5,245	5,903	5,856	4,703

Source: CANSIM Table 128-0003 - Supply and demand of primary and secondary energy in natural units, computed annual total (Megawatt hour).

Table 35: Electricity Power Statistics, British Columbia (GWh)

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Overall Total Gen	60,662	58,006	71,765	66,961	67,710	68,045	68,241	57,332	64,945	63,051	60,496	67,774	61,598	71,830	66,072	63,211
Total Utility Gen	47,742	43,165	57,654	53,073	53,938	53,742	54,368	45,630	51,630	49,243	46,647	54,129	48,080	58,603	52,795	49,917
Total Industrial Gen	12,921	14,842	14,111	13,888	13,772	14,303	13,873	11,702	13,315	13,808	13,849	13,645	13,517	13,227	13,277	13,294
Total Hydro Gen	57,245	49,814	67,329	61,772	60,849	61,588	59,754	48,338	58,627	56,689	53,281	60,327	54,247	64,287	58,699	56,447
By Utility	46,387	38,471	56,629	51,370	50,851	51,530	50,346	40,679	49,396	46,797	43,653	50,305	44,464	54,706	48,634	46,248
By Industry	10,858	11,342	10,700	10,402	9,997	10,058	9,409	7,659	9,231	9,892	9,629	10,022	9,783	9,581	10,065	10,199
Total Convent Steam	3,197	7,248	3,531	4,247	5,903	5,312	7,138	7,615	4,319	4,230	4,908	4,997	5,370	5,007	4,774	4,369
By Utility	1,224	4,637	966	1,643	2,993	1,917	3,547	4,380	1,106	1,144	1,555	1,414	1,674	1,385	1,592	1,295
By Industry	2.0	2,612	2,565	2,604	2,910	3,396	3,591	3,235	3,213	3,086	3,353	3,583	3,696	3,622	3,182	3,074
Total Int'l Combust	220	64	75	70	73	56	69	69	74	73	80	102	48	83	90	126
By Utility	130	56	59	61	62	53	50	49	61	54	59	62	11	58	60	105
By Industry	89.9	7	16	9	12	3	19	20	13	19	21	39	37	24	31	21
Total Combust Turb	0.4	880	830	872	885	1,088	1,280	1,310	1,925	2,059	2,226	2,348	1,932	2,454	2,509	2,270
By Utility	0.4	0	0	0	31	242	426	522	1,067	1,248	1,381	2,348	1,932	2,454	2,509	2,270
By Industry	0	880	831	873	853	847	854	788	858	812	845	0	0	0	0	0

Source: CANSIM Table 127-0001 - Electric power statistics, computed annual total (Megawatt hour).

Appendix B: Cogeneration Data Tables, 2009

NOTE: Data updating and review are not complete; data reflects previous assessments and do not reflect current systems.

Table 1. Cogeneration for British Columbia

NAICS	Start Year	Operator	Type of Business	Primary Thermal Host	Electrical Capacity (kW)	Thermal Capacity (kW)	Cogen Type	Fuel
2211	1968	BC Hydro	Electric Utility	Imperial Oil	157,500	12,000	CST	NG
2211	2000	BC Hydro	Utility	Fort Nelson Gas Processing Plant	47,000		GT	
2211	1999	Calpine Island Cogeneration	Independent Power Producer	Norske Skogindustrier, Elk Falls	290,000	78,051	GT	NG
2211	1993	Atco Power	Electric Utility	Duke Energy	120,000		GT	NG
2213	1998	Greater Vancouver Regional Dist.	Water Treatment Plant	Iona Island WWT Plant	4,050	3,963	SI	Digester
3113	1973	Rogers Sugar	Food Manufacturer	Rogers Sugar	3,000	3,778	BPST	NG
3211	1985	Riverside Forest Products	Wood Products	Riverside Forest Products	12,000	55,560	CST	Hog
3211	1999	Tolko Industries Ltd.	Wood Products		22,000	33,000	BPEST	
3212	1936	Louisianna Pacific	Wood Products	Louisianna Pacific	7,500	18,750	ECST	Hog
3221	1945	Western Pulp Ltd.	Pulp and Paper	Squamish Pulp Operations	8,000	240,000	ST	
3221	1949	Western Pulp Ltd.	Pulp and Paper	Port Alice Operations	11,000	97,500	BPST, ECST	SPL
3221	1950	Skeena Cellulose Inc.	Pulp Mill	Skeena Cellulose Inc.	42,000	95,300	BPEST	SPL
3221	1963	Pope and Talbot Inc.	Pulp and Paper	Pope and Talbot Harmac Pulp	30,000	373,603	BPST	SPL
3221	1964	Norske Canada	Pulp and Paper	Port Alberni Pulp and Paper Div.	18,000	137,400	BPEST	Hog
3221	1968	Tembec Industries Inc.	Pulp Mill	Tembec Industries Inc.	58,000		BPEST	SPL
3221	1968	Catalyst Paper	Pulp and Paper		36,000	254,468	BPEST	
3221	1972	Weyerhaeuser Canada Ltd.	Pulp and Paper	Weyerhaeuser Canada Ltd.	70,000	1,058,000	BPST, CST	SPL
3221	1972	Cariboo Pulp and Paper	Pulp and Paper	Cariboo Pulp and Paper	32,000	387,890	BPEST	SPL
3221	1972	Kamloops Pulp	Pulp Mill		69,000		BPST, CST	
3221	1973	Canadian Forest Products	Pulp and Paper	CANFOR – Northwood	55,400		BPEST	SPL
3221	1979	Pope and Talbot Ltd.	Pulp and Paper	Mackenzie Pulp Operation	20,000	206,000	BPEST	SPL
3221	1980	Norske Skogindustrier	Pulp and Paper	Crofton Pulp & Paper	38,700	45,267	BPST	
3221	1989	Howe Sound Pulp and Paper	Pulp and Paper	Howe Sound Pulp and Paper	112,500	414,600	BPEST, ECST	SPL
3221	1993	Celgar Pulp Co.	Pulp and Paper	Celgar Pulp Co.	52,000	342,807	BPEST	SPL
3221	1996	Abitibi Consolidated	Pulp and Paper	Mackenzie Paper Division	13,900	281,000	BPEST	Hog
3221	2001	Skookumchuck	Pulp and Paper		43,500	276,625	ECST	
3221	2001	Skookumchuck	Pulp and Paper	Tembec Inc	35,000		ECST	
3221	2005	Prince George Pulp and Paper	Pulp and Paper		60,000			
				Total	**1,468,050**	**4,415,561**		

Note: Summary for Province = BC (28 detail records)
Source: Canadian Cogeneration Database, CIEEDAC

Appendix C: Renewable Energy Data, 2009

NOTE: Data updating and review are not complete; data reflects previous assessments and do not reflect current systems.

Table 1. Biogas – Landfill Gas Facilities

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
Hartland Landfill	Maxim Power Corp.	Victoria		1,600				2004	
Jackman Landfill	ToGro Greenhouses Ltd.	Langley	Agriculture					1995	
Port Mann Landfill	Georgia Pacific	Surrey	Wallboard Manufacturer		Yes	No		1993	
Vancouver Landfill	Maxim Power Corp.	Delta		5,550			99,540	2003	
Total				**7,150**			**110,040**		

Table 2. Biogas – Sewage Facilities

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
Annacis Island	Greater Vancouver Regional District	Richmond	Regional Wastewater Treatment Facility	4,400	Yes	Yes	3,300	1975	
Iona Islands	Greater Vancouver Regional District	Richmond	Regional Wastewater Treatment Facility	3,750	Yes	No	1,500	1995	
TOTAL:				**8,150**			**4,800**		

Table 3. Solar Photovoltaic Installations

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
BCIT Solar Installation		Burnaby	College	4	No	No		2000	
CMHC Home Solar Installation	BCIT Technology Center	Burnaby	Academic Research and Development	2	No	No		2000	
Operations Centre	City of White Rock	White Rock						2003	
Prince George Solar Installation	Private home	Prince George	Residences	1	No	No		1996	
Solar Plus	Solar Plus	Mill Bay	Renewable Electricity Generator	1	Yes			1987	
TELUS Solar Installation	TELUS Inc.	Vancouver	Telecommunications	3	No	No		2000	

Table 3. Solar Photovoltaic Installations, Continued

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
Victoria Solar House	SPS Energy	Victoria	Diversified Electricity Generator	1	No	No		2001	
Victoria Solar House 2		Victoria		2				2004	
Williams Farrel Building		Vancouver						2000	
TOTAL				**14**					

Table 4. Hydroelectricity – Storage Facilities

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
Alouette	BC Hydro	Alouette Lake	Crown Corporation	9,000	No	Yes		1928	
Arrow Lakes Generating Station	Columbia Power Corporation	Columbia River		185,000	No			2002	
Ash River	BC Hydro	Ash River	Crown Corporation	27,000	No	Yes		1959	
Bridge River #1	BC Hydro	Bridge River	Crown Corporation	191,000	No	Yes		1948	
Bridge River #2	BC Hydro	Bridge River	Crown Corporation	275,000	No	Yes		1959	
Cheakamus	BC Hydro	Cheakamus River	Crown Corporation	157,000	No	Yes		1957	
Clowhom	BC Hydro	Clowhom River	Crown Corporation	33,000	No	Yes		1957	
Comox Dam	BC Hydro	Puntledge River	Crown Corporation					1953	
Corra Linn	FortisBC	Kootenay River	Utility	45,000	No	No		1932	
Falls River	BC Hydro	Falls River	Crown Corporation	7,000	No	Yes		1930	
Gordon M. Shrum	BC Hydro	Peace River	Crown Corporation	2,730,000	No	Yes		1968	
John Hart	BC Hydro	Campbell River	Crown Corporation	126,000	No	Yes		1947	
Jordan River	BC Hydro	Jordan River	Crown Corporation	170,000	No	Yes		1971	
Kemano Generating Station	Alcan Primary Metal – BC	Kemano	Aluminum Smelter	960,000	No	Yes		1954	
Kootenay Channel	BC Hydro	Kootenay River	Crown Corporation	572,000	No	Yes		1975	
La Joie	BC Hydro	Dounton Lake	Crown Corporation	25,000	No	Yes		1957	
Ladore Falls	BC Hydro	Campbell River	Crown Corporation	47,000	No	Yes		1956	
Lake Buntzen #1	BC Hydro	Lake Buntzen	Crown Corporation	55,000				1951	
Lake Buntzen #2	BC Hydro	Lake Buntzen	Crown Corporation					1914	

Table 4. Hydroelectricity – Storage Facilities, Continued

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
Lois	Brookfield Power Operations: BC Operations	Lois Lake	Renewable Electricity Generators	34,660	No	Yes		1930	
Mica	BC Hydro	Columbia River	Crown Corporation	1,805,000	No	Yes		1976	
Moresby Lake	Northern Utilities Inc. and Queen Charlotte Power Corp.	Moresby Lake	Renewable Electricity Generator	5,700				1990	
Powell River	Brookfield Power Operations: BC Operations	Powell Lake	Renewable Electricity Generators	47,250	No	No		1911	
Revelstoke	BC Hydro	Columbia River	Crown Corporation	1,980,000	No	Yes		1984	
Ruskin	BC Hydro	Hayward Lake	Crown Corporation	10,500	No	Yes		1930	
Seton	BC Hydro	Seton Creek	Crown Corporation	48,000	No	Yes		1956	
Seven Mile	BC Hydro	Pend D'Oreille River	Crown Corporation	804,000	No	Yes		1979	
Shuswap Falls	BC Hydro	Shuswap River	Crown Corporation	6,000	No	Yes		1929	
Stave Falls	BC Hydro	Stave Lake	Crown Corporation	90,000	No	Yes		1912	
Strathcona	BC Hydro	Campbell River	Crown Corporation	64,000	No	Yes		1958	
Wahleach	BC Hydro	Wahleach Lake	Crown Corporation	63,000	No	Yes		1952	
Whatshan	BC Hydro	Wahleach Lake	Crown Corporation	54,000	No	Yes		1972	
Total				**10,720,610**					

Table 5. Earth Energy Installations

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
100 Mile House Recreation Centre	Canlan Ice Sports Corporation	100 Mile House	Recreational Facility				773.784	2002	
Airport Hangar Campbell River		Campbell River					70.344	2004	
APEG Building	Association of Professional Engineers	Burnaby	Office Building				246		

Table 5. Earth Energy Installations, Continued

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
Art Holdings Area	Icekube Systems	Chase	Recreational Facility				562.752	1999	
Beaver Flats		Whistler						2002	
Blue River Resort	Mike Wiegele Helicopter Skiing		Hotel						
Bob McMath Secondary School	Bob McMath Secondary School	Richmond	School					1997	
Bow Mel Chrysler		Duncan					87.93	2004	
Brentwood College		Mill Bay	College				246.204	2002	
Burnaby Mountain Secondary		Burnaby	School						
Caper's Building	Kalico Developments Ltd. & Salt Lick Projects Ltd.	Vancouver	Real Estate Developer		Yes		739	1993	
Ciele Condominum		Vancouver							
City of Vancouver Works Building		Vancouver					175.86	2004	
Copcan Contracting		Nanaimo					123.102	2002	
Cornerstone Building		Burnaby					120	2004	
Discovery Bay Resort		Kelowna					2321.352	2002	
First Lutheran Church		Kelowna					211.032	2002	
Gleneagles Community Centre	District of West Vancouver	Vancouver	Community Centre					2003	
Gulf Islands Secondary School	Gulf Islands Secondary School	Salt Spring Island	School					1993	
Heritage Woods Secondary School		Port Moody	School				298.962	2004	
Ice Box Arena	Icekube Systems	Kamloops	Recreational Facility				562.752	1999	
Ice Box Arena	Icekube Systems	Kamloops	Recreational Facility				281.376	2000	
Kitsilano Condo Development		Kitsilano					527.58	1993	
Landmark Technology Centre	Stober Construction	Kelowna	Office Complex						
Living Waters Church		Fort Langley					70.344	2002	
Mission Centre Office	Icekube Systems	Kelowna	Recreational Facility				506.4768	2003	
Nature Centre		Masset					17.586	2002	
Nestor School		Coquitlam	School				140.688	2000	
Nicola Valley Arena	Icekube Systems	Merritt	Recreational Facility				562.752	2001	
Ocean Farms		Duncan					70.344		
Oliver Curling Club	Oliver Curling Club	Oliver	Recreational Facility					1994	

Table 5. Earth Energy Installations, Continued

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
Pacific Agrifood Research Centre	Agriculture and Agri-Foods Canada	Agassiz	Research Institution						
Pacific Gardens		Nanaimo							
Pacific Sands Beach Resort		Tofino					316.548	2004	
Peace Arch Visitors Centre		Surrey							
Poet's Cove		South Pender Island						2003	
Quarry Stone Lakeside Villas		Mara					119.5848	2003	
Rockridge Canyon Youth Camp		Princeton					140.688	2004	
Rutland Elementary School	Rutland Elementary School	Kelowna	School						
S.F.Home	Kalico Developments Ltd. & Salt Lick Projects Ltd.		Real Estate Developers						
Saltspring Elementary School		Salt Spring Island	School				105.516	2001	
Saturna Island Community Centre		Saturna Island	Community Centre				105.516	2004	
Seaview School		Coquitlam					105.516	2000	
Serene Lea Farms		Mara					140.688	2003	
Shoal Point, Fisherman's Wharf		Victoria						2003	
Sk'Elp School of Excellence	Kamloops Indian Band	Kamloops						2002	
Spruce Grove Field House	Resort Municipality of Whistler	Whistler	Government					2000	
Sto-Lo Nation Medical Building		Chilliwack					105.516	2004	
Sun Rivers Golf Resort	Sun Rivers Golf Resort Community	Kamloops						2004	
Sundance Lodge Resort		Kelowna					703.44	2004	
Tekmar Control Systems Ltd.	Tekmar Control Systems Ltd.	Vernon	Factory						
Telkwa Faith Reformed Church		Telkwa	Church				211.032	2003	
TOTAL							**10,770.27**		

Table 6. "Low Impact" Hydro Facilities

Name	Company	Location	Type of Business	Electrical	Purchase	Sell	Thermal	Start Year	Eco-

				Capacity (kW)	Electricity from Grid?	Electricity to Grid?	Capacity (kW)		certification
Aberfeldie	BC Hydro	Bull River	Crown Corporation	5,000	No	Yes		1922	
Akolkolex	Canadian Hydro Developers Inc.	Revelstoke	Diversified Electricity Generator	10,000	No	Yes		1995	ECP Eco-Logo
Bonnington Falls Generating Station	Nelson, Corp of the City of	Kootenay River	Integrated Electric Utility	15,350	Yes	No		1905	Environmental Choice Program, Eco-Logo, 1999
Boston Bar Generating Station	Algonquin Power Income Fund	Scuzzy Creek	Hydro Site Managers	7,200	Yes	Yes		1995	
Brilliant	Columbia Power Corp.	Kootenay River	Renewable Electricity Generator	149,000	No	No		1943	
Brown Lake	EPCOR Generation Inc.	Prince Rupert	Electricity Generation	7,000				1996	
Clayton Falls	BC Hydro	Clayton Falls	Crown Corporation	2,000	No	Yes		1961	
Eagle Lake Micro Hydro at C2 Reservoir	Pacific Cascade Hydro Inc. & District of West Vanc	West Vancouver	Municipality	200	Yes	Yes		2003	BC Hydro Green Certified, 2003
Elko Plant	BC Hydro	Elk River	Crown Corporation	12,000	No	Yes		1924	
Hluey Lake Hydro Project	Regional Power	Dease Lake	Renewable Electricity Generator	200	Yes	Yes		2003	Environmental Choice Certified
Hystad and East Twin Creek	East Twin Creek Hydro Ltd.	Valemount	Renewable Electricity Generator	6,000	Yes	Yes		1989	B.C. Hydro Green Certified, 2002
Lower Bonnington	FortisBC	Kootenay River	Utility	49,500	No	No		1925	
Mamquam	TransCanada Energy	Mamquam River	Renewable Electricity Generator	50,000				1996	
Miller Creek	EPCOR Generation Inc.	Pemberton	Electricity Generation	29,500				2003	
Peace Canyon	BC Hydro	Peace River	Crown Corporation	694,000	No	Yes		1980	
Pingston Creek	Canadian Hydro Developers Inc.	Revelstoke	Renewable Electricity Generator	45,000	No	Yes		2003	BC Hydro Green Certified
Puntledge	BC Hydro	Puntledge River	Crown Corporation	24,000	No	Yes		1955	
Purcell Mountain Lodge	Purcell Mountain Lodge	Purcell Mountain Lodge	Lodge	15				1992	
Raging River	Raging River Power and Mining Inc	Port Alice	Mining and Energy Company	1,750	Yes	Yes		2002	BC Hydro Green IPP, 2003
Rutherford Creek	Innergex Inc.	Pemberton							

Table 6. "Low Impact" Hydro Facilities, Continued

Sechelt	Clean Power Income Fund	Sechelt Creek	Renewable Electricity Generator	16,000	Yes	Yes		1997	Environmental Choice Certified
South Slocan	FortisBC	Kootenay River	Utility	53,100	No	No		1928	
Spillimacheen	BC Hydro	Spillimacheen River	Crown Corporation	4,000	No	Yes		1955	
Upper Bonnington	FortisBC	Kootenay River	Utility	61,630	No	No		1907	
Upper Mamquam	Canadian Hydro Developers Inc.	Squamish						2005	
Walden Hydro Plant	BC Hydro	Lillooet	Crown Corporation	16,000	No	No		1974	
Walter Hardman	BC Hydro	Cranberry Creek	Crown Corporation	8,000	No	Yes		1960	
Waneta Generating Station	Columbia Power Corporation	Pend d'Oreille River						1952	
Wilsey dam	BC Hydro	Shuswap River	Crown Corporation					1929	
TOTAL				**1,269,245**					

Table 6. "Low Table 7. Biomass – Wood Residue Facilities

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
Armstrong	Tolko BC	Armstrong	Pulp and Paper Company	20,000	Yes	Yes		2000	
Campbell River	Norske Canada	Campbell River	Pulp and Paper Company	25,000	Yes	No			
Celgar	Celgar Pulp Co.	Castlegar	Pulp and Paper Company	49,400	Yes	Yes	325,667	1960	
Chetwynd	Tembec Inc.	Chetwynd	Pulp and Paper Company					1980	
Crofton	Norske Canada	Crofton	Pulp and Paper Company	38,000	Yes	No		1981	
Fraser Flats	Canadian Forest Products	Prince George	Pulp and Paper Company	45,428	Yes	No		1973	
Golden EWP Division	Louisiana-Pacific Engineered Wood	Golden	Pulp and Paper Company	7,000	Yes	Yes	18,375	1936	
Harmac	Pope and Talbot Inc.	Nanaimo	Pulp and Paper Company	27,300			283,414	1963	
Kelowna	Tolko BC	Kelowna	Pulp and Paper Company	12,000		Yes	32,250	1948	

Table 7. Biomass – Wood Residue Facilities, Continued

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
Mackenzie	Abitibi Consolidated Inc.	Mackenzie	Pulp and Paper Company	11,120	No	No	224,800	1997	
Port Alberni	Norske Canada	Port Alberni	Pulp and Paper Company	17,680	Yes	No	93,432	1963	
Port Alice	Western Pulp Ltd.	Port Alice	Pulp and Paper Company	19,200	Yes		170,400	1949	
Powell River	Norske Canada	Powell River	Pulp and Paper Company	25,000	Yes	Yes		1910	
Pulp Mill	Norske Skog Canada Ltd.								
Quesnel Plywood	Quesnel Plywood	Quesnel	Forestry	29,024	Yes		20,517	1972	
Western Manufacturing Division	Scott Paper Ltd. (Kruger)	New Westminister	Pulp and Paper Company	14,000	Yes	No	11,389	1950	
Western Pulp Ltd.	Western Pulp Ltd.		Woodfibre	7,000				1947	
Williams Lake	TransCanada Power LP	Williams Lake	Diversified Electricity Generator	72,000	Yes	Yes		1993	
TOTAL				**419,152**			**1,181,743.89**		

Table 8. Biomass – Other Facilities

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
EYA-UBC Biodiesel Project	Environmental Youth Alliance / UBC	Vancouver	Non-Profit / Academic	11,120				2002	
Neoteric Biofuels Inc.		Westbank							
TOTAL									

Table 9. Standard Hydro Facilites

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
Klemtu Hydro project	Kitasoo First Nation	Klemtu	First Nation Government	620				1981	
Mears Creek	Synex Energy Resources Ltd.	Gold River	Diversified Electricity Generator	3,800					BC Hydro Green IPP
Ocean Falls	Central Coast Power Corp.	Link Lake	Renewable Electricity Generator	12,200				1917	

Table 9. Standard Hydro Facilites, Continued

Name	Company	Location	Type of Business	Electrical Capacity (kW)	Purchase Electricity from Grid?	Sell Electricity to Grid?	Thermal Capacity (kW)	Start Year	Eco-certification
Port Alice	Western Pulp Ltd.	Victoria Lake	Pulp and Paper Company	2,000				1953	
Tennant Lake	NVI Mining Ltd.	Tennant Lake	Mining Company	3,060				1966	
Thelwood Hydro	NVI Mining Ltd	Thelwood Lake	Mining Company	8,200				1985	
Waneta	Teck-Cominco Metals	Pend D'Oreille River	Mining Company	337,700	Yes			1954	
Woodfibre	Western Pulp Ltd.	Henrietta Lake	Pulp and Paper Company	2,587				1947	
TOTAL				**370,167**					