



A Review of Existing Cogeneration Facilities in Canada

Prepared by

Catherine Strickland
John Nyboer

of the

Canadian Industrial Energy End-Use Data
and Analysis Center

Simon Fraser University

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Executive Summary

CIEEDAC published the original version of *A Review of Cogeneration Facilities in the Canadian Industrial Sector* in March 1999. The original purpose of the report was to identify the size (electrical capacity, kW_e), location, and thermal host of industrial cogeneration facilities in Canada. That purpose was expanded in 2002 it include data on commercial /institutional and district energy cogeneration systems. In 2003, the database was expanded again to include performance characteristics of cogeneration systems operating in Canada 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 two 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.

The database now contains information on over 200 cogeneration systems with an operating capacity of approximately 6.8 GW_e. Currently, Alberta has 2.4 GW_e of operating cogeneration capacity and Ontario has 2.0 GW_e. Together, the two provinces account for almost 65% of total capacity in Canada. By system operator, the electric power generation industry has the most cogeneration, 3.4 GW_e or almost 51% of total operational capacity. The forest products sector has the next highest cogeneration capacity of 1.6 GW_e, which represents 23% of operating capacity.

This year we have also allocated capacity based on thermal host. Under this allocation method, the pulp and paper sector acts as thermal host to 2.2 GWe of cogeneration capacity (33%), the chemical sector to 1.7 GWe of capacity (25%) and the oil and gas sector to 1.6 GWe or 24% of the total.

The performance of cogeneration systems in Canada varies widely from a low of 37% to a high of 95%. On average, gas turbine systems are the most efficient (77%) and diesel systems are the least efficient (42%). The independent power sector is on average the least efficient of the sectors for which we have data and the defense sector is the most efficient. Fifty-nine percent of all operating cogeneration capacity (4.0 GW_e) has been installed since 1995.

The average amount of electricity generated per kW_e of installed capacity is 5,351 kWh/yr. The average heat rate¹ of systems operating in Canada is 4,764 kilojoules/kWh (4,518 BTU / kWh) for an average system efficiency of 75.6%. The average heat to power ratio of systems operating in Canada is 6.4.

This report has four appendices. The first appendix contains the questionnaire that was sent to each cogeneration facility this year. The next two show the database records for

¹ 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.

all cogeneration projects included in this year's review sorted by Sector (Appendix A) and Region (Appendix B). The fourth appendix describes formulas for allocating CO₂ emissions to the thermal and electrical products of cogeneration.

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A Review of Existing Cogeneration Facilities Canada

1. Introduction

Cogeneration, also referred to as combined heat and power (CHP), is the simultaneous production of electrical and 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 CO₂ emission reduction strategies. National and international commitments to reducing CO₂ emissions, has increased interest in cogeneration.

Cogeneration has been widely adopted in many European countries for use in industrial, commercial and residential applications. In Denmark, Finland and The Netherlands cogeneration accounts for over 30% of national electricity generation. However, in Canada cogeneration represents 7% of national electricity generation. This low penetration rate may be attributable to low energy prices and electric utility policies on the provision of back-up power and the sale of surplus electricity. Despite these barriers, cogeneration is common in some sectors (pulp and paper and chemical products sectors) and electricity market restructuring in Alberta and Ontario is fueling a dramatic rise in utility-scale cogeneration facilities.

CIEEDAC's Cogeneration Database aims to provide a comprehensive list of cogeneration projects in Canada 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. Descriptions of cogeneration systems in use in Canada.
2. The methodology used to identify cogeneration projects in Canada.
3. A summary of cogeneration facilities in Canada by region and sector, system average performance characteristics and a timeline of cogeneration installations.
4. Conclusions

2. Cogeneration Systems

Cogeneration is defined as the simultaneous generation of both electricity (which includes direct drive power from steam turbines) and useful thermal energy. 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.

The heat-to-power ratio is the ratio of the amount of useful thermal energy available to the amount of power generated usually expressed in terms of kW of heat (kW_{th}) per kW of power (kW_e).² Heat-to-power ratios vary depending on the type of prime mover (drive system) and range from 0.5:1 to 20:1.

Overall system efficiency is the percent of the fuel converted to electricity plus the percent of fuel converted to useful thermal energy. Typically, cogeneration systems have overall efficiencies of between 65% and 85%.

Heat output from cogeneration systems varies greatly depending on the system type. The output can range from high pressure, high temperature (500 to 600°C) steam to warm water (80°C or below). High pressure, high temperature steam is considered high quality thermal output because it can meet most industrial process needs. Hot water is considered a low quality thermal output because it can only be used for a limited number of thermal applications.

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

2.1 Steam Turbine

Steam turbines are the most common cogeneration system used in industrial applications. They range in size from a 500 kW_e to 80 MW_e . The smaller sized systems may not be economical unless the fuel used has no alternative commercial value (i.e., hog fuel). Steam turbine cogeneration systems usually produce significantly more heat than electricity per unit of fuel consumed and therefore have high heat-to-power ratios. The ratios vary from site to site and range from 3:1 to 10:1. The thermal needs of the site typically determine this ratio. The lower the quality of heat required (i.e., the lower the temperature and pressure), the greater the amount of electricity generated per unit of fuel.

Steam turbine cogeneration systems generate steam in a high-pressure steam boiler. The steam expands through a turbine to produce mechanical energy. This mechanical energy drives an electric generator.³ The output heat serves process applications such as drying wood, pulp or papermaking, etc.

Steam turbines come in two types, back-pressure turbines and condensing turbines. Back-pressure turbines exhaust steam at a pressure higher than atmosphere. Condensing turbines exhaust steam at pressures lower than atmosphere (i.e., a vacuum) and therefore require a condenser. With either type, steam can be extracted part way through at a pressure required by the thermal user. Condensing turbines produce more electricity per

² The heat-to-power ratio is the ratio of thermal energy to electricity produced by the cogeneration system. It can be expressed in different units such as Btu / kWh but in this report it is presented by the same power unit (kW).

³ The mechanical energy can also be used to drive equipment in the plant. However, this type of system is not covered in this report.

unit of fuel than back-pressure turbines because more of the energy contained in the steam is extracted by the turbine making less available for thermal applications.

Steam turbines can consume almost any fuel including the waste products of industrial processes, a key advantage in some applications.

2.2 Gas Turbine (GT)

Gas turbines act as the most common prime mover in the large cogeneration systems built recently. They range in electricity output from 250 kW_e to 200 MW_e. GT systems produce more electricity per unit of fuel than steam turbines and have an average heat-to-power ratio of 2:1. Supplemental heating through secondary firing of the exhaust gases can increase this ratio to 5:1. Steam injection, which increases the volumetric flow through the turbine, can increase the electrical output by 15%.

Gas turbine systems produce high temperature, high pressure gases in a combustion chamber. These gases expand through a turbine producing mechanical energy that drives the generator. The gases exit the turbine at temperatures of between 450 and 550°C and are used to meet the thermal requirements of the site. They can be used directly for drying, or indirectly to produce high, medium or low pressure steam or hot water.

2.3 Reciprocating Engine

Reciprocating engines are internal combustion engines operating by the same principles as a car engine. Systems range in size from 20 kW_e to 6 MW_e. The heat-to-power ratio ranges from 0.5:1 to 2.5:1. As with gas turbines, supplemental firing can be used to increase the thermal output.

It is harder to use the thermal output from reciprocating engines because it comes from two sources, the exhaust gas and the engine cooling system. The exhaust gases are of high heat (up to 400°C) but the cooling system provides only low-grade heat (below 90°C). Often one cascades the two heat sources to produce hot water. These systems produce more electrical energy per unit of fuel (35% to 53%) than either steam or gas turbines.

2.4 Combined Cycle Gas Turbine (CCGT)

CCGT cogeneration systems have a gas turbine connected in series with a steam turbine. The hot exhaust gases from the gas turbine produce steam for the steam turbine. Thermal energy remaining in the steam exhausted from the steam turbine goes to process applications. The main advantage of the CCGT is its high electrical energy efficiency compared to the other systems described above.

2.5 Microturbines

Some small industry and institutional CHP applications use microturbines. Microturbine cogeneration systems are small versions of gas turbine systems. They range in size from 20 kW_e to 250 kW_e. Microturbine systems consist of packaged high-speed generator plants with the turbine, compressor and generator all on one shaft. Microturbine cogeneration systems add a heat recovery unit to the packaged microturbine. They

typically contain power electronics to deliver electricity to the grid and can run on natural gas or other liquid fuels including landfill gas and flare gas from oil, natural gas and coal extraction. Microturbine cogeneration systems are becoming increasingly cost-effective in regions such as Alberta where electricity prices are high relative to the cost of natural gas.

Microturbines have become commercially available only in the last few years, and so successful microturbine installations are still relatively few, and total market share is limited. Some analysts predict widespread adoption of microturbine systems because of their modularity, low cost, low emissions and load flexibility.

2.6 New Technologies

Fuel cells and stirling engines are emerging technologies to supply combined heat and power.

2.6.1 Fuel Cells

A fuel cell captures the chemical energy released by the electrochemical reaction between hydrogen and oxygen and converts it to electrical energy. Fuel cells use an electrolyte to combine hydrogen (the fuel) with oxygen from the air to produce hot water or steam, depending on the type of fuel cell, and an electrical current. Hydrogen can be obtained directly from fossil fuels (natural gas or coal) or from renewable sources such as biomass or via electrolysis of water powered by renewable electricity.

Typical fuel cells produce only a small voltage (~1 volt). Combined in series (a “stack”), they produce enough power for distributed generation applications. One can apply the hot water or steam to thermal applications. Fuel cell systems for use in residential cogeneration applications could range from about 1 kW_e to 5 kW_e.⁴ They have high efficiencies even at small sizes and low load conditions, have no moving parts which reduces interruptions in service, generate no or low emissions (they use pure hydrogen or natural gas), are quiet and can be sited almost anywhere.

Fuels cells are classified according to the material used for the electrolyte. The five types currently under development are phosphoric acid fuel cells (PAFCs), molten carbonate fuel cells (MCFCs), solid oxide fuel cells (SOFCs), alkaline fuel cells (AFCs), and proton exchange membrane (also called polymer electrolyte membrane) fuel cells (PEMFCs). PEMFCs operate below 200°C, while all other fuel cells operate at higher temperatures. This has several important implications. First, because they operate at low temperatures, the exhaust heat temperature in PEMFCs is low, and can only be used where there is demand for low quality heat (e.g., hot water). Other types of fuel cells can provide higher quality thermal output. Second, operating at high temperature enables fuel cells to internally reform natural gas into hydrogen and carbon dioxide, meaning that an external reformer is not required. In contrast, PEMFCs require an external reformer if they are to use a hydrocarbon fuel. Third, the lower temperatures of PEMFCs mean that materials do not have to be as temperature resistant in this type of fuel cell compared to the others.

⁴ Fuel cell systems can be even smaller than 1 kW but these systems would not be used for cogeneration.

2.6.2 Stirling Engines

Stirling engines are *external combustion* engines in which a fuel is burned outside of the cylinder containing the engine's working fluid. This allows the fuel to be burned continuously, rather than in a series of discrete firings as in the internal combustion engine. It also allows for fuel flexibility – any type of fuel that can be used in a conventional boiler can also be used in a Stirling engine. Finally, it enables good heat recovery – the thermal efficiency of a Stirling engine is close to that of an equivalently sized conventional boiler. The gasses used inside a Stirling engine never leave the engine, so there is no need for exhaust valves and the engine runs very quietly. Stirling engines have relatively high heat to power ratios, which makes them suitable for the load requirements of the residential sector.

Stirling engines are currently being developed for combined heat and power application in the residential housing market, primarily in Europe and Japan.

2.7 Efficiencies, Heat-to-Power Ratios and Thermal Quality

Table 1 summarizes the efficiencies, heat-to-power ratios and the quality of the thermal output for cogeneration systems according to system type.

Table 1: Efficiencies, Heat-to-Power Ratios and Thermal Quality

Cogeneration System	Electrical Energy Output (% of fuel input)	Overall Efficiency (%)	Heat-to-Power ratio	Thermal Qualities
Back-pressure steam turbine	14-28	84-92	4.0-22	High
Condensing steam turbine	22-40	60-80	2.0-10.0	High
Gas turbines	24-42	70-85	1.3-2.0	High
Reciprocating engine	33-53	75-85	0.5-2.5	Low
Combined cycle gas turbine	34-55	69-83	1.0-1.7	Medium
Fuel Cells	40-70	75-85	0.33-1	Low to High
Microturbines	15-33	60-75	1.3-2.0	Medium to Low

Source: UNESCAP and the European Association for the Promotion of Cogeneration

3. Good Quality Cogeneration

It is sometimes assumed that all CHP is good, i.e. better than the alternative stand-alone electricity and thermal energy generation both from an economic and an environmental perspective. This is not always the case, particularly in systems with high heat-to-power ratios and moderate system efficiencies or systems that operate at part load for significant portions of time. For example, a natural gas-fired steam turbine with a system efficiency of 65% and a heat to power ratio of 5 would be less efficient than using an 80% boiler

and a combined-cycle gas turbine to generate the electricity and thermal energy separately.

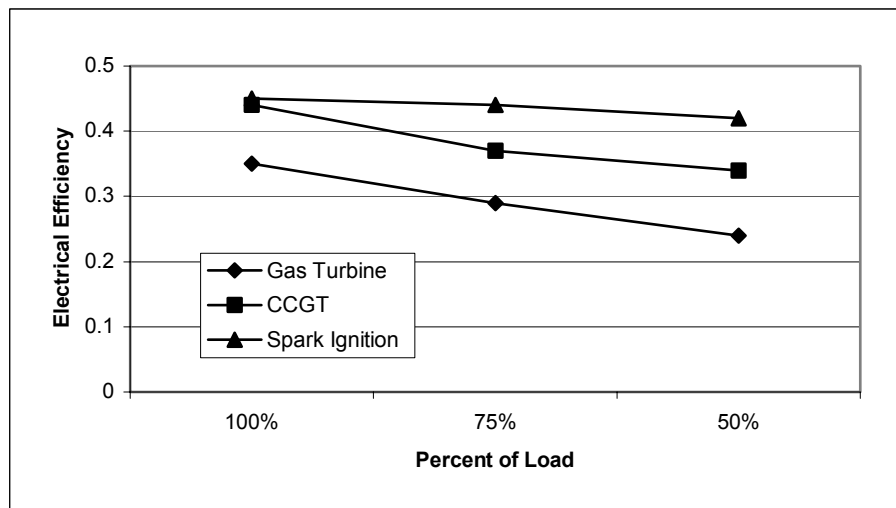
This section defines the characteristics that maximize the environmental and economic benefits of CHP systems and suggests more meaningful parameters to describe CHP systems that allow for more accurate comparisons to alternative systems.

3.1 Maximizing CHP Benefits

There are two key conditions that maximize the benefits of CHP. They are maximizing the production of electricity while closely matching the thermal load requirements in terms of both quantity and energy quality. The thermal capacity of a CHP system should be sized to meet the base thermal load required by the host facility. The quality of the thermal output should not be significantly higher than that required to meet the needs because it means the unused thermal energy could have been used to generate more electricity. The ratio of electricity production to thermal energy output and the thermal energy quality are determined by the choice of generator and auxiliary equipment.

Some CHP technologies, such as reciprocating engines, retain a high level of efficiency at part load, while others such as gas and steam turbines do not. Figure 1 compares the part load efficiencies of three major CHP system types. If a gas turbine, steam turbine or CCGT system is operated at part load for a significant portion of time, the economic and environmental advantage of using a CHP system may be lost.

Figure 1: Part Load Efficiencies of Generators



The benefits of CHP systems are correlated to the alternative electrical and thermal energy system that would have been in their place. For example, industrial thermal loads are usually met with industrial boilers with efficiencies above 80%. However, residential heating and hot water loads are served using less efficient devices. Therefore, the minimum efficiency threshold for good quality CHP in an industrial application would be higher than in a residential or district energy application.

Finally, the benefits of CHP systems that generate excess electricity are maximized if the system is located in an area of the grid that requires additional generation capacity. This location issue is of particular importance to the CHP systems being proposed in the oil sands region of Alberta. The oil sands currently hosts 1,214 MW of cogeneration capacity with an additional 245 MW under construction. However, not all of this electricity can be consumed by the projects in the immediate region. The Athabasca Regional Issues Working Group estimated that there would be roughly 1,000 MW of excess generation capacity in the oil sands region by 2010.

3.2 Alternative Parameters to Define CHP Systems

The current parameters that are used to define the characteristics of CHP systems are inadequate for assessing whether or not a CHP system is better than the alternatives. CHP systems are usually defined by their total electrical capacity and the system efficiency. These two parameters do not provide enough information to accurately assess the value of a CHP system and do not allow for direct comparison with stand-alone generation and thermal energy systems.

3.2.1 CHP System Efficiency

The current use of system efficiency to describe CHP systems is inadequate for evaluation and comparison to stand alone systems. To demonstrate this, we compare a reciprocating engine system with an efficiency of 84% and a heat to power ratio of 1.4 to a steam turbine system with an efficiency of 81% and a heat to power ratio of 14.2.⁵ The reciprocating engine system reduces GHG emissions by 67 Tonnes of CO_{2e} per GWh of total energy while the steam turbine system only reduces emissions by 11 TCO_{2e} per GWh of total energy.⁶

An alternative efficiency measure used by the US Environmental Protection Agency is Effective Electric Efficiency. Effective electric efficiency (E3) is defined as the electrical output from a CHP system divided by the total energy output from the system minus the thermal output divided by the assumed efficiency of the alternative boiler. For an alternative boiler that is 80% efficient, the effective electric efficiency would be calculated as follows:

$$E3 = (\text{CHP electrical power output}) / (\text{Total energy input to CHP system} - \text{total heat recovered} / 0.80)$$

E3 is a more informative way of comparing the efficiency of CHP systems because it makes it easier to compare CHP systems to stand-alone generators and determine their value. It also treats the CHP system as primarily a thermal energy device with electricity as the byproduct of the process.

Table 2 shows the efficiencies of several CHP systems in the Canadian Cogeneration Database and compares their system efficiency with their effective electric efficiency.

⁵ Data from the Canadian Cogeneration Database at CIEEDAC.

⁶ Strickland, C. and Nyboer, J., "Allocating GHG Emissions Among the Products of Cogeneration", November, 2003.

Table 2: Efficiencies of Canadian Cogeneration Systems

Location	System type	Efficiency	E3
Nanaimo, BC	Steam Turbine	74%	45%
Hamilton, ON	Reciprocating Engine	71%	65%
Regina, SK	Microturbine	67%	51%
ON	Gas Turbine	81%	81%

From these data we can see that the system efficiency does not correlate to the E3. In addition, we can easily see that the Nanaimo CHP system would only be advantageous when compared to electricity generated at an efficiency level below 45%. Since some CCGT systems currently exceed this efficiency level, this cogeneration system may not always result in environmental benefits. In this case, the majority of the fuel used in the Nanaimo system is hog fuel and black liquor, so there would be a reduction in GHG and other emissions.

3.2.2 Capacity Factor

Another issue not addressed by the current method of characterizing CHP systems is that CHP systems do not always have the same capacity factor as stand-alone generation systems. Base load electricity generation facilities tend to have capacity factors above 93%. This means that the generator produces electricity equal to the total electrical capacity multiplied by the total number of hours in a year (8,760) multiplied by 93%. However, the average capacity factor of electricity generation in Canada is approximately 63%.⁷ Capacity factor is affected by how many hours a system is running and at what load level. For example, a CHP system running 50% of the time at full capacity would have the same capacity factor as a CHP system running at 50% capacity full time. Because of the large variation, the capacity factor of a CHP system should be included as one of its defining parameters.

4. Methodology

For the last two years we have gathered data on Canadian cogeneration system through by means of a survey sent to all facilities listed in our database.⁸ Through this process we identified several cogeneration systems that are no longer operational, some sites that were never cogeneration facilities and some duplicate listings. In addition we are gathering new data on the performance characteristics of cogeneration systems operating in Canada. The resulting database is more reliable and contains data that will enhance understanding of the opportunities for and limitations of cogeneration in Canada. In addition, we have identified new cogeneration systems through websites, industry contacts and utility personnel.

⁷ Calculated from data for 2002 from the Canadian Electricity Association website.

⁸ The questionnaire is in Appendix A.

We feel that the Canadian Cogeneration Database is a comprehensive list of large and small cogeneration systems operating in Canada. However, a few systems may be missing because they are small or operate in remote locations. We hope to include any omissions in next year's update.

4.1 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 for the database are:

- Canadian Gas Association (CGA): In 1996, the CGA released a listing of Canadian gas-fired cogeneration systems that were in operation on December 31, 1995. These data focus only on natural gas-fired systems, and as a result miss a large number of systems fired by other fuels (i.e., oil, hog fuel, spent pulping liquor, coke oven gas, etc.). This database has not been updated.
- Environment Canada: Environment Canada has developed a database of gas-fired cogeneration facilities and combined cycle power plants, which it updates annually.
- Consultants: Several consultants in the cogeneration business were contacted for information about existing facilities. Thermoshare Inc. and Gerald Schwinn generously shared their cogeneration databases with CIEEDAC.
- Independent Associations: A number of industrial associations such as the Independent Power Producers Society of Ontario (IPPSO) and the Independent Power Producers Society of Alberta (IPPSA) provided data on facilities in their region.
- Electric and Gas Utilities: Most electrical and gas utilities were asked to provide data on cogeneration facilities in their service area.
- Statistics Canada (STC): (catalogue no. 57-206-XPB, Electric Power Generating Stations, 1998). This publication lists the capacity of electric generating stations in Canada both utility and privately owned, by province and by type (i.e., steam turbine, internal combustion and combustion turbine plant capacities, etc.). Used as a cross-reference, it does not explicitly distinguish cogeneration systems from any other generating system. In addition, the catalogue does not explicitly identify combined cycle gas turbines facilities; rather, it lists the combustion turbine separately from the steam turbine component of the system. The publication includes, with a few exceptions, all the cogeneration systems identified by the other report references. Some inconsistencies with respect to plant names, locations and capacities were noted when compared to other sources.
- Other Sources: Additional sources of information included corporate and government websites, cogeneration manufacturers brochures and industry journals.

5. Results

The following section summarizes the results of this year's cogeneration database survey.
Regional Results

Table 3 summarizes Canadian cogeneration capacity by region for 2002 and compares it to last year's results.

Table 3: Canadian Cogeneration by Region

Province	2002		2003	
	Capacity (kW)	% of Total	Capacity (kW)	% of Total
Newfoundland	17,500	0.2%	17,500	0.3%
Prince Edward Island	2,050	0%	2,050	0.0%
Nova Scotia	91,931	1.3%	91,931	1.4%
New Brunswick	164,500	2.4%	177,500	2.6%
Québec	188,840	2.8%	211,840	3.1%
Ontario	1,983,306	29.0%	2,029,514	29.8%
Manitoba	22,000	0.3%	22,000	0.3%
Saskatchewan	557,600	8.2%	557,720	8.2%
Alberta	2,584,900	37.8%	2,418,502	35.5%
British Columbia	1,204,050	17.6%	1,274,050	18.7%
Territories and Nunavut	15,400	0.2%	15,460	0.2%
TOTAL	6,832,077	100%	6,818,067	100%

Source: Canadian Cogeneration Database, CIEEDAC

The total operational cogeneration capacity for 2003 is slightly less than last year's total. The decrease occurred primarily because a cogeneration system in Alberta was operated in straight generation mode for the year. There were a significant number of systems added to the database this year, but most of them were small. This is the first year that microturbine cogeneration systems are included in the database.

Based on the data received this year, Alberta continues to have more operational cogeneration capacity (2.4 GWe) than any other region of Canada. Ontario is second with 2.0 GWe of operational cogeneration capacity.

5.1 Sector Results

This year we allocate cogeneration capacity by both system operator and primary thermal host. The North American Industrial Classification System (NAICS) was used to code the facilities. Table 4 shows cogeneration capacity by system operator and Table 5 shows capacity by thermal host.

Table 4: Canadian Cogeneration by System Operator

Sector	NAICS	Amount	% of Total
Greenhouse Agriculture	1114	3,100	0.0%
Oil Sands	2111	210,000	3.1%
Non-Metallic Mineral Mining	2123	69,231	1.0%
Non-Utility Generation	2211	3,442,710	50.5%
District Energy	2213	38,800	0.6%
Food and Beverage Manufacturing	3111	232,250	3.4%
Forest Products	3221	1,569,470	23.0%
Chemical Manufacturing	3251	1,009,781	14.8%
Fabricated Metal Products	3252	14,075	0.2%
Scientific Research	5417	4,810	0.1%
Sewage Treatment	5622	7,230	0.1%
Universities	6113	62,730	0.9%
Hospitals	6221	107,432	1.6%
Defense and Corrections Services	9111	9,900	0.1%
Other		36,448	0.5%
Total		6,832,007	100.00%

Source: Canadian Cogeneration Database, CIEEDAC

Table 5: Canadian Cogeneration by Thermal Host

Sector	NAICS	Amount	% of Total
Greenhouse Agriculture	1114	3,190	0.1%
Oil and Gas	2111	1,653,600	24.3%
Non-Metallic Mineral Mining	2123	329,231	4.8%
District Energy	2213	38,800	0.6%
Food and Beverage Manufacturing	3111	350,250	5.1%
Forest Products	3221	2,174,470	32.9%
Chemical Manufacturing	3251	1,682,281	24.7%
Fabricated Metal Products	3252	304,575	4.5%
Scientific Research	5417	8,368	0.1%
Sewage Treatment	5622	7,230	0.1%
Universities	6113	62,730	0.9%
Hospitals	6221	130,352	1.9%
Defense and Corrections Services	9111	9,900	0.3%
Other		55,160	1.3%
Total		6,832,007	100.00%

Source: Canadian Cogeneration Database, CIEEDAC

5.2 Cogeneration System Performance Characteristics

This year we did not receive significant additional data on system performance. The data presented below are from last year's report and are based on data from 97 sites. We have data on average annual electricity generation from 97 sites, data on heat rate⁹ from 64 sites, and data on heat to power ratio from 77 sites.

Table 6 displays the average performance characteristics of cogeneration systems currently in operation in Canada. The average amount of electricity generated per kW_e of installed capacity is 5,351 kWh/yr. The highest rate of electricity production, 7,834 kWh/kW/yr occurs in the manufacturing sector. This high output likely occurs because manufacturing facilities operate 24 hours a day and have a demand for both heat and electricity year round. The lowest rate, 3,209 kWh/kW/yr occurs at hospitals.

Table 6: Canadian Cogeneration System Performance

Sector	Electricity Generation	Heat Rate	Average Efficiency	Heat to Power Ratio
	kWh/kW per year	kJ/kWh		
Agriculture	4,716	4,218	85.0%	1.5
Utilities	4,903	6,307	57.1%	2.0
Food and Beverage	6,055	4,664	77.2%	3.4
Forest Products	5,494	4,897	73.5%	10.2
Manufacturing	7,834	n/a	n/a	n/a
Universities	3,742	4,488	81.0%	6.7
Military & Corrections	6,543	4,104	87.7%	3.1
Average for Canada	5,351	4,764	75.6%	6.4

Source: Canadian Cogeneration Database, CIEEDAC

The average heat rate of systems operating in Canada is 4,764 kJ/kWh (4,518 BTU/kWh). This translates to an average system efficiency of 75.6%. The highest efficiencies occur in the military & corrections and the agriculture sectors. The lowest efficiency is in the utility sector.

The average heat to power ratio of systems operating in Canada is 6.4. This means that for every kWh of electricity produced by cogeneration systems, 6.4 kWhs of useful thermal energy are produced. Table 6 shows that the forest products sector has the highest average heat to power ratio of all sectors. This industry demands high quality thermal energy leaving less energy available to produce electricity. The agriculture and utility sectors have low heat to power ratios. Utilities have low heat to power ratios because their systems are designed to maximize electrical output.

Table 7 shows the average system efficiency for each type of cogeneration system. It shows that gas turbine cogeneration systems have the highest average efficiency (77%)

⁹ 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.

while diesel systems have the lowest (42%). The second lowest is combine-cycle gas turbine cogeneration system. However, for all system types the range of efficiencies is very large and the sample size is small.

Table 7: Canadian Cogeneration System Performance

System Type	Average Efficiency	Range	No. of Units
Gas Turbine	77%	53% to 95%	17
Steam Turbines			
BPST	74%	53% to 91%	14
BPEST	72%	58% to 88%	9
ECST	70%	46% to 93%	7
CCGT	66%	53% to 83%	7
Spark Ignition	75%	60% to 87%	10
Diesel	42%	37% to 48%	8
Microturbines	72%	67% to 74%	7
Total			79

5.3 Cogeneration Installations by Date

Table 8 shows the amount of cogeneration capacity by start year to illustrate the evolution of cogeneration in Canada.¹⁰ There are two periods of significant growth in cogeneration. The first is in the 1970s and the second began in 1990 and is ongoing. The first period coincides with a dramatic increase in energy prices in Canada. Cogeneration systems may have been installed as a response to these prices and to a perceived scarcity of energy resources.

The current period of growth is likely a response to three stimuli. First, electric utilities across Canada responded to public protest over large-scale energy projects by offering to purchase power from independent power projects (IPPs). This created a market opportunity for industry to install cogeneration systems and sell excess power to the electricity grid. Second, smaller cogeneration systems are becoming increasingly cost effective expanding market opportunities beyond large-scale installations. And third, full retail access to the electricity grid in Alberta and Ontario has stimulated the development of large, grid-connected cogeneration systems. Since 1995, private utilities have installed almost 2.5 GWs of cogeneration capacity.

¹⁰ Table 5 excludes approximately 720 MW_e of operating cogeneration capacity because data on the starting year of these projects are missing.

Table 8: Cogeneration plants by start year and system operator (kW_e)

Sector	Pre 1950	1950-59	1960-69	1970-79	1980-89	1990-94	1995-99	2000+	Total
Agriculture					500	1,600	1,000		3,100
Mining, Oil and Gas		13,900	4,000		20,000		45,000	35,000	117,900
Utilities						118,500	923,730	1,586,000	2,628,230
Food and Textiles Man.	2,000		4,000			14,200			20,200
Forest Products and Chemicals	33,000	94,000	43,000	319,500	139,500	232,300	113,600	230,900	1,205,800
Metal Manufacturing							7,760	815	8,575
Scientific Research							810		810
Universities					600	6,000	6,500		13,100
Hospitals			1,200		550	3,200			4,950
Military							3,400	4,070	7,470
Unclassified	10,000	86,150	56,500	335,800	153,881	435,120	455,060	567,540	2,100,051
Total	45,000	194,050	108,700	655,300	315,031	810,920	1,556,860	2,424,325	6,110,186

Source: Canadian Cogeneration Database, CIEEDAC

5.4 Data Tables

The database is published in two appendices of this report.

- Appendix B is a list of operating cogeneration systems and their characteristics by province or territory.
- Appendix C is a list of operating cogeneration systems and their characteristics by industry.

The following characteristics are provided for each site (if available):¹¹

System Operator: The company that is responsible for operation of the cogeneration system.

Type of Business: A description of the type of business activity conducted by the company operating the system.

NAICS: The North American Industrial Classification System (NAICS) code for the system operator.

City: The city nearest to the site.

Province: The province in which the system is located.

Start Year: The in-service date of the cogeneration unit.

System Owner: The company that owns the cogeneration system, if different from the system operator.

¹¹ Only data that have been authorized for publication by the system operator are listed.

Primary Thermal Host: The facility that consumes most of the thermal energy produced by the cogeneration system.

Thermal Capacity: The thermal capacity of the system in kW.

Electric 1: The primary consumer of the electricity produced by the system.

Total Elec Capacity (kW): The electrical capacity of the cogeneration system in kW.

Annual Elec Gen (MWh): The average amount of electricity generated annually in MWh.

All Elec Sold to Grid?: Yes/No

Some Elec Sold to Grid: Yes/No

Cogen1 and Cogen2: Type of generation equipment. Selected from the following:

- ST - Steam turbine.
- GT - Gas turbine.
- BPST – Back-pressure steam turbine.
- BPEST – Back-pressure extraction steam turbine.
- ECST – Extraction steam turbine
- CST – Condensing steam turbine.
- D – Diesel engine.
- SI – Spark ignition engine.
- FC – Fuel cell.

Total No. of Units: Number of individual generating units (steam turbine, gas turbine, etc.) within the facility.

Heat Rate (KJ/kWh): The KJs of fuel consumed divided by the sum of the kWhs of power generated and the kWhs of thermal energy used.

System Efficiency: The thermal performance of the system.

Heat to Power Ratio: The ratio of the thermal output to the power output.

Fuel1: The primary fuel consumed by the system.

Fuel2: The secondary fuel consumed.

Fuel3: The tertiary fuel consumed.

6. Conclusions

This is CIEEDAC's sixth annual review of cogeneration in Canada. The database contains information on 6.82 GW_e of cogeneration capacity in Canada.

Currently, Alberta has the largest cogeneration capacity of 2.4 GW_e, ahead of Ontario at 2.0 GW_e of operating cogeneration capacity. Together, the two provinces account for 65% of total capacity in Canada. When classed by system operator, the electric power generation industry has the most cogeneration, 3.4 GW_e or almost 51% of total operational capacity. The forest products sector has the next highest cogeneration capacity of 1.6 GW_e, which represents 23% of operating capacity.

When allocated by thermal host sector, the results are very different. The pulp and paper sector acts as thermal host to 2.2 GWe of cogeneration capacity (33%), the chemical sector hosts 1.7 GWe of capacity (25%) and the oil and gas sector hosts 1.6 GWe or 24% of the total.

The performance of cogeneration systems in Canada varies widely from a low of 37% to a high of 95%. On average, gas turbine systems are the most efficient (77%) and diesel systems are the least efficient (42%). The independent power sector is on average the least efficient of the sectors for which we have data and the defense sector is the most efficient.

Canadian cogeneration capacity is concentrated in regions with high electricity prices, access to the electricity grid and robust industries with high simultaneous demand for electricity and thermal energy. In particular, retail access in Alberta and Ontario has stimulated the development of over 1.5 GWe of large-scale, utility-owned cogeneration since 2000.

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.

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Appendix A

Canadian Cogeneration Database

Update Survey Questionnaire



Canadian Industrial Energy End-use Data and Analysis Centre
School of Resource and Environmental Management
Simon Fraser University
Burnaby, BC V5A 1S6
P (604) 291-3068 F (604) 291-4968
E-mail: cieedac@sfu.ca Internet: www.cieedac.sfu.ca

Canadian Cogeneration Database Update 2004

Conducted for Natural Resources Canada (NRCan)

by the
Canadian Industrial Energy End Use Data and Analysis Centre
(CIEEDAC).

Survey of Canadian Cogeneration Facilities



Part I: Introduction

The purpose of this survey is to update data contained in the Canadian Cogeneration Database. The Canadian Cogeneration Database was developed by CIEEDAC to be a single source of data on all cogeneration projects operating in Canada. Cogeneration is the simultaneous production of electricity and thermal energy from a single fuel. Cogeneration is an important component of Canada's strategy to improve energy efficiency, increase industrial competitiveness and reduce greenhouse gas emissions. This database is used by government agencies, industry and non-governmental organizations to support the growth of cogeneration in Canada.

The **cogeneration plant manager** or the company **energy manager** should complete this survey. The results of the survey will be incorporated into the Canadian Cogeneration Database. Your participation in this survey will ensure that the Canadian Cogeneration Database has accurate and complete data on your facility. Accurate data will assist policymakers to better understand the scope and opportunity for cogeneration in Canada and to develop effective policies and programs to support increased cogeneration capacity.

CIEEDAC will produce a report summarizing the results of this year's survey. Each participant will receive a copy of the report in late spring.

Thank you for your participation.

Part II: Instructions

This survey consists of 4 sections:

- Section I: Operator / Owner Information
- Section II: System Users
- Section III: Capacity and Equipment
- Section IV: Plant Operation

Please answer all the questions, even if you have to enter "DON'T KNOW". Most questions can be answered by ticking one box, all relevant boxes, or by providing short answers. Please print your responses in the spaces provided, but if your answer cannot be accommodated, please answer the question on the back of the sheet. If you have difficulties answering a question please contact Catherine Strickland at (604) 980-1239 or email cstrickland@shaw.ca.

When you have completed the form, please return it by fax to (604) 980-1283, email or by mail to:

Catherine Strickland
1395 Paisley Road
North Vancouver, BC
V7R 1C2



Part III: Survey

Section I: System Operator / Owner Information

Please provide the contact information for the cogeneration facility. If the system owner is a different company, please note below.

Company Information

Type of Business _____

North American Industry Classification System (NAICS) code (if known): _____

Contact Information for the Cogeneration Facility

Company Name _____

Contact Name _____

Title _____

Mailing Address: Street/Box: _____

City: _____

Province: _____

Postal code: _____

Phone: () _____

Fax: _____

E-mail: _____

Contact Information for the Cogeneration System Owner (if different from above)

Company Name: _____

Contact Name: _____

Phone: () _____



Section II: Energy Users

Electricity

1) List the company name and type of business for each electricity user. Please list in order of size (i.e. biggest to smallest user), if known.

- Don't know, all cogenerated electricity is sold to the grid.
- Cogenerated electricity is consumed by (Please include your company if applicable):

<u>Company Name</u>	<u>Type of Business</u>
i	
ii	
iii	

- Some cogenerated electricity is sold to the grid.

2) If electricity is sold to the grid, is it sold wholesale or retail? _____
(Wholesale means that it is sold to a power pool or an electric utility, retail means it is sold to the user directly).

3) Does the prime electricity user require additional electricity from the grid? _____

4) Can the facility be isolated from the grid in the case of a general outage? _____

Thermal Energy

5) What is the thermal product of the cogeneration system?

- High pressure steam (greater than 30 psi)
- Low pressure steam (less than 30 psi)
- High temperature water (greater than 80°C)
- Low temperature water (less than 80°C)

6) List the company name and type of business for each user of steam or hot water produced by the cogeneration system. If known, please list in order of size of thermal load.

- i. _____
- ii. _____
- iii. _____



7) What is the thermal energy used for (if known)?

- Process Heat
- Process Steam
- Space Heat
- Preheat
- Refrigeration/Cooling
- Other (please specify) _____

Greenhouse Gas Emissions

8) Which company is allocated the greenhouse gas emissions from the facility? If more than one, please identify each company and the proportion of emissions it is responsible for.

<u>Company Name</u>	<u>Percentage</u>
_____	_____
_____	_____
_____	_____

Section III: Capacity and Equipment

- 1) What is the electrical capacity of the cogeneration system? _____ MW
- 2) What is the average annual electricity production? _____ MWh/yr
- 3) What is the average annual amount of thermal energy produced by the cogeneration system? (i.e., lbs of steam/yr, MMBTUs/yr, GJ/yr) _____

4) What type of generator(s) are in operation? Please specify the type (see below), capacity, year installed and number of each for a given capacity. If you have two generators of the same type but different capacities, please list them separately.

<u>Type of generator</u>	<u>Capacity</u>	<u>Year Installed</u>	<u>No. of this size</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Please use the following codes:
 Back-pressure Steam Turbine (BPST), Back-pressure Extraction Steam Turbine (BPEST),
 Extraction Condensing Steam Turbine (ECST), Gas Turbine (GT), Diesel Engine (D), Spark-
 ignition Engine (SI), Fuel Cells (FC)



5) Is this a combined cycle plant? _____

6) What additional components does the system have? (Check all that apply)

- Regenerative Feedwater Heating
- Duct Burners
- Steam Injection

7) List the fuels consumed by the cogeneration system, with the approximate annual percentage (e.g., natural gas, 30%; hog fuel, 30%; black liquor, 40%) and the annual amounts (include units, i.e. tonnes, MMBtu, m³ or GJ).

<u>Fuel Type</u>	<u>Percentage</u>	<u>Annual Amount</u>
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Appendix B

Operating Cogeneration Facilities In Canada

By Sector

Cogeneration Facilities by Sector 2003

NAICS 0

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	2002	NRCan	Research	Health Canada	58	MT	NG

NAICS 1114

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1989	WestbrookFloral	Flower Grower	Westbrook Greenhouses Ltd.	500	IC	NG
ON	1992	Rosa Flora Ltd	Greenhouse	Rosa Flora Ltd.	1600	SI	NG
ON	1995	Westbrook Greenhouses Ltd.	Flower Grower	Westbrook Greenhouses Ltd.	1000	IC	NG

NAICS 2111

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
AB	1961	Keyspan Energy Canada Inc	Gas Plant	Rimby Gas Plant	4000	ST	
AB	1975	Syncrude	Mining Heavy Oil Upgradi	Syncrude	45000	GT	

NAICS 2123

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
AB	1958/ 1964	Canadian Salt Co. Ltd.	Mining	Canadian Salt Co. Ltd.	13900	BPST	
NS	1980	Canadian Salt Co. Ltd.	Salt Mining and Processing	Canadian Salt Co.	35	BPST	Bunker C
NS	1987	Canadian Salt Co. Ltd.	Salt Mining and Processing	Canadian Salt Co.	52	BPST	Bunker C
NS	1998	Canadian Salt Co. Ltd.	Salt Mining and Processing	Canadian Salt Co.	244	BPST	Bunker C
SK	1981	IMC Canada Ltd.	Potash Mine	IMC Potash Belle Plaine	20000	BPST	NG
SK	2001	IMC Canada Ltd.	Potash Mine	IMC Potash Belle Plaine	35000	BPST	NG

NAICS 2211

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
AB	1998	ATCO/Canadian Natural Resour	Non-Utility Generator	CNRL	85000	GT	NG
AB	1999	Husky Oil	Non-Utility Generator	Husky Oil	45000	GT	NG
AB	1999	Fort Saskatchewan Cogeneration	Non-Utility Generator	Dow Chemical Canada Inc.	124000	GT	NG
AB	2000	Joffre Cogeneration	Non-Utility Generator	NOVA Chemicals	480000	GT	NG
AB	2001	Transalta Energy Corpoation	Non-Utility Generator	Suncor Energy	365000	GT	NG
AB	2001	TransCanada Energy	IPP	Agrium	80000	GT	NG
AB	2001	Mariah Energy Corp	IPP	Walker Court Condominiums	30	MT	NG
AB	2001	ATCO Power	Non-Utility Generator	Husky Oil	45000	GT	NG
AB	2001	TransCanada Energy Ltd.	IPP	Williams Energy Redwater Fraction	40000	GT	NG
AB	2001	TransCanada Energy	IPP	Cancarb Thermal Carbon Black pla	40000	ECST	NG
AB	2002	Muskeg River Cogeneration	Non-Utility Generator	Muskeg River Mine/ Athabasca Oil	170000	GT	NG
AB	2003	Mariah Energy Corp	IPP	Suntec Greenhouses	90	MT	NG
AB	2003	TransCanada Energy	IPP	Petro-Canada Oil Sands	165000	GT	NG
BC	1968	BC Hydro	Electric Utility	Imperial Oil	157500	CST	NG
BC	1993	Duke Energy/ATCO	Gas Processing	Duke Energy	120000	GT	NG
BC	1999	Calpine Island Cogeneration LP	Independent Power Produce	Norske Skogindustrier, Elk Falls	290000	GT	NG
BC	2000	BC Hydro	Utility	Fort Nelson Gas Processing plant	47000	GT	
NB	1964	NB Power	Electric Utility	Irving Pulp and Paper	13000	BPST	#6 Oil
NS	1995	Brooklyn Power Corporation	Non-utility generator	Bowater Mersey Paper Co.	30000	ECST	Hog
NW	2002	Northwest Territories Power Cor	IPP	Midnight Sun Recreation Centre	60	MT	NG
ON		Sudbury District Energy	IPP		5000	GT	NG
ON		Imperial Oil	Gas refinery	Imperial Oil, Nanticoke Refinery	20000	ST	

ON	1990	Abitibi Consolidated Canada	IPP	Abitibi Consolidated (Fort Frances)	112000	GT	NG
ON	1995	West Windsor Power	Non-Utility Generator	Canadian Salt Co.	118000	GT	NG
ON	1995	AES Kingston Inc.	Non-Utility Generator	Kosa Canada	110000	GT	NG
ON	1996	Iroquois Falls Power Corp. / Nort	Independent Power Produce	Abitibi Consolidated Inc. (Iroquois)	110000	GT	NG
ON	1996	Transalta Energy/Windsor Essex	Non-Utility Generator	DailmerChrysler Canada	68000	GT	NG
ON	1998	Whitby Cogeneration Limited Pa	Non-utility generator	Atlantic Packaging Products Ltd.	58000	GT	NG
PE	1986	Northeast Energy	Utility		850	IC	
PQ	1992	Boralex Inc.	Thermal Utility	Cascades Inc. (Papier Kingsey Falls)	31000	GT	NG
PQ	2003	CHI Canada Inc.	IPP	Alliance Forest Products	23000	BPST	Hog
SK	1999	Meridian Cogeneration Project	Non-Utility Generator	Husky Oil Lloydminster	220000	GT	NG
SK	2002	ATCO Power/Sask Power Int'l	Non-Utility Generator	Cory Potash Mine	260000	GT	NG

NAICS 2212

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1990	Union Gas	Gas Utility	Union Gas Halton Division Office	60	IC	
ON	1994	Union Gas	Natural Gas Distributor	Union Gas Head Office	6000	GT	

NAICS 2213

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
BC	1998	Greater Vanc. Regional District	Water Treatment Plant	Iona Island WWT plant	3750	SI	Digester g
NU	1979	Nunavut Power Corp	District Energy	District Energy	600	D	Diesel
NU	1981	Nunavut Power Corp	District Energy	District Energy	540	D	Diesel
NU	1989	Nunavut Power Corp	District Energy	District Energy	720	D	Diesel
NU	1993	Nunavut Power Corp	District Energy	District Energy	720	D	Diesel
NU	1994	Nunavut Power Corp	District Energy	District Energy	960	D	Diesel

NU	1994	Nunavut Power Corp	District Energy	District Energy	300	D	Diesel
NU	1995	Nunavut Power Corp	District Energy	District Energy	480	D	Diesel
NU	1995	Nunavut Power Corp	District Energy	District Energy	800	D	Diesel
NU	1995	Nunavut Power Corp	District Energy	District Energy	1680	D	Diesel
NU	1996	Nunavut Power Corp	District Energy	District Energy	600	D	Diesel
NU	2001	Nunavut Power Corp	District Energy	District Energy	900	D	Diesel
NW		DND Alert, NWT	District heating	DND Alert, NWT	6600	IC	
NW		Eureka	District heating	Eureka	500	IC	
NW	1997	Fort McPherson	District Energy	Fort McPherson District Energy		IC	
ON	1993	City of Barrie	Wastewater Treatment	Barrie Waste Water Treatment Plant	500	SI	Digester
ON	1995	CDH District Heating Ltd.	District Heating	Institutional and Commercial	5000	SI	NG
ON	1995	City of Guelph	Wastewater Treatment	Wastewater Treatment plant	580	SI	Digester
ON	1996	Core Energy	Municipality	Trigen	3500	GT,ST	
ON	2001	Markham District Energy	Commercial/residential	IBM Canada	3500	SI	NG
ON	2001	Sudbury District Energy	IPP	Sudbury Regional Hospital	6700	SI	NG
ON	2003	Hamilton Community Energy	District Energy	City of Hamilton	3500	SI	NG
PE	1997	PEI Energy Systems	District Energy	District Energy (80+ Customers)	1200	BPST	Wood
SK	2002	Regina General Hospital	Hospital	Regina General Hospital	120	MT	ng

NAICS 3111

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1994	Casco Inc.	Feed Industry	Casco Inc.	10000	GT	NG

NAICS 3112

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1995	Casco Inc.	Corn-based Sweeteners	Casco Inc.	15000	GT	NG

NAICS 3113

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
AB	1949	Rogers Sugar Ltd.	Sugar Beet Processing Plant	Rogers Sugar Ltd.	2000	BPST	NG
AB	1967	Rogers Sugar Ltd.	Sugar Beet Processing Plant	Rogers Sugar Ltd.	4000	BPST	NG
BC	1973	Rogers Sugar	Food Manufacturer	Rogers Sugar	3000	BPST	NG
ON	1996	Redpath Sugar Ltd.	Sugar Refining, Packaging	Redpath Sugar Ltd.	5600	BPST	NG

NAICS 3116

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1999	Maple Lodge Farms	Food Processing	Maple Lodge Farms	4750	GT	NG

NAICS 3119

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1990	H.J. Heinz Company Of Canada	Food Manufacturing	H.J. Heinz Company Of Canada Ltd	8600	GT	NG
ON	1994	Cardinal Power Of Canada Inc. C	Food Industry	Casco Inc./ Benson Public School	156000	CCGT	
ON	2001	Jungbunzlauer	Food Manufacturer	Jungbunzlauer	10000	GT	NG

NAICS 3121

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
AB	1996	Black Velvet Distillers	Distillery Process	Palliser Distillers	450	IC	
ON	1955	Hiram Walker And Sons	Distiller	Hiram Walker And Sons	2500	BPEST	NG
ON	1969	Hiram Walker And Sons	Distiller	Hiram Walker And Sons	5000	BPST	NG

ON	1985	Hiram Walker And Sons	Distiller	Hiram Walker And Sons	350	D	Deisel
ON	1993	Labatt Brewing Co. Ltd.	Brewery	Labatts	5000	GT	NG

NAICS 3151

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1994	Phantom Industries	Hoisery and Swimwear	Phantom Industries	600	SI	NG

NAICS 3211

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
BC	1985	Riverside Forest Products	Wood Products	Riverside Forest Products	5000	CST	Hog
BC	2000	Riverside Forest Products	Wood Products	Riverside Forest Products	7000	CST	Hog

NAICS 3212

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
BC	1936	Louisiana Pacific	Wood Products	Louisiana Pacific	7500	ECST	Hog

NAICS 3221

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
AB	1957	Weldwood Of Canada Ltd.	Pulp and Paper	Weldwood Of Canada Ltd. (Hinton	23000	ECST	SPL
AB	1973	Weyerhauser Canada Ltd.	Pulp and Paper	Weyerhauser Canada Ltd. (Alberta	34500	ST	
AB	1989	Weldwood Of Canada Ltd.	Pulp and Paper	Weldwood Of Canada Ltd. (Hinton	28000	BPST	SPL
AB	1989	Daishowa - Marubeni Internation	Pulp and Paper	Daishowa- Marubeni International	40000	BPEST	SPL
AB	1992	Alberta Pacific Forest Industries	Pulp and Paper	Alberta Pacific Forest Industries	92000	ST	SPL
BC		NorskeCanada	Pulp and Paper	Powell River Division	40000	BPEST	Hog
BC	1945	Western Pulp Ltd.	Pulp and Paper	Squamish Pulp Operations	8000	ST	
BC	1949	Western Pulp Ltd.	Pulp and Paper	Port Alice Operations	3500	BPST	SPL
BC	1950	Skeena Cellulose Inc.	Pulp Mill	Skeena Cellulose Inc.	10000	BPEST	SPL

BC	1956	Western Pulp Ltd.	Pulp and Paper	Port Alice Operations	7500	ECST	SPL
BC	1963	Pope and Talbot Inc.	Pulp and Paper	Pope and Talbot Harmac Pulp	30000	BPST	SPL
BC	1964	Norske Canada	Pulp and Paper	Port Alberni P&P Division	26000	BPEST	Hog
BC	1968	Skeena Cellulose Inc.	Pulp Mill	Skeena Cellulose Inc.	32000	BPEST	SPL
BC	1968	Tembec Industries Inc.	Pulp and Paper	Crestbrook Forest Ind.	17500	ST	
BC	1972	Weyerhaeuser Canada Ltd.	Pulp and Paper	Weyerhaeuser Canada Ltd.	46000	BPST	SPL
BC	1972	Cariboo Pulp and Paper	Pulp and Paper	Cariboo Pulp & Paper	32000	BPEST	SPL
BC	1973	Canadian Forest Products	Pulp and Paper	CANFOR-Northwood	27400	BPEST	SPL
BC	1977	Western Pulp Ltd.	Pulp and Paper	Port Alice Operations	16500	BPST	SPL
BC	1979	Pope and Talbot Ltd.	Pulp and Paper	Mackenzie Pulp Operation	20000	BPEST	SPL
BC	1981	Norske Skogindustrier	Pulp and Paper	Crofton Pulp & Paper	38000	ST	
BC	1981	Canadian Forest Products	Pulp and Paper	CANFOR-Northwood	28000	BPEST	SPL
BC	1989	Howe Sound Pulp And Paper	Pulp and Paper	Howe Sound Pulp And Paper	62500	BPEST	SPL
BC	1992	Howe Sound Pulp And Paper	Pulp and Paper	Howe Sound Pulp And Paper	50000	ECST	SPL
BC	1993	Celgar Pulp Co.	Pulp and Paper	Celgar Pulp Co.	52000	BPEST	SPL
BC	1996	Abitibi Consolidated	Pulp and Paper	Mackenzie Paper Division	13900	BPEST	HOG
BC	2001	Tembec Industries	Pulp and paper	Tembec Industries	43500	ECST	SPL
BC	2003	Weyerhaeuser Canada Ltd.	Pulp and Paper	Weyerhaeuser Canada Ltd.	29000	CST	SPL
MB	2002	Tolko Manitoba Inc.	Pulp and Paper	Tolko Manitoba Inc. - Formerly Re	22000	BPEST	SPL
NB	1956	Irving Pulp And Paper Ltd.	Pulp and Paper	Irving Pulp And Paper Inc.	32500	BPEST	SPL
NB	1965	UPM-Kymmene Mirsmichi Inc.	Pulp and Paper	UPM-Kymmene Miramichi Inc.	17000	BPEST	SPL
NB	1972	Ste. Anne-Nackawic Pulp Co. Lt	Pulp and Paper	Ste. Anne-Nackawic Pulp Co. Ltd.	25000	BPEST	SPL
NB	1983	AVCell	Pulp and Paper	Av Cell	21000	BPEST	Red Liqu
NB	1989	UPM-Kymmene Mirsmichi Inc.	Pulp and Paper	UPM-Kymmene Miramichi Inc.	23000	BPST	SPL

NB	1996	Fraser Papers Inc.	Pulp and Paper	Nexfor/Fraser Papers	46000	BPEST	Hog
NF	2003	Cornerbrook Pulp and Paper	Pulp and Paper	Corner Brook Pulp and Paper Ltd	17500	BPEST	Hog
NS		Minas Basin Pulp And Paper Ltd	Pulp and Paper	Minas Basin Pulp And Paper Ltd.	6400	ST	
NS		Stora Forest Industries Ltd.	Pulp and Paper	Stora Forest Industries Ltd.	29500	ST	
NS	1967	Kimberly Clark Nova Scotia Inc.	Pulp and Paper	Kimberly Clark Nova Scotia Inc. (F	25700	ECST	SPL
ON		Bowater	Pulp and Paper	Bowater	76570	ST	
ON		Bowater Thunder Bay	Paper Mill	Bowater Thunder Bay	67000	ST	
ON		Kimberly-Clark Inc.	Pulp and Paper	Kimberly-Clark Inc. Terrace Bay	20000	ST	
ON	1944	Marathon Pulp Inc.	Pulp and Paper	Marathon Pulp Inc.	9500	BPEST	SPL
ON	1946	Marathon Pulp Inc.	Pulp and Paper	Marathon Pulp Inc.	4500	BPEST	SPL
ON	1958	Tembec Industries Inc.	Pulp and Paper	Spruce Falls Inc. (Kapusksasing Mill	21600	ST	
ON	1975	Tembec Industries Inc.	Pulp and Paper	Tembec Industries Inc.	12500	BPEST	Hog Fuel
ON	1985	Tembec Industries Inc.	Pulp and Paper	Tembec Industries Inc.	12500	ECST	Hog Fuel
ON	1989	Domtar Inc.	Pulp and Paper	Domtar	24000	ST	
ON	1993	Sonoco Ltd.	Paper Products	Sonoco Ltd. (Branford Mill)	4000	GT	
ON	2000	Sonoco	Paper Products	Sonoco Paper Mill	7800	GT	NG
PQ		La Compagnie Gaspesia Ltee	Pulp and Paper	La Compagnie Gaspesia Ltee	6000	ST	
PQ	1993	Tembec Industries Inc.	Pulp and Paper	Tembec Inc. (Specialty Cellulose Di	9500	ST	
PQ	1996	Donohue Inc.	Pulp and Paper	Abitibi Consolidated Inc. (St. Felici	28600	ST	
PQ	1997	Bowater Forest Products	Pulp and Paper	Bowater Forest Products	28000	ECST	Hog
PQ	1998	Domtar Inc.	Pulp and Paper	Domtar (Norkraft Quevillon Inc.)	48500	BPST	SPL
PQ	2001	Domtar Inc.	Pulp and Paper	Domtar Inc	32000	BPEST	SPL
SK	1968	Weyerhaeuser Canada	Forest Products	Weyerhaeuser Canada Ltd.	21000	ST	

NAICS 3241

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
AB	2002	Imperial Oil Resources Ltd	Heavy Oil Production	Imperial Oil	165100	GT	NG

NAICS 3251

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
AB	1954	Celanese Canada	Chemical	Celanese Canada	21000	ECST	NG
AB	1979	Dow Chemical Canada Inc.	Chemical	Dow Chemical Canada Inc.	180000	CCGT	NG
ON		General Chemical	Chemical Processing	General Chemical	10950	ST	
ON		Terra International	Chemicals	Terra International	15500	GT	
ON	1972	TransAlta	Chemical Processing	Dow Chemical	161000	CCGT	
ON	1983	TransAlta	Chemical processing	Bayer Rubber	51031	ST	
ON	1997	Commercial Alcohols Inc.	Ethanol Production	Commercial Alcohols Inc.	5000	GT	NG
ON	2003	TransAlta- Sarnia Cogen	Chemical Processing	Bayer, Dow and NOVA Chemicals	440000	GT	

NAICS 3252

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
AB	2000	Air Liquide	Chemical Processing	Shell Chemical	84000	GT	
ON	1992	Dupont	Chemical plant	Dupont	38300	GT	NG

NAICS 3254

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1994	Aventis Pasteur Ltd.	Pharmaceutical Manufactur	Aventis Pasteur Ltd.	3000	GT	

NAICS 3312

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1930	Stelco	Steel Manufacturer	Stelco	10000	ST	

NAICS 3328

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1997	Kuntz Electroplating	Metals	Kuntz Electroplating	2445	SI	NG
ON	1999	Kuntz Electroplating	Metals	Kuntz Electroplating	815	SI	NG
ON	2000	Kuntz Electroplating	Metals	Kuntz Electroplating	815	SI	NG

NAICS 3332

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
PQ	2000	Pratt & Whitney		Pratt & Whitney	1840	GT	

NAICS 3361

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1995	Ford Motor Company Of Canada	Automobile Manufacturer	Ford Motor Company	28000	ECST	NG

NAICS 3399

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1995	Kodak Canada Inc.	Photo Equipment Manufact	Kodak Canada Inc.	4500	GT	NG

NAICS 5417

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1994	NRCC	Government Agency	NRCC	4000	GT	
ON	1996	Canada Centre for Inland Waterw	Research facility	Canada Centre for Inland Waterway	810	IC	NG

NAICS 5622

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON	1997	Ottawa-Carlton Regional Municipality	Waste Water Treatment	Robert Pickard Environment Centre	2400	SI	Digester

NAICS 6112

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
ON		Mohawk College	College	Mohawk College	810	IC	
SK	1993	Saskenergy	Educational Institution	Saskatchewan Hospital	800	IC	

NAICS 6113

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
AB		University of Alberta	University	University of Alberta	13300	GT	
ON		Brock University	University	Brock University	6560	IC	
ON	1986	University of Ottawa	University	University of Ottawa	600	SI	NG
ON	1992	University of Toronto	University	University of Toronto	6000	GT	NG
ON	1993	University of Windsor	University	University of Windsor	3800	GT	NG
ON	1994	Centra Gas	University	Orillia Soldiers	13300	ST	
ON	1995	University of Ottawa	University	University of Ottawa	1500	BPST	NG
ON	1997	York University	University	York University	5000	GT	NG

NAICS 6115

Province	Start Year	Operator	Type of Business	Primary Thermal Host	Elec Cap. (kw)	Cogen type	Fuel
AB	1998	Southern Alberta Institute of Technology	Educational Institute	SAIT	3000	BPST	NG
AB	2003	SAIT	College	SAIT	60	MT	NG

Appendix C

Operating Cogeneration Facilities in Canada

By Province or Territory

Cogeneration by Province 2003

Province

AB

NAICS	Start Year	Operator	Type of Business	Primary Thermal Ho	Capacity (kw)	Cogen type	Fuel
2111	1961	Keyspan Energy Canada Inc	Gas Plant	Rimby Gas Plant	4,000	ST	
2111	1975	Syncrude	Mining Heavy Oil Upgrading	Syncrude	45,000	GT	
2123	1958/ 1964	Canadian Salt Co. Ltd.	Mining	Canadian Salt Co. Ltd.	13,900	BPEST	
2211	1998	ATCO/Canadian Natural Re	Non-Utility Generator	CNRL	85,000	GT	NG
2211	1999	Husky Oil	Non-Utility Generator	Husky Oil	45,000	GT	NG
2211	1999	Fort Saskatchewan Cogenera	Non-Utility Generator	Dow Chemical Canada Inc.	124,000	GT	NG
2211	2000	Joffre Cogeneration	Non-Utility Generator	NOVA Chemicals	480,000	GT	NG
2211	2001	TransCanada Energy	IPP	Cancarb Thermal Carbon Black plant	40,000	ECST	NG
2211	2001	TransCanada Energy Ltd.	IPP	Williams Energy Redwater Fractionatio	40,000	GT	NG
2211	2001	TransCanada Energy	IPP	Agrium	80,000	GT	NG
2211	2001	Mariah Energy Corp	IPP	Walker Court Condominiums	30	MT	NG
2211	2001	Transalta Energy Corpoation	Non-Utility Generator	Suncor Energy	365,000	GT	NG
2211	2001	ATCO Power	Non-Utility Generator	Husky Oil	45,000	GT	NG
2211	2002	Muskeg River Cogeneration	Non-Utility Generator	Muskeg River Mine/ Athabasca Oil San	170,000	GT	NG
2211	2003	Mariah Energy Corp	IPP	Suntec Greenhouses	90	MT	NG
2211	2003	TransCanada Energy	IPP	Petro-Canada Oil Sands	165,000	GT	NG
3113	1949	Rogers Sugar Ltd.	Sugar Beet Processing Plant	Rogers Sugar Ltd.	2,000	BPST	NG

3113	1967	Rogers Sugar Ltd.	Sugar Beet Processing Plant	Rogers Sugar Ltd.	4,000	BPST	NG
3121	1996	Black Velvet Distillers	Distillery Process	Palliser Distillers	450	IC	
3221	1957	Weldwood Of Canada Ltd.	Pulp and Paper	Weldwood Of Canada Ltd. (Hinton Div	23,000	ECST	SPL
3221	1973	Weyerhaeuser Canada Ltd.	Pulp and Paper	Weyerhaeuser Canada Ltd. (Alberta Divi	34,500	ST	
3221	1989	Weldwood Of Canada Ltd.	Pulp and Paper	Weldwood Of Canada Ltd. (Hinton Div	28,000	BPST	SPL
3221	1989	Daishowa - Marubeni Intern	Pulp and Paper	Daishowa- Marubeni International Ltd.	40,000	BPEST	SPL
3221	1992	Alberta Pacific Forest Indust	Pulp and Paper	Alberta Pacific Forest Industries	92,000	ST	SPL
3241	2002	Imperial Oil Resources Ltd	Heavy Oil Production	Imperial Oil	165,100	GT	NG
3251	1954	Celanese Canada	Chemical	Celanese Canada	21,000	ECST	NG
3251	1979	Dow Chemical Canada Inc.	Chemical	Dow Chemical Canada Inc.	180,000	CCGT	NG
3252	2000	Air Liquide	Chemical Processing	Shell Chemical	84,000	GT	
6113		University of Alberta	University	University of Alberta	13,300	GT	
6115	1998	Southern Alberta Institute of	Educational Institute	SAIT	3,000	BPST	NG
6115	2003	SAIT	College	SAIT	60	MT	NG
6221	1960	Alberta Hospital Ponoka	Hospital	Alberta Hospital Ponoka Site	1,200	BPST	NG
6221	1964	Calgary Health Region	Hospital	Foothills Hospital	18,000	ST	
6221	1969	Alberta Hospital	Hospital	Alberta Hospital, Edmonton	3,000	ST	
6221	1980	Alberta Hospital Ponoka	Hospital	Alberta Hospital Ponoka Site	550	BPST	NG
6221	1992	Chinook Health Region	Hospital	Lethbridge Regional Hospital	2,750	SI	NG
6221	1994	Chinook Health Region	Hospital	Lethbridge Regional Hospital	450	SI	NG
6221	1996	David Thompson Health Re	Hospital	Red Deer Hospital	2	SI	NG
7139	2003	Medicine Hat Family Leisur	Recreation Facility	Medicine Hat Family Leisure Centre	120	MT	NG

Summary for 'Province' = AB (39 detail records)

Electrical Capacity for Province

2,418,502

Province BC

NAICS	Start Year	Operator	Type of Business	Primary Thermal Ho	Capacity (kw)	Cogen type	Fuel
2211	1968	BC Hydro	Electric Utility	Imperial Oil	157,500	CST	NG
2211	1993	Duke Energy/ATCO	Gas Processing	Duke Energy	120,000	GT	NG
2211	1999	Calpine Island Cogeneration	Independent Power Producer	Norske Skogindustrier, Elk Falls	290,000	GT	NG
2211	2000	BC Hydro	Utility	Fort Nelson Gas Processing plant	47,000	GT	
2213	1998	Greater Vanc. Regional Dist	Water Treatment Plant	Iona Island WWT plant	3,750	SI	Digester
3113	1973	Rogers Sugar	Food Manufacturer	Rogers Sugar	3,000	BPST	NG
3211	1985	Riverside Forest Products	Wood Products	Riverside Forest Products	5,000	CST	Hog
3211	2000	Riverside Forest Products	Wood Products	Riverside Forest Products	7,000	CST	Hog
3212	1936	Louisiana Pacific	Wood Products	Louisiana Pacific	7,500	ECST	Hog
3221		NorskeCanada	Pulp and Paper	Powell River Division	40,000	BPEST	Hog
3221	1945	Western Pulp Ltd.	Pulp and Paper	Squamish Pulp Operations	8,000	ST	
3221	1949	Western Pulp Ltd.	Pulp and Paper	Port Alice Operations	3,500	BPST	SPL
3221	1950	Skeena Cellulose Inc.	Pulp Mill	Skeena Cellulose Inc.	10,000	BPEST	SPL
3221	1956	Western Pulp Ltd.	Pulp and Paper	Port Alice Operations	7,500	ECST	SPL
3221	1963	Pope and Talbot Inc.	Pulp and Paper	Pope and Talbot Harmac Pulp	30,000	BPST	SPL
3221	1964	Norske Canada	Pulp and Paper	Port Alberni P&P Division	26,000	BPEST	Hog
3221	1968	Skeena Cellulose Inc.	Pulp Mill	Skeena Cellulose Inc.	32,000	BPEST	SPL
3221	1968	Tembec Industries Inc.	Pulp and Paper	Crestbrook Forest Ind.	17,500	ST	
3221	1972	Weyerhaeuser Canada Ltd.	Pulp and Paper	Weyerhaeuser Canada Ltd.	46,000	BPST	SPL

3221	1972	Cariboo Pulp and Paper	Pulp and Paper	Cariboo Pulp & Paper	32,000	BPEST	SPL
3221	1973	Canadian Forest Products	Pulp and Paper	CANFOR-Northwood	27,400	BPEST	SPL
3221	1977	Western Pulp Ltd.	Pulp and Paper	Port Alice Operations	16,500	BPST	SPL
3221	1979	Pope and Talbot Ltd.	Pulp and Paper	Mackenzie Pulp Operation	20,000	BPEST	SPL
3221	1981	Norske Skogindustrier	Pulp and Paper	Crofton Pulp & Paper	38,000	ST	
3221	1981	Canadian Forest Products	Pulp and Paper	CANFOR-Northwood	28,000	BPEST	SPL
3221	1989	Howe Sound Pulp And Pape	Pulp and Paper	Howe Sound Pulp And Paper	62,500	BPEST	SPL
3221	1992	Howe Sound Pulp And Pape	Pulp and Paper	Howe Sound Pulp And Paper	50,000	ECST	SPL
3221	1993	Celgar Pulp Co.	Pulp and Paper	Celgar Pulp Co.	52,000	BPEST	SPL
3221	1996	Abitibi Consolidated	Pulp and Paper	Mackenzie Paper Division	13,900	BPEST	HOG
3221	2001	Tembec Industries	Pulp and paper	Tembec Industries	43,500	ECST	SPL
3221	2003	Weyerhaeuser Canada Ltd.	Pulp and Paper	Weyerhaeuser Canada Ltd.	29,000	CST	SPL

Summary for 'Province' = BC (31 detail records)

Electrical Capacity for Province 1,274,050

Province MB

NAICS	Start Year	Operator	Type of Business	Primary Thermal Ho	Capacity (kw)	Cogen type	Fuel
3221	2002	Tolko Manitoba Inc.	Pulp and Paper	Tolko Manatoba Inc. - Formerly Repap	22,000	BPEST	SPL

Summary for 'Province' = MB (1 detail record)

Electrical Capacity for Province 22,000

Province NB

NAICS	Start Year	Operator	Type of Business	Primary Thermal Ho	Capacity (kw)	Cogen type	Fuel
2211	1964	NB Power	Electric Utility	Irving Pulp and Paper	13,000	BPST	#6 Oil
3221	1956	Irving Pulp And Paper Ltd.	Pulp and Paper	Irving Pulp And Paper Inc.	32,500	BPEST	SPL

3221	1965	UPM-Kymmene Mirsmichi I	Pulp and Paper	UPM-Kymmene Miramichi Inc.	17,000	BPEST	SPL
3221	1972	Ste. Anne-Nackawic Pulp C	Pulp and Paper	Ste. Anne-Nackawic Pulp Co. Ltd.	25,000	BPEST	SPL
3221	1983	AVCell	Pulp and Paper	Av Cell	21,000	BPEST	Red Liqu
3221	1989	UPM-Kymmene Mirsmichi I	Pulp and Paper	UPM-Kymmene Miramichi Inc.	23,000	BPST	SPL
3221	1996	Fraser Papers Inc.	Pulp and Paper	Nexfor/Fraser Papers	46,000	BPEST	Hog

Summary for 'Province' = NB (7 detail records)

Electrical Capacity for Province 177,500

Province NF

NAICS	Start Year	Operator	Type of Business	Primary Thermal Ho	Capacity (kw)	Cogen type	Fuel
3221	2003	Cornerbrook Pulp and Paper	Pulp and Paper	Corner Brook Pulp and Paper Ltd	17,500	BPEST	Hog

Summary for 'Province' = NF (1 detail record)

Electrical Capacity for Province 17,500

Province NS

NAICS	Start Year	Operator	Type of Business	Primary Thermal Ho	Capacity (kw)	Cogen type	Fuel
2123	1980	Canadian Salt Co. Ltd.	Salt Mining and Processing	Canadian Salt Co.	35	BPST	Bunker
2123	1987	Canadian Salt Co. Ltd.	Salt Mining and Processing	Canadian Salt Co.	52	BPST	Bunker
2123	1998	Canadian Salt Co. Ltd.	Salt Mining and Processing	Canadian Salt Co.	244	BPST	Bunker
2211	1995	Brooklyn Power Corporation	Non-utility generator	Bowater Mersey Paper Co.	30,000	ECST	Hog
3221		Minas Basin Pulp And Paper	Pulp and Paper	Minas Basin Pulp And Paper Ltd.	6,400	ST	
3221		Stora Forest Industries Ltd.	Pulp and Paper	Stora Forest Industries Ltd.	29,500	ST	
3221	1967	Kimberly Clark Nova Scotia	Pulp and Paper	Kimberly Clark Nova Scotia Inc. (Form	25,700	ECST	SPL

Summary for 'Province' = NS (7 detail records)

Electrical Capacity for Province 91,931

Province NU

NAICS	Start Year	Operator	Type of Business	Primary Thermal Ho	Capacity (kw)	Cogen type	Fuel
2213	1979	Nunavut Power Corp	District Energy	District Energy	600	D	Diesel
2213	1981	Nunavut Power Corp	District Energy	District Energy	540	D	Diesel
2213	1989	Nunavut Power Corp	District Energy	District Energy	720	D	Diesel
2213	1993	Nunavut Power Corp	District Energy	District Energy	720	D	Diesel
2213	1994	Nunavut Power Corp	District Energy	District Energy	960	D	Diesel
2213	1994	Nunavut Power Corp	District Energy	District Energy	300	D	Diesel
2213	1995	Nunavut Power Corp	District Energy	District Energy	800	D	Diesel
2213	1995	Nunavut Power Corp	District Energy	District Energy	1,680	D	Diesel
2213	1995	Nunavut Power Corp	District Energy	District Energy	480	D	Diesel
2213	1996	Nunavut Power Corp	District Energy	District Energy	600	D	Diesel
2213	2001	Nunavut Power Corp	District Energy	District Energy	900	D	Diesel

Summary for 'Province' = NU (11 detail records)

Electrical Capacity for Province 8,300

Province NW

NAICS	Start Year	Operator	Type of Business	Primary Thermal Ho	Capacity (kw)	Cogen type	Fuel
2211	2002	Northwest Territories Power	IPP	Midnight Sun Recreation Centre	60	MT	NG
2213		DND Alert, NWT	District heating	DND Alert, NWT	6,600	IC	
2213		Eureka	District heating	Eureka	500	IC	
2213	1997	Fort McPherson	District Energy	Fort McPherson District Energy		IC	

Summary for 'Province' = NW (4 detail records)

Electrical Capacity for Province 7,160

Province

ON

NAICS	Start Year	Operator	Type of Business	Primary Thermal Ho	Capacity (kw)	Cogen type	Fuel
0	2002	NRCan	Research	Health Canada	58	MT	NG
1114	1989	WestbrookFloral	Flower Grower	Westbrook Greenhouses Ltd.	500	IC	NG
1114	1992	Rosa Flora Ltd	Greenhouse	Rosa Flora Ltd.	1,600	SI	NG
1114	1995	Westbrook Greenhouses Ltd.	Flower Grower	Westbrook Greenhouses Ltd.	1,000	IC	NG
2211		Sudbury District Energy	IPP		5,000	GT	NG
2211		Imperial Oil	Gas refinery	Imperial Oil, Nanticoke Refinery	20,000	ST	
2211	1990	Abitibi Consolidated Canad	IPP	Abitibi Consolidated (Fort Frances)	112,000	GT	NG
2211	1995	West Windsor Power	Non-Utility Generator	Canadian Salt Co.	118,000	GT	NG
2211	1995	AES Kingston Inc.	Non-Utility Generator	Kosa Canada	110,000	GT	NG
2211	1996	Transalta Energy/Windsor E	Non-Utility Generator	DailmerChrysler Canada	68,000	GT	NG
2211	1996	Iroquois Falls Power Corp. /	Independent Power Producer	Abitibi Consolidated Inc. (Iroquois Fall	110,000	GT	NG
2211	1998	Whitby Cogeneration Limite	Non-utility generator	Atlantic Packaging Products Ltd.	58,000	GT	NG
2212	1990	Union Gas	Gas Utility	Union Gas Halton Division Office	60	IC	
2212	1994	Union Gas	Natural Gas Distributor	Union Gas Head Office	6,000	GT	
2213	1993	City of Barrie	Wastewater Treatment	Barrie Waste Water Treatment Plant1	500	SI	Digester
2213	1995	CDH District Heating Ltd.	District Heating	Institutional and Commercial	5,000	SI	NG
2213	1995	City of Guelph	Wastewater Treatment	Wastewater Treatment plant	580	SI	Digester
2213	1996	Core Energy	Municipality	Trigen	3,500	GT,ST	
2213	2001	Sudbury District Energy	IPP	Sudbury Regional Hospital	6,700	SI	NG
2213	2001	Markham District Energy	Commercial/residential	IBM Canada	3,500	SI	NG

2213	2003	Hamilton Community Energ	District Energy	City of Hamilton	3,500	SI	NG
3111	1994	Casco Inc.	Feed Industry	Casco Inc.	10,000	GT	NG
3112	1995	Casco Inc.	Corn-based Sweeteners	Casco Inc.	15,000	GT	NG
3113	1996	Redpath Sugar Ltd.	Sugar Refining, Packaging	Redpath Sugar Ltd.	5,600	BPST	NG
3116	1999	Maple Lodge Farms	Food Processing	Maple Lodge Farms	4,750	GT	NG
3119	1990	H.J. Heinz Company Of Can	Food Manufacturing	H.J. Heinz Company Of Canada Ltd.	8,600	GT	NG
3119	1994	Cardinal Power Of Canada I	Food Industry	Casco Inc./ Benson Public School	156,000	CCGT	
3119	2001	Jungbunzlauer	Food Manufacturer	Jungbunzlauer	10,000	GT	NG
3121	1955	Hiram Walker And Sons	Distiller	Hiram Walker And Sons	2,500	BPEST	NG
3121	1969	Hiram Walker And Sons	Distiller	Hiram Walker And Sons	5,000	BPST	NG
3121	1985	Hiram Walker And Sons	Distiller	Hiram Walker And Sons	350	D	Deisel
3121	1993	Labatt Brewing Co. Ltd.	Brewery	Labatts	5,000	GT	NG
3151	1994	Phantom Industries	Hoisery and Swimwear	Phantom Industries	600	SI	NG
3221		Bowater	Pulp and Paper	Bowater	76,570	ST	
3221		Kimberly-Clark Inc.	Pulp and Paper	Kimberly-Clark Inc. Terrace Bay	20,000	ST	
3221		Bowater Thunder Bay	Paper Mill	Bowater Thunder Bay	67,000	ST	
3221	1944	Marathon Pulp Inc.	Pulp and Paper	Marathon Pulp Inc.	9,500	BPEST	SPL
3221	1946	Marathon Pulp Inc.	Pulp and Paper	Marathon Pulp Inc.	4,500	BPEST	SPL
3221	1958	Tembec Industries Inc.	Pulp and Paper	Spruce Falls Inc. (Kapusking Mill)	21,600	ST	
3221	1975	Tembec Industries Inc.	Pulp and Paper	Tembec Industries Inc.	12,500	BPEST	Hog Fuel
3221	1985	Tembec Industries Inc.	Pulp and Paper	Tembec Industries Inc.	12,500	ECST	Hog Fuel
3221	1989	Domtar Inc.	Pulp and Paper	Domtar	24,000	ST	

3221	1993	Sonoco Ltd.	Paper Products	Sonoco Ltd. (Branford Mill)	4,000	GT	
3221	2000	Sonoco	Paper Products	Sonoco Paper Mill	7,800	GT	NG
3251		Terra International	Chemicals	Terra International	15,500	GT	
3251		General Chemical	Chemical Processing	General Chemical	10,950	ST	
3251	1972	TransAlta	Chemical Processing	Dow Chemical	161,000	CCGT	
3251	1983	TransAlta	Chemical processing	Bayer Rubber	51,031	ST	
3251	1997	Commercial Alcohols Inc.	Ethanol Production	Commercial Alcohols Inc.	5,000	GT	NG
3251	2003	TransAlta- Sarnia Cogen	Chemical Processing	Bayer, Dow and NOVA Chemicals	440,000	GT	
3252	1992	Dupont	Chemical plant	Dupont	38,300	GT	NG
3254	1994	Aventis Pasteur Ltd.	Pharmaceutical Manufacturer	Aventis Pasteur Ltd.	3,000	GT	
3312	1930	Stelco	Steel Manufacturer	Stelco	10,000	ST	
3328	1997	Kuntz Electroplating	Metals	Kuntz Electroplating	2,445	SI	NG
3328	1999	Kuntz Electroplating	Metals	Kuntz Electroplating	815	SI	NG
3328	2000	Kuntz Electroplating	Metals	Kuntz Electroplating	815	SI	NG
3361	1995	Ford Motor Company Of Ca	Automobile Manufacturer	Ford Motor Company	28,000	ECST	NG
3399	1995	Kodak Canada Inc.	Photo Equipment Manufacturer	Kodak Canada Inc.	4,500	GT	NG
5417	1994	NRCC	Government Agency	NRCC	4,000	GT	
5417	1996	Canada Centre for Inland W	Research facility	Canada Centre for Inland Waterways	810	IC	NG
5622	1997	Ottawa-Carlton Regional M	Waste Water Treatment	Robert Pickard Environment Centre	2,400	SI	Digester
6112		Mohawk College	College	Mohawk College	810	IC	
6113		Brock University	University	Brock University	6,560	IC	
6113	1986	University of Ottawa	University	University of Ottawa	600	SI	NG

6113	1992	University of Toronto	University	University of Toronto	6,000	GT	NG
6113	1993	University of Windsor	University	University of Windsor	3,800	GT	NG
6113	1994	Centra Gas	University	Orillia Soldiers	13,300	ST	
6113	1995	University of Ottawa	University	University of Ottawa	1,500	BPST	NG
6113	1997	York University	University	York University	5,000	GT	NG
6221		St. Vincent Hospital	Hospital	St. Vincent Hospital	420	IC	NG
6221		St. Catharine's Hospital	Hospital	St. Catharines Hospital	250	IC	
6221	1972/ 1999	London Health Sciences Cen	Hospital	University Hospital/ Victoria Hospital	11,000	ST	
6221	1992	TransAlta Energy Corp. / Co	Health	Ottawa Health Science Centre	68,000	CCGT	
6221	1994	Union Gas	University	Union Gas Halton Div. Office	6,000	IC	
6221	1994	Orillia Soldiers Hospital	Hospital	Orillia Soldiers	760	IC	
6221	1997	Royal Victoria Hospital	Hospital	Royal Victoria Hospital	250	SI	NG
6222		Union Gas		Lutherwood Childrens Mental Health C	2,000	ST	
9111	1992	Canadian Forces	National Defense	Canadian Forces Station Alert	3,000	D	Deisel
9111	2000	Department of National Defe	Military	CFB Petawawa	3,500	GT	NG
9112	1997	Corrections Canada	Correctional facility	Corrections Canada	760	IC	
9112	2002	Correctional Services Canad	Corrections/Government	Warkworth Institute	570	D	NG

Summary for 'Province' = ON (81 detail records)

Electrical Capacity for Province

2,029,514

Province

PE

NAICS	Start Year	Operator	Type of Business	Primary Thermal Ho	Capacity (kw)	Cogen type	Fuel
2211	1986	Northeast Energy	Utility		850	IC	
2213	1997	PEI Energy Systems	District Energy	District Energy (80+ Customers)	1,200	BPST	Wood

Summary for 'Province' = PE (2 detail records)

Electrical Capacity for Province

2,050

Province PQ

NAICS	Start Year	Operator	Type of Business	Primary Thermal Ho	Capacity (kw)	Cogen type	Fuel
2211	1992	Borex Inc.	Thermal Utility	Cascades Inc. (Papier Kingsey Falls Inc.	31,000	GT	NG
2211	2003	CHI Canada Inc.	IPP	Alliance Forest Products	23,000	BPST	Hog
3221		La Compagnie Gaspesia Ltee	Pulp and Paper	La Compagnie Gaspesia Ltee	6,000	ST	
3221	1993	Tembec Industries Inc.	Pulp and Paper	Tembec Inc. (Specialty Cellulose Div.)	9,500	ST	
3221	1996	Donohue Inc.	Pulp and Paper	Abitibi Consolidated Inc. (St. Felicien	28,600	ST	
3221	1997	Bowater Forest Products	Pulp and Paper	Bowater Forest Products	28,000	ECST	Hog
3221	1998	Domtar Inc.	Pulp and Paper	Domtar (Norkraft Quevillon Inc.)	48,500	BPST	SPL
3221	2001	Domtar Inc.	Pulp and Paper	Domtar Inc	32,000	BPEST	SPL
3332	2000	Pratt & Whitney		Pratt & Whitney	1,840	GT	
9111	1999	Department of National Defe	Military	CFB Valcartier	3,400	GT	NG

Summary for 'Province' = PQ (10 detail records)

Electrical Capacity for Province

211,840

Province SK

NAICS	Start Year	Operator	Type of Business	Primary Thermal Ho	Capacity (kw)	Cogen type	Fuel
2123	1981	IMC Canada Ltd.	Potash Mine	IMC Potash Belle Plaine	20,000	BPST	NG
2123	2001	IMC Canada Ltd.	Potash Mine	IMC Potash Belle Plaine	35,000	BPST	NG
2211	1999	Meridian Cogeneration Proje	Non-Utility Generator	Husky Oil Lloydminister	220,000	GT	NG
2211	2002	ATCO Power/Sask Power In	Non-Utility Generator	Cory Potash Mine	260,000	GT	NG
2213	2002	Regina General Hospital	Hospital	Regina General Hospital	120	MT	ng

3221	1968	Weyerhaeuser Canada	Forest Products	Weyerhaeuser Canada Ltd.	21,000	ST
6112	1993	Saskenergy	Educational Institution	Saskatchewan Hospital	800	IC
6221	1951	SaskEnergy	Hospital	Saskatchewan Hospital	800	ST

Summary for 'Province' = SK (8 detail records)

Electrical Capacity for Province	557,720
Total Electrical Capacity	6,818,067

Appendix D

Allocation of CO₂ Emissions from Cogeneration

Allocation of CO₂ Emissions from Cogeneration

This appendix summarizes seven methods that can be used to allocate the CO₂ emissions generated by cogeneration systems to the electrical and thermal products. When the owner / operator, the thermal host and the electricity consumer are not the same, the allocation of emissions to each product is necessary to ensure that each stakeholder is credited with their share of the CO₂ emissions produced by the system.

The following adapts six calculations of fuel allocation to the thermal and electrical products of a cogeneration system¹². The fuel allocation is multiplied by the appropriate CO₂ emission factor to calculate the share of emissions for each product.

Allocation based on energy content of the products

This is a simple method of allocation of CO₂ emissions. The main criticism is that it does not account for the *quality* of the energy produced and its ability to do useful work. Therefore, it underrates the electricity share of energy and emissions.

$$C_E = \left(\frac{E}{E + H} \right) F \phi \qquad C_H = \left(\frac{H}{E + H} \right) F \phi$$

Where:

C_E = amount of CO₂ emissions allocated to electrical production;

C_H = amount of CO₂ emissions allocated to heat production;

E = net electricity production of the cogeneration system

H = net heat production of the cogeneration system

F = primary fuel consumed by the cogeneration system; and,

ϕ = CO₂ emission coefficient (i.e., unit of CO₂ produced per unit of primary fuel consumed)

Allocation based on exergy content of the products

Allocation based on exergy¹³ content accounts for the quality the energy form. As a result, the allocation of fuel and emissions is lower for the thermal product than the allocation based on energy content.

$$C_E = \left(\frac{E}{E + \beta H} \right) F \phi \qquad C_H = \left(\frac{\beta H}{E + \beta H} \right) F \phi$$

Where:

β = ratio of exergy to energy content of heat produced. The ratio for electricity is 1.0, 0.6 for steam at 600 degrees C and 0.2 for water at 90 degrees C (*Wall, G., Energy, Society and Morals, 1997*).

¹² Phylipsen, et.al, Handbook of International Comparisons of Energy Efficiency in the Manufacturing Sector, 1996.

¹³ Exergy is defined as the maximum amount of work (work here being the physics definition of work) that can be obtained from an energy carrier.

Allocation based on economic value of the products

This method may have some advantages for owner / operators that sells the electrical and thermal products independently.

$$C_E = \left(\frac{C_e E}{c_e E + c_h H} \right) F \phi \qquad C_H = \left(\frac{C_h H}{c_e E + c_h H} \right) F \phi$$

Where:

c_e = the economic value of electricity produced

c_h = the economic value of thermal energy produced

Allocation of incremental fuel consumption to electrical production

This method considers electricity to be a byproduct of the thermal process and is consistent with the “Fuel Charged to Power” (FCP) calculation done by many consultants in the cogeneration field. The FCP calculation nets out the fuel consumed by the reference boiler (i.e., an independent boiler providing the same steam as the cogeneration system) from the total fuel consumed by the cogeneration system.

$$C_E = \left[F - \left(\frac{H}{\eta_b} \right) \right] \phi \qquad C_H = \frac{H}{\eta_b} \phi$$

Where:

η_b = efficiency of the boiler that would have been used in the production of the same amount of heat energy as produced by the cogeneration system (i.e., reference boiler).

Allocation of incremental fuel consumption to the heat production

In contrast to the previous method, this calculation nets out the fuel used by an independent generator / power plant needed to provide the same amount of electricity.

$$C_E = \frac{E}{\eta_{pp}} \phi \qquad C_H = \left[F - \left(\frac{E}{\eta_{pp}} \right) \right] \phi$$

Where:

η_{pp} = efficiency of the power plant that would have been used in the production of the same amount of electricity as produced by the cogeneration system (i.e., reference power plant).

Allocation based on a shared emission savings between heat and electricity

A shared-savings approach may be a compromise to allocating all savings to either the electrical or thermal products.

$$C_E = \left(\frac{\frac{E}{\eta_{pp}}}{\frac{E}{\eta_{pp}} + \frac{H}{\eta_b}} \right) F \phi \qquad C_H = \left(\frac{\frac{H}{\eta_b}}{\frac{E}{\eta_{pp}} + \frac{H}{\eta_b}} \right) F \phi$$

Allocation by agreement

In some cases, the allocation of CO₂ emissions to each product of cogeneration will be determined by a contractual agreement between the various parties to the project.

Allocation of CO₂ emissions associated with transmission and distribution

One of the advantages of cogeneration systems is that they are typically located close to the thermal load and the electricity user(s). Under these conditions, the losses associated with transmission and distribution of electricity are reduced or eliminated. However, accounting for these reductions would be on a case-by-case basis. If the electricity is sold to the grid, this spatial advantage of cogeneration is lost.