

THE STATE OF INDUSTRIAL COGENERATION IN CANADA

By Gordon Robb

Canada has a new association to promote cogeneration nationally. Here, President of COGENCanada Gordon Robb surveys the industrial cogeneration and wider energy scene by province, noting that woody biomass is perhaps the most important fuel sector.

The TransAlta 400 MW combined-cycle plant serves four petrochemical complexes in Sarnia, Ontario. The plant incorporates three 115 MW Alstom gas turbines and a 120 MW steam turbine. COGENCanada was created in mid-2004 to promote cogeneration and provide related training throughout Canada. The Association is also promoting cogeneration-based 'Eco Industrial Networking', a concept that involves using outputs and waste from one industrial process as inputs to other processes.

Canada's provinces have jurisdiction over electricity within the country. The Federal Government deals with nuclear safety and, through the National Energy Board, licences exports and certifies export transmission lines.

A decade ago, electricity was supplied throughout Canada by vertically integrated monopoly utilities. With two exceptions, they have not built cogeneration systems, and cogeneration systems were owned by steam users. Most provinces are now in the process of restructuring.

Forest industries account for a large fraction of the cogeneration systems in Canada. In recent years, the lumber and pulp and paper industries have become integrated, with chips for making pulp coming from adjacent saw mills. Wood residues from the saw mills are used as fuel for steam generation and cogeneration by the pulp mills, as is pulping liquor. There are also many newsprint mills in Canada. Paper mills using recycled paper are ideal candidates for cogeneration. However, the increased use of thermo-mechanical pulping has reduced the scope for cogeneration because that pulping process generates steam for paper drying.

Here is a survey by province:

NOVA SCOTIA

Nova Scotia Power remains a vertically integrated monopoly in the province of Nova Scotia. Most generation is with low-sulphur coal, although some oil is also used. The coal-fired plants are 'grandfathered', having been built before scrubbers were required. The electricity cost is relatively low. Natural gas has recently become available from the Sable Island offshore source, and ground has been broken for an LNG (Liquid Natural Gas) import terminal.

Natural gas cogeneration is likely to become viable in the future as additional increments of firm power are required. The province recently adopted a policy whereby if the Public Utilities Board deems a cogeneration system, proposed by an independent power producer (IPP) or steam user, to be superior to an increment of generation planned by Nova Scotia Power, then the utility must buy from the cogenerator.

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Paper mills using recycled paper are ideal candidates for cogeneration

Kimberly Clark has a 28 MW steam turbine cogeneration system in its Nova Scotia kraft pulp mill. It uses the utility for stand-by supplies and frequency stabilization. Fuels are pulping liquor, wood residues and some heavy fuel oil. There is an IPP-owned cogeneration system using a fluidized bed to burn wood residue and selling steam to a newsprint mill. Here, the power is sold to the utility at a premium price while the mill buys from the utility at a lower price. Nova Scotia Power seems reluctant to enter into other such contracts.

The Bear Head (Point Tupper) LNG terminal will be a short distance from a 150 MW coal-fired power plant and a pulp and paper mill with biomass cogeneration. The plan is to use condensing

water from the coal-fired power plant or the paper mill to vaporize the LNG, creating a cogeneration system. Also interesting is the paper mill's use of a thermo-mechanical pulping system which generates all the steam required for drying the paper most of the time. This reduces the scope for cogeneration.

NEW BRUNSWICK

The province has separated generation from transmission and has an independent system operator. There are a number of biomass cogeneration systems owned by pulp and paper mills. Sable Island natural gas has recently become available in southern New Brunswick, but a large fraction of the province depends on heavy fuel oil to supplement biomass for cogeneration.

The government-owned utility, New Brunswick Power, owns the transmission and most of the generation. It owns an oil-fired steam turbine cogeneration system using a back-pressure steam turbine to deliver steam to a newsprint mill. That unit is in an older, oil-fired power plant. One unit of that plant has been repowered by an IPP by replacing the boiler with a gas turbine heat-recovery steam generator (HRSG). There is potential for cogeneration there but it has yet to be implemented. The IPP sells power to the New England market some of the time and to New Brunswick Power some of the time.

TransCanada Power, an IPP, is building a combined-cycle system with two gas turbine HRSG units to supply steam to Canada's largest oil refinery, which is owned by the Irving family in the province.

QUÉBEC

Hydro-Québec, the vertically integrated monopoly utility, is wholly owned by the provincial government. All but a small fraction of the electrical generation in the province of Québec is hydro. Much of it is fully depreciated. The low-cost sites have been developed, and newer generation has much higher costs. Very long transmission from newer, remote hydro sites to loads means much higher

costs. For some years, a pulp mill self-sufficient in thermal and electrical energy from biomass has been operating a steam turbine cogeneration system. A cogeneration system with two GE LM1600 gas turbines supplying steam to a Cascades paper mill in southern Québec has also been operating for several years, under special arrangements with Hydro-Québec. However, in general, pulp and paper mills cannot justify owning back-pressure steam turbines because of the low cost of purchased power.

Hydro-Québec is able to store large blocks of electricity in reservoirs behind hydro plants. They have a winter peak and use high-capacity DC transmission lines to export to the US. The very long transmission lines are vulnerable to failure due to ice storms – an argument for more distributed generation.

Over the past few years, TransEnergie has been established to operate the Hydro-Québec Transmission system, with Hydro-Québec Generation operating generation. Hydro-Québec Distribution buys power from other sources, including cogeneration systems. IPPs are allowed only if they are awarded contracts with Hydro-Québec, thus competing with Hydro-Québec Generation.

In 2003, Hydro-Québec Distribution issued a call for tenders for 100 MW of biomass generation. Most responses were cogeneration. In one case, where the mill had a high-pressure wood residue boiler, Hydro-Québec has agreed to buy the electrical output of a 20 MW back-pressure steam turbine owned by the mill at about 6 Canadian cents (5 US cents) per kWh. The mill continues to buy its full electrical requirement at 3-4 Canadian cents (2.5-3.3 US cents) – an average cost-based price. The 6 cents is what the utility deems to be the avoided cost of new generation. This has been done in a number of cases.

In August 2004, construction started on Québec's first natural gas combined-cycle cogeneration system in the Becancour Industrial Park near the Trois-Rivieres. The electrical capacity of this TransCanada Energy plant is 550 MW. Process steam will be sold to Norsk Hydro and Pioneer Chemical. The electrical output will be sold to Hydro-Québec under a 20-year contract, at about 6 Canadian cents (5 US cents) per kWh. The steam load is relatively small but the electrical load in the park is very large.

In late 2004, Hydro-Québec

Distribution issued a call for 350 MW of cogeneration. An efficiency of 70% is specified. The Official Gazette of the Province of Québec contains a 'Regulation respecting energy produced by cogeneration', which suggests that 800 MW of cogeneration is to be installed before 2013. Of that, 200 MW is to be installed by 2007. Efficiency is defined in the regulation as the ratio of 'the sum of the energy content of the steam and electricity produced to the energy content of the fuel used'.

ONTARIO

The cogeneration plant in Whitby, Ontario, uses a Rolls-Royce Trent gas turbine and sells steam to Atlantic Packaging, a newsprint and tissue mill. Electricity in Ontario is from a blend of nuclear and coal-fired generation, with some oil and natural gas. Until recently, Ontario Hydro, a government-owned, vertically integrated utility owned most of the generation, transmission and some distribution. There are a number of user-owned steam turbine cogeneration systems in pulp and paper mills as well as other industries.

One of the most interesting plants built by an NUG a decade ago is a TransAlta combined-cycle cogeneration system at the Ottawa Health Science Center.

About a decade ago, the influence of the Public Utility Regulatory Act (PURPA) in the US led the Ontario Government to tell Ontario Hydro to buy cogeneration from 'non-utility generators' (NUGs). Ontario Hydro signed long-term contracts at prices high enough to ensure that revenue requirements would be met. At the time, the federal income tax incentive was a 50% straight-line capital cost allowance for qualifying projects – much more powerful than the current incentive.

One of the most interesting plants built by an NUG a decade ago is a TransAlta combined-cycle cogeneration system at the Ottawa Health Science Center, a complex of hospitals. There is one 40 MW gas turbine generator with HRSG and one extraction condensing steam turbine. The steam turbine produces 30 MW with supplementary firing, or 12 MW without. Absorption chillers in the cogen plant supply chilled water loops. One of the larger hospitals, about 1 km from the cogen plant, is both heated and cooled by a single hot water loop. The hospital has its own absorption

chillers.

In 1973, Dow Chemical converted a coal-fired high-pressure cogeneration system serving the Sarnia chemical and petrochemical complex into a 165 MW combined-cycle plant. The system used aluminium-finned tubes in the HRSG to heat water and reduce the stack temperature to the 57°-66°C range, a demonstration of condensing heat recovery. It also demonstrated the ability of a cogeneration system to maintain electrical supply to a large industrial complex during grid failure. The cogeneration system was connected directly to the Dow Complex to supply electricity. It was also connected to the grid for frequency stabilization and back-up. During grid failures, low frequency relays disconnected it from the grid. Some selective load-shedding allowed islanding and continued operation of the complex.

In 1998, Ontario Hydro was restructured into five new government corporations: Ontario Power Generation (OPG), (all generation); Hydro One (all transmission); the Independent System Operator (IMO); the Electricity Safety Operator; and the Ontario Electricity Financial Corporation (OEFC). The OEFC honours the contracts which had been signed by Ontario Hydro. OPG owns no cogeneration. IPPs are allowed to build generation if they can finance it. The IMO manages the power pool.

TransAlta recently took over the 1973 Dow Sarnia plant and added a new 400 MW combined-cycle cogeneration system supplying steam to four chemical/petrochemical complexes owned by Nova, Bayer, Dow and Suncor. The new system is connected only to the electricity grid, and electricity is sold directly to the steam users through the grid.

In August 2003 there was a major grid failure in north-eastern US and Ontario. Because it was connected only to the grid, the 400 MW TransAlta system in Sarnia was shut down for hours, as was most of Ontario. According to a study reported by the US-based Electricity Consumers Resources Council, 30 chemical, petrochemical and oil-refining facilities near Sarnia suffered outages costing an estimated CAN\$10-20 million (US\$8.3-17 million) per hour of outage. Had there been islanding and selective load-shedding arrangements, with the TransAlta plant connected directly to local loads, it could have kept

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the Sarnia region operating.

The Ontario Government has said it plans to phase out coal-fired generation. It has devised a somewhat complex approach to attracting new, clean generation but some combined-cycle systems without cogeneration are planned. They have asked for ideas as to how more cogeneration can be attracted.

MANITOBA

This province has far more hydro generation than it can use and exports to the US. Unlike Québec, it plans to meet future requirements with hydro and, except for some interest in biomass, cogeneration is not planned. There is a cogeneration system in a pulp and paper mill in the north.

SASKATCHEWAN

A large fraction of generation is based on lignite but there is some natural gas. A pulp and paper mill in northern Saskatchewan has biomass cogeneration. Saskatchewan Power remains a vertically integrated monopoly, but does buy power from IPP-owned cogeneration systems. ATCO has a combined-cycle system in a potash-processing plant at Cory near Saskatoon.

Husky, a major oil producer, has a heavy oil upgrader in Lloydminster on the Alberta-Saskatchewan border. TransAlta has worked with Husky to develop the Meridian 450 MW cogeneration system, supplying about 50 kg/second of steam to the upgrader. It uses two GE 85 MW gas turbines and a 45 MW condensing steam turbine.

ALBERTA

Prior to restructuring, Alberta had three vertically integrated utilities serving different franchised regions of the province. Two of them, TransAlta and ATCO, are investor-owned. The third, EPCOR, is owned by the city of Edmonton. A large fraction of electricity generation in Alberta is low-cost at surface coal mines. Alberta is also Canada's main natural gas producer.

There are steam turbine cogeneration systems in pulp mills and food-processing plants. The first combined-cycle cogeneration system in Alberta was developed in 1979 at the Dow Chemical Fort Saskatchewan complex near Edmonton. It uses two 70 MW GE gas turbines and two 20 MW back-pressure steam turbines. Both gas turbines have duct burners using some natural gas and some process gases such as hydrogen. Until restructuring this was the only combined-cycle cogeneration system in the province.

Restructuring led to a number of gas turbine cogeneration projects. TransAlta and Air Liquide jointly own a new combined-cycle system recently installed in the Dow plant at Fort Saskatchewan. It uses one 85 MW GE gas turbine and one 40 MW condensing extraction steam turbine. Dow operates the new system under contract with the owners.

There is a great deal of oil refining and petrochemical development near Edmonton. In that region, Air Liquide has built a gas turbine cogeneration system supplying Shell Chemicals at Scotford. ATCO operates a combined-cycle cogeneration system supplying the Shell Scotford refinery using partially processed crude oil from the oil sands near Fort McMurray.

Estimated crude oil reserves in the oil sands of northern Alberta are comparable with those of Saudi Arabia. Some of it is near the surface and is mined before hot water processing. Heating the water is an ideal cogeneration application. The large Syncrude and Suncor synthetic crude refineries in Fort McMurray have large combined-cycle cogeneration systems. Shell mines bitumen near Fort McMurray, partially processes it there, then pumps it to the Scotford refinery near Edmonton where it becomes synthetic crude.




Another form of cogeneration is used for bitumen too deep to be mined economically. High-pressure steam is forced down drill holes to soften the bitumen. The mixture of bitumen and water is then forced to the surface to a processing plant which separates the water. The high-pressure steam is generated in special horizontal-tube HRSGs. The recycled water leaving the processing plant is contaminated, so 20% of it flows through the tubes as water carrying the contaminants with it. The steam then returns to the bitumen.


An ATCO cogeneration system consisting of two 170 MW Siemens Westinghouse gas turbines and one 170 MW steam turbine serves a large petrochemical complex at Joffre, near Red Deer, owned mainly by Nova. The plant is a joint venture between ATCO, EPCOR and NOVA. ATCO manages the plant while Nova and EPCOR contribute staff. There were gas and steam turbines in the huge complex before the new system was built, so NOVA was able to contribute staff with applicable experience.

BRITISH COLUMBIA

Most electrical generation in British Columbia is hydro. Most of the cogeneration serves the many pulp and paper mills in the province. Fuels are mostly wood residue trucked from the saw

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mills, and pulping liquor. Some natural gas and some residual fuel oil is also used. A few cogeneration systems serve saw mills. BC Hydro, the vertically integrated, government-owned monopoly utility co-operates in providing back-up power and buying surplus electricity.

There is more hydro potential but its environmental approval is difficult. The utility is helping finance biomass cogeneration where there remains potential in the pulp and paper industry. British Columbia produces a good deal of natural gas in the north-east; this is pipelined to Vancouver and to Vancouver Island. There is a 110 MW gas turbine cogeneration system in the McMahon gas-processing plant in the north-east.

Vancouver Island has saw mills, two large, integrated forest product complexes and two chemical pulp mills. The two integrated forest product complexes contain chemical pulp mills, mechanical pulp mills, newsprint paper machines, kraft and paper machines. They have had steam turbine cogeneration for some time. There is now a combined-cycle cogeneration system owned by Calpine, called Island Cogeneration, at the Campbell River Complex.

The situation in British Columbia is similar to that in Québec. The monopoly utility does not cogenerate but will buy power under long-term contract from independent cogenerators. BC Hydro has issued a request for proposals for more generation on the island. There is a steam-generating municipal waste incinerator, forming part of a cogeneration system selling steam to a paper mill and power to BC Hydro in Burnaby near Vancouver.

THE FUTURE

Given the amount of biomass fuel available in the forest industries, gasification of wood residues – along with pulping liquor – would allow conversion of many Canadian biomass cogeneration systems using only steam turbines to combined-cycle operation. This would more than double the electrical output. One gasification system is currently operating in a corrugating medium paper mill at Trenton Ontario.

A key objective of COGENCanada is to promote policies which ensure that developers building combined-cycle power plants take advantage of the cogeneration potential available. Developers seem determined to build large plants, so convincing governments it is important that incentives should apply to the true cogeneration increment, regardless of total plant capacity, is crucial. This should encourage the building of power plants near steam loads, particularly in industrial parks.

While policymakers talk about wind and solar energy, few appear to understand and appreciate cogeneration. COGENCanada, working with other associations, aims to change that.

Gordon Robb is the President of COGENCanada

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