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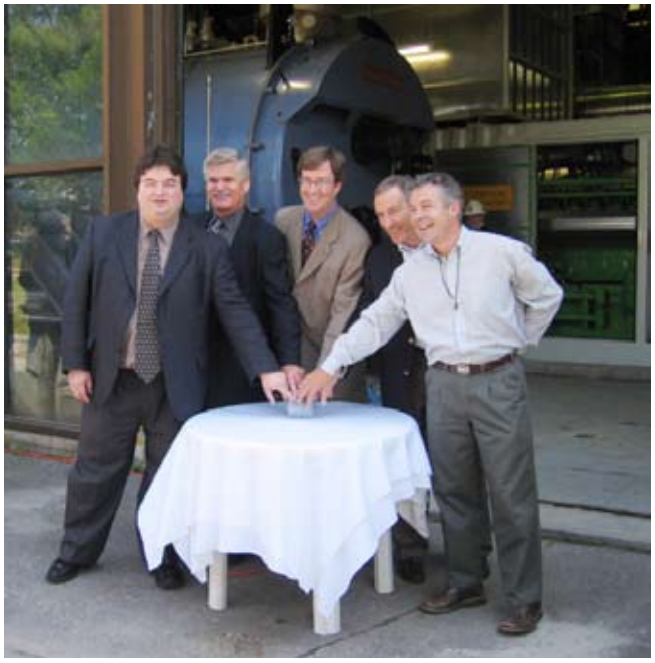
Places of Power

ADVANCING COMBINED HEAT AND POWER IN THE INSTITUTIONAL AND MUNICIPAL SECTOR

ONTARIO CLEAN AIR ALLIANCE

Institutions, whether they are schools, hospitals or municipal facilities, can be large energy users. And they often operate within very demanding fiscal constraints. That's why many in this sector are starting to explore the advantages of highly efficient combined heat and power (CHP) systems. These systems can provide multiple advantages: utility cost savings, greater security of supply, expanded emergency power and improved power quality.



Firing up the combined heat and power system at Queensway-Carleton Hosptial. The system saves the hospital $350,000 per year in utility costs.

But they also provide many external benefits that are harder to quantify on a balance sheet. Reduced greenhouse gas and smog causing emissions, and reduced need to build new, high-cost central generating plants (particularly nuclear), and high-voltage transmission lines are the kinds of benefits that system owners provide but don't directly benefit from.

"We need to find strategies to recognize these benefits and support these systems," says John Martin of Queensway-Carleton Hospital. "I think any business case for these sorts of systems should take into consideration some of the qualitative benefits as well as the quantitative benefits." For institutions like hospitals, a CHP system could mean the difference between being able to continue to fully operate during a multi-day power outage, such as was experienced during the 1998 ice storm, or having to shut down systems due to fuel shortages.

While the Ontario Government is slowly introducing programs to provide some greater certainty and support for clean power, such as the renewable standard offer program (SOP) and the Clean Energy Standard Offer Program (CESOP), many industry observers believe these programs have failed to recognize the full benefits of clean and efficient decentralized power systems.

Joe VanSchaick of Toromont, for example, notes that one large potential revenue source for clean power systems is greenhouse gas credit sales. But under the government's renewable SOP program, these credits are retained by the government, not the power producer.

Many believe that the kind of agreement struck 20 years ago by the University of Toronto and Ontario Hydro, which recognizes that it was cheaper for Hydro to support a decentralized system than to try to pump more electricity over an overloaded grid, should be the rule rather than an exception.

Recent calculations by the Ontario Clean Air Alliance show that of the 10,636 MW of new supply the Ontario Government had contracted for as of October 2007, only 1,098 MW came from combined heat and power facilities. Clearly, we have only scratched the surface of the potential for CHP in institutions in Ontario.

The University of Toronto's St. George Campus is served by a combined heat and power system that can provide six megawatts of electricity to the campus. The Medical Sciences Building (top) features two absorption chillers that uses system steam for cooling.

Green learning

The University of Toronto is like a city within a city. Its large downtown campus uses plenty of energy to heat, cool and power numerous classrooms, offices, laboratories and residences. So it is not surprising that the institution has developed its own small-scale district energy system on the St. George Campus.

At the heart of the system is a six megawatt Siemens gas turbine that produces enough electricity to meet roughly a quarter of the campus' average demand and, in combination with a waste heat boiler, about 50% of its steam requirements. In fact, over the four summer months, the system can easily handle the campus' full heat load, while in the winter it is supplemented by boilers as necessary.

The system is connected to approximately 85 buildings through steam pipes that feed heat exchangers for space heating in each building. It also supplies steam to some non-U of T buildings, including the Royal Ontario Museum, Gardiner Museum and the Centre for Addiction and Mental Health.

"It's almost a little utility," says Helmut Krueger, Manager of Central Mechanical Services for the University. And this little utility has been working almost non-stop since 1992, he adds, generally running 24 hours a day, seven days a week.

More recently, the University added two 1,500 tonne absorption chillers to its Medical Sciences Building to take advantage of the steam produced by the system in summer. Krueger estimates these chillers displace up to 2 MW of electricity use. And while overall system use does drop off in the summer, it still contributes a respectable 5 MW overall to the campus' electrical supply over the warmer months.

Like with all combined heat and power systems, the economics of the U of T system are heavily driven by the "spark gap" — the difference between gas and electricity prices. In fact, in one period of high gas prices, the system was being shutdown on nights and weekends, says Krueger. But the bigger issue than gas prices, in Krueger's view, has been the province's decision to hold down electricity prices, which have led to early projections for electricity cost savings being off the mark.

That said, however, the system has been an astute investment for the University, saving it $1 million a year on utility costs. It has also benefitted from a 20-year contract with Ontario Hydro that recognizes the important contribution the system makes to relieving pressure on the overloaded downtown Toronto power grid.

The most recent upgrade to the system was a $4.5 million investment in an exhaust gas heat exchanger system. In this system, the generally corrosive exhaust gas from boilers is counterbalanced by the drier exhaust produced by the turbine. The system produces lower level heat that is used either to produce building hot water or to pre-heat intake air.

With a growing — both in size and environmental consciousness — campus to serve, Krueger notes that "we have to do everything we can to squeeze out every BTU." And while he acknowledges that the U of T system is a large and complex system that requires "skilled support," it is also a major contributor to making the country's largest university more than a shade greener.

Good medicine

Thanks to an expansion completed in 2004, Ottawa's Queensway-Carleton Hospital is close to one-third larger than it used to be. This big growth spurt could have meant a rapidly rising utility bill to power and heat new operating theatres, patient rooms and other facilities. But before embarking on its expansion, Queensway-Carleton called in Johnson Controls Inc. to help it get a handle on its energy use.

> At winter temperatures as cold as -5 degrees C, the system will meet all the hospital's hot water, space heating and steam demand needs.

Johnson, in turn, suggested the facility look at the advantages of a combined heat and power system that could help meet a major share of

The Jenbacher system at Queensway-Carleton Hospital.

the 264-bed facility's electricity and heating needs. The hospital agreed and installed a 1 MW Jenbacher natural gas engine-based system.

John Martin, Director of Hospital Services, says that on an average winter day, the system can meet more than 90% of the hospital's electricity demand. This drops to around 70% on summer days when cooling demand increases.

"We built the system around the hospital's base load heating demand," he explains, and at winter temperatures as cold as -5 degrees C, the system will meet all the hospital's hot water, space heating and steam demand needs. To make the system as efficient as possible, the hospital also did extensive work during the renovation and expansion to put in new chillers, lighting and steam traps, thereby reducing electricity demand and making the most use possible from the heat recovered from the system's engine jacket, oil and exhaust.

While the hospital has maintained its existing fleet of diesel emergency generators, these units now have an additional level of support now that they are backed up by the combined heat and power system, which can also run on propane in the event of a natural gas supply interruption.

"This is one of the biggest advantages of the system," says Martin. "In the event of a power disruption, the hospital could operate in 'island mode' and continue to provide most normal operational services." The traditional emergency back-up system is much more limited, he explains. "In the operating rooms, for example, it would keep the lights and outlets working, but not sterilization equipment."

Being in the health care business, Martin thinks it only makes sense for hospitals to look at what they can do to reduce polluting emissions associated with their operations. "I think health care is an area where there are real opportunities to be more environmentally sensitive."

Hospitals, Martin points out, tend to have above-average heat loads, requiring extensive amounts of steam for humidification and sterilization equipment. That, in part, is why it was easy to make "a straight business case" for incorporating the combined heat and power system, Martin says. In fact, since the $3 million system was fired up in 2004, it has consistently delivered utility savings in the range of $350,000 per year.

"You have to be constantly measuring it to ensure it is performing how you thought it would operate, producing what you intended and that you are fully utilizing the energy it is producing," says Martin, "but the economics are pretty good."

Being in the health care business, Martin thinks it only makes sense for hospitals to look at what they can do to reduce polluting emissions associated with their operations. "I think health care is an area where there are real opportunities to be more environmentally sensitive," he says. At Queensway-Carleton, they've made an excellent start.

Waste Not

The City of Hamilton's Woodward Avenue wastewater treatment plant has no shortage of gas. And that gas is mostly one of the most powerful global warming contributors – methane. The city's solution for many years

was to flare the gas off, but then it had a better idea – use the gas to make electricity for the grid and heat for the plant itself.

The city formed Hamilton Renewable Power Inc. to pursue this goal, and was one of the successful bidders under the Ontario Ministry of Energy's 2004 request for renewable power proposals, landing a 20 year contract to supply the province with renewable power.

The Woodward Avenue waste water treatment plant is now a valuable source of renewable energy thanks to a biogas CHP system.

With the help of Toromont Cat Power Systems, Hamilton Renewable Power installed a Cat G3520C reciprocating engine and generator capable of producing 1.6 megawatts of electricity using the 6 million cubic meters of biogas produced each year by the plant. But while using what had been mostly a waste product to produce useful electricity seems like a no-brainer, there were complications, notes Joe VanSchaick, CHP Market Manager with Toromont.

"Biogas presents challenges," he notes, because of higher levels of contamination and moisture. "Our experience is that a conventional turbine that is not adapted to deal with the contaminants in the gas will wreck the system," he explains. "The biggest issue for a reciprocating engine is acid formation," he adds, while for the turbine itself it is the blades getting coated and ruining the aerodynamics.

Toromont strove to address these concerns without adding extensive fuel conditioning steps. According to the company's summary of the project "A specially designed cooling system elevates jacket water to the optimum temperature to prevent condensation of fuel-borne sulfur compounds and the formation of sulfuric acid, which can damage engine components. A crankcase ventilation pump ejects potentially acidic blowby gases and draws in fresh, filtered air. In addition, aluminum and unprotected steel are eliminated from key components including aftercooler cores and main and connecting rod bearings."

The result of these precautionary steps is a system that has been happily burning digester gas without causing system indigestion since 2006, VanSchaick notes.

For the Woodward Avenue plant, the system has also bolstered back-up power supplies while meeting the facility's heating needs. In fact, much of the heat from the system is fed back into the sewage treatment process, which, in turn, leads to the production of more gas.

And compared to flaring, the new system offers "greater combustion efficiency due to higher

temperatures and pressures, which leads to better methane destruction," VanSchaick points out. As well, the state-of-the-art engine has greatly reduced nitrogen oxides emissions compared to a standard diesel engine.

Markham's Warden Energy Centre currently serves the heating and cooling needs of more than 300,000 m^2 of building space, which will nearly double by 2009.

But the Hamilton project is interesting not just from a technical perspectives — it is also structured to minimize risk for the municipality. With Toromont providing guaranteed support on a per kilowatt hour basis and a projected payback of five years, the system made it easy for the city to get involved in the growing renewable power business.

Power sharing in Markham

For the Town of Markham, it was a once-in-a-lifetime opportunity. With a 1,000 acre Greenfield area ripe for development right in the centre of town, municipal leaders saw a chance to both develop a strong urban core and to walk the talk on environmental sustainability.

The result was a decision to build a district energy system, complete with an initial 3.5 megawatts of CHP, to service the new Markham Centre area. And the ultimate outcome will be a 50% reduction in emissions associated with heating and cooling the commercial and residential buildings springing up in the fast-growing core.

CHP Benefits

Security of supply: By being in a position to generate some or all of its own power, a building is less exposed to brownouts or blackouts, especially in areas where the electricity grid is already overloaded.

Reduced costs: The cost savings of in-house electricity and heat generation will likely grow as electricity prices increase.

More robust emergency power: CHP systems can provide more than just evacuation power and can keep a building functional during an extended blackout.

Extra revenue generation: There is potential for CHP-equipped buildings to participate in the province's Clean Energy Standard Offer Program or to sell peak power to market aggregators (companies that purchase power from many small suppliers) at premium rates. More information: www.powerauthority.on.ca - search for "Clean Energy Standard Offer."

Reduced emissions: By reducing demand for electricity from the provincial power grid, CHP systems reduce the demand for dirty coal power. Every kilowatt of electricity generated by CHP systems is much cleaner than power from coal plants due to their much higher efficiency levels — 80-90% vs. 34% — and cleaner fuel sources. Such systems can also contribute to better local air quality by reducing NOx emissions from less-efficient conventional boilers or furnaces.

The Markham District Energy System will have four locations when completed. Photo left – Construction nears completion on the second site in April 2008.

As Bruce Ander, president of Markham District Energy Inc., notes, such an approach would have been nothing new in Europe, where district energy systems are common place. But for Ontario, the Markham approach was novel, and it took some convincing early on to get developers to hook up to the system. A look at the economics and convenience eventually led to 100% participation in the system, he says. In fact, Ander credits the system with being a key factor in helping IBM decide to locate a 2,500 employee research facility in Markham.

Developers who chose to forgo installing their own boilers and chillers in favour of connecting to the Markham system have been treated to a system that has "not had a single hour of downtime" since it started operating on Dec. 1, 2000, Ander points out. This sort of high reliability is in the nature of district energy systems, where there is a high level of redundancy and integration between components. And, for Markham, this will only increase as it completes work on its second district energy facility of a planned total of four.

For the municipality, the 2003 North American blackout was also an excellent demonstration of some of the other advantages of the CHP-equipped system. While the Markham system generally sends power to the grid, it can operate in island mode during a blackout and keep the lights and systems on in key municipal buildings (as well as keeping these buildings warm or cool). During an extended blackout, this provides the municipality with a tremendous emergency response advantage, Ander points out.

For corporate customers, the district energy system means avoided up-front capital costs, avoided risk, and eliminates the need to integrate large heating and cooling facilities. In fact, Ander says the major obstacle in convincing corporate customers of the economic benefits of hooking up to the system is their own poor understanding of their actual current utility costs.

"Building operators will often report that their boilers are operating at 80-90% efficiency simply because of the nameplate rating. But when we actually test boilers, we find they are running at much lower efficiencies — 70% or sometimes lower," he notes.

For Markham District Energy, on the other hand, the CHP system is finely calibrated to the system's thermal load to maximize efficiency. "In the summer and even in the shoulder seasons, the CHP system can meet all or most of our thermal load" while producing power to sell to the grid, Ander explains. "We have a good

heat sink for the thermal output the CHP system produces."

Markham is actually about to significantly step up its CHP output by adding a new 5 MW system in its second plant. "Our plan is to eventually have 30 MW" of CHP capacity, says Ander, adding that it is the CHP element that delivers the real emission savings for the Markham system.

"Prior to the changes in the Energy Act [in the 1990s], we could have had a district heating and cooling system, but wouldn't have been able to install CHP. And CHP is a key element for most mature district energy systems," he explains, because it allows the input fuel to be used to produce both heat or cooling *and* power.

As it is about to expand to serving six million square feet of building space, Ander thinks the Markham system is maturing nicely. Part of what made the CHP expansion possible, he notes, was a successful bid in response to the Ontario Power Authority's first request for proposals for CHP projects.

"If you had to completely take the fuel price risk — if you were betting on low gas prices and high electricity prices to ensure economic viability — nobody would build it" Ander says. In fact, the provincial government's decision to continue to subsidize the cost of electricity has made economic returns on the initial CHP system "marginal," he notes.

With the Clean Power Standard Offer Program in the works, however, Ander is feeling optimistic that CHP systems will become more popular. "What programs like this do is recognize that there are real hard system benefits to things like CHP. These programs may look like they are paying premiums [for power], but in reality they are providing a mechanism to reward the CHP owner/operator for the long-term system benefits," not to mention also recognizing the environmental benefits of greater efficiency.

"It's the right thing to do," Ander believes.

Warden Energy Centre

- Heating: 3 natural gas–fired 12.0 MWt boilers
- Cooling: 2 - 1100-tonne and 3 - 700 tonne centrifugal chillers and 1 - 300-tonne hot water absorption chiller
- Electricity: 1 - 3.5 MW Caterpillar 3616 spark-ignited engine and 2 - 2.5 MW Caterpillar G3612 reciprocating natural gas–fired engines
- Production Capacity: 12 MWt hot water, 4,600 tons chilling, 8.5 MW electricity

The Ontario Clean Air Alliance is a coalition of health and environmental organizations, faith communities, municipalities, utilities, unions, corporations and individuals working for cleaner air through a coal phase-out and the shift to a renewable electricity future. Our partner organizations represent more than six million Ontarians.

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