Powering the Future: How Hamilton Health Sciences Put Cogeneration to Work for Healthcare

William B. MacLeod and Murray T. Martin

Abstract
The absolute necessity of a stable and uninterrupted power supply within hospitals makes many of these facilities uniquely suited to cogeneration plants. Hamilton Health Sciences recently completed the largest hospital cogeneration project ever undertaken in the country. Spanning three acute care hospitals and generating a combined total of 22.75 megawatts of electricity, Hamilton Health Sciences' cogeneration plants address energy supply issues by offering a clean and reliable power source completely within the hospital's control, and provide the organization with the potential to generate its own revenue into the future by selling excess electricity back to the province.

The following article highlights Hamilton Health Sciences' approach to the project, including some important lessons learned, and may serve as an example for other publicly funded institutions interested in implementing similar projects.

Ontario's Energy Challenge

Energy conservation and generation initiatives are becoming increasingly important in Ontario. More and more, organizations are being asked or even mandated to actively pursue energy-conservation strategies. Hospitals are no exception. Early last year, the Government of Ontario passed Bill 21, The Energy Conservation Responsibility Act, which will see the Ontario Power Authority assume responsibility for ensuring hospitals, universities and other municipal buildings participate in programs to increase conservation and demand management. Under this legislation, hospitals are required to prepare energy-conservation strategies on a regular basis and report on energy consumption, proposed conservation measures and progress on achieving results.

While social responsibility is an important component of energy conservation for hospitals, there is also the very real and immediate issue of ensuring that hospitals have access to a stable and uninterrupted power supply. In August 2003, this issue was highlighted when a series of power surges over a 12-second period triggered a cascade of shutdowns at more than 100 generating plants in eight US states and across Ontario. The result was the biggest blackout in North American history. Over 50 million people were affected, and 61,800 megawatts of power were lost (Independent Electricity System Operator 2003). The blackout tested the limits of emergency backup power within the province's hospitals and drove home the need for alternative energy sources.

Less than a year later, the Honourable Dwight Duncan (2004), Ontario's energy minister, stated that if the province is going to keep pace with the demand for electricity, it "will need to refurbish, rebuild, replace or conserve 25,000 megawatts worth of generating capacity by the year 2020. To put that in perspective – that's more than 80 per cent of Ontario's current electricity generating capacity." (According to Hydro One [2006], one megawatt is equal to 1,000 kilowatts, and a 100-watt light bulb burning for 10 hours would use one kilowatt-hour of energy.) A mandate of that magnitude will require involvement from every sector. Since hospitals have a vested interest in ensuring that the lights stay on, no matter what, they have an important role to play.

While social responsibility is an important component of energy conservation for hospitals, there is also the very real and immediate issue of ensuring that hospitals have access to a stable and uninterrupted power supply.

Exploring Solutions at Hamilton Health Sciences

In 2001, Hamilton Health Sciences began exploring the possibilities of cogeneration. As one of Ontario's largest multi-site teaching hospitals, Hamilton Health Sciences provides care to a population base of more than 2.3 million from Hamilton and central south and central west Ontario. With three acute care sites, a cancer centre and a non-acute care hospital, Hamilton Health Sciences consumes 100 million kilowatt-hours of energy annually and can never afford to be without power. Hospitals are also logical locations to establish temporary emergency management response centres during times of crisis, provided they are able to power their own operations and those of other emergency response services.

Cogeneration produces both electricity and useful thermal energy. The thermal energy can be used in heating, which includes the generation of steam or hot water, or cooling applications, which require the use of absorption chillers to convert the steam to cool air. There are a range of technologies that can be used to achieve cogeneration, but the system must always include an electricity generator and a heat recovery system. The heat-to-power ratio, overall efficiency and characteristics of the heat output are key attributes of cogeneration systems (Strickland and Nyboer 2002).

As a technology, cogeneration offers a number of benefits. In addition to providing a clean and independent energy source, it also can be adapted and customized to suit a variety of buildings and situations, provided there is a constant and relatively consistent demand for energy. Cogeneration is also a form of embedded energy generation, which means the electricity is produced where it is used and pressure on local power grids is reduced.

Although the technology behind cogeneration has developed and expanded considerably over the past decade or so, the concept itself is nothing new. In fact, cogeneration accounts for 50% of Denmark's national power production, 40% of the Netherlands' and 35% of Finland's (Cogen Europe 2001). In Canada, cogeneration represents just over 6% of national electricity production (Strickland and Nyboer 2002).

Despite the relatively low penetration of cogeneration facilities in Canada, environmental groups, government officials and others recognize the value and potential of this technology to help reduce demand on traditional energy-producing systems and as an environmentally friendly alternative. According to a joint strategy released by the World Wildlife Fund, Greenpeace, the Pembina Institute, the Sierra Club, Ontario Clean Air Alliance and the David Suzuki Foundation (2006), "Opportunities to move towards combined heat and power systems (known as cogeneration) should not be missed. If fossil fuels are going to be burned to produce heat, they might as well do double-duty and generate electricity at the same time. Research prepared for the Ontario Ministry of Energy found that there is the capacity for generating 16,514 MW of electricity in combined heat and power plants by 2020. Most of this (14,037 MW) is in large industrial facilities like paper mills and refineries, but some of it (2,477 MW) is in small commercial buildings, hospitals and schools." While cogeneration is arguably not any hospital's core business, it does address issues that are core concerns of many Canadians.

With three acute care sites located throughout the city of Hamilton, including one on the same campus as McMaster University, Hamilton Health Sciences recognized that the potential existed to build its own power-generating plants and made a decision to go forward with cogeneration. The project was ambitious, particularly for a hospital without the resources and expertise necessary to finance, build and operate three separate cogeneration plants. However, it was also a project with tremendous potential to generate valuable economic, environmental and sustainability returns over the long term.

Getting Cogeneration off the Ground

Financing has been cited as one of the major inhibitors to cogeneration, particularly in Canada, where there is not the same level of political support for cogeneration and energy-saving technologies as there is in Europe. "Although cogeneration is a long-term investment, with equipment lifetimes of up to 40 years, in most cases it has to compete with other potential business projects that are expected to yield rapid returns. In addition, since cogeneration is often not considered to be core plant business, it receives lower priority. These factors may mean that schemes fall outside a company's investment criteria for a utility plant so alternative methods of financing often need to be investigated if cogeneration is to be implemented" (Cogen Europe 2001).

For most hospitals in Ontario, it is a challenge to access enough funding to cover essential core activities. Therefore, it was clear from the beginning that Hamilton Health Sciences would not be able to shoulder the costs related to planning and building three cogeneration facilities, even if the venture promised to deliver economic returns over the longer term.

The hospital decided to work in collaboration with Bay Area Health Trust (BAHT), an arm's-length entity created to develop revenue-generating opportunities for Hamilton Health Sciences. Hamilton Health Sciences' vice-president of Research and Corporate Development was also the president of BAHT at the time, which helped to ensure that business ventures were in tune with the hospital's core values and philosophies and that a good understanding existed between the two organizations. BAHT had already undertaken several projects related to Hamilton Health Sciences but was eager to pursue a larger-scope initiative such as the cogeneration project.

BAHT established a long-term business model for the project that attempted to capture all the costs and included a strategy that would ensure the capital costs of the project as well as costs of borrowing were paid back within eight to 10 years. With Hamilton Health Sciences as its primary customer, BAHT was able to leverage its relationship with the hospital to secure a $45 million loan at a rate close to what would equate with government debt. This collaborative approach was beneficial to both parties. With BAHT assuming ownership of the project and related equipment, the risk of the project to Hamilton Health Sciences was greatly reduced. Moreover, the hospital would still benefit from access to a consistent and independent energy supply and be able to profit from the project.

Implementation: The Three-Site Challenge

Under the business plan, three cogeneration plants would be constructed at the Henderson General Hospital, the Hamilton General Hospital and McMaster University Medical Centre (MUMC) simultaneously. By pursuing the three projects at the same time, BAHT and Hamilton Health Sciences were able to benefit from reduced pricing on the purchase of bulk equipment for the facilities and obtain a better rate on the overall project loan than would have been possible had each project been financed and implemented individually.

The scope for each project was slightly different. The Henderson required four generator sets and would produce seven megawatts of electricity, the General required three generator sets that would yield 5.25 megawatts and MUMC required six generator sets that would produce 10.5 megawatts.

The buildings of both the Henderson and the General hospitals are owned by Hamilton Health Sciences, which made selecting locations for the cogeneration facilities relatively straightforward. Location selection was based on adjacency to existing power production and switching equipment.

At MUMC, the location selection was complicated by the fact that Hamilton Health Sciences leases its hospital building from McMaster University and did not have a power plant. Until the completion of the cogeneration project, Hamilton Health Sciences had relied on the university's central power plant at the MUMC site. As a result, Hamilton Health Sciences needed to work closely with the university to obtain approval for the project and to select an appropriate location. MUMC's relationship with and proximity to the university also presented opportunities for Hamilton Health Sciences to supply power back to some or all of the university's facilities in the future, particularly as the university grows and develops with the addition of new buildings on campus. For that reason, the cogeneration facility was designed to produce more energy than at the other two sites.

Since cogeneration technology is well established, particularly within European countries, selecting vendors for the project was relatively simple. BAHT conducted a worldwide search and invited vendors to bid on the projects. Equipment costs constituted about 50% of the entire project budget, and, in the end, projections from the successful company proved to be quite accurate, coming in at within 5% of the original estimate.

Hamilton Health Sciences selected natural gas as the fuel source to power the electrical generator sets in all of its cogeneration facilities. Basically, a reciprocating engine works with an alternating current generator to produce electricity. Although other technologies are available and even arguably more efficient, by using a number of reciprocating engines at each facility, Hamilton Health Sciences and BAHT were able to build equipment redundancy into the overall designs. This means that in the event of equipment failure, the entire system will not be immobilized. Heat-recovery equipment is added so that 65–70% of the total energy typically wasted in the production process can be recovered and used within the hospital's heating systems. Waste heat boilers are also used to recover the heat and work with water heat exchangers attached to the engine's internal water-cooling circuits. Steam absorption–type water chillers allow waste heat to be cooled and used during warmer months in the hospital's air conditioning systems.

Implementing the three projects simultaneously created definite challenges for BAHT and Hamilton Health Sciences. Simply managing the three projects proved to be one of the biggest, and both organizations quickly realized that they did not have the necessary resources in house. Eventually, an external team was hired to manage the projects; however, even then, the projects proved to be much bigger and more complicated than originally expected. Original timelines were delayed, and construction costs were driven up. In the end, actual construction costs were between 40 and 50% higher than originally estimated.

In hindsight, project leaders agreed that the cogeneration facilities could have been constructed more efficiently if they had allocated more resources and capacity for project management from the very beginning. It also would have been prudent and beneficial to obtain more estimates for construction costs before beginning any of the projects since none of the original quotes came close to the actual construction costs.

Although there may have been some merit in cascading the projects and pursuing the MUMC project at the end since it was, by far, the largest and most complicated of the three, such an approach would have undermined the objective of the business case, which was to maximize the project's value by realizing associated savings as soon as possible. Delaying any of the projects would have compromised this approach.

While others interested in implementing similar cogeneration projects might consider taking a more conservative approach, there is definite value in what Hamilton Health Sciences did and accomplished. For instance, this ambitious and innovative project could easily have been delayed if the first installation did not meet expectations. Although this might have been a fiscally responsible approach in the short term, it would have negated the long-term value of the project, which will be measured in stable power to the hospital, eventual monetary returns and conservation of the environment.

Powering the Future

In combination, the three cogeneration plants at Hamilton Health Sciences produce 22.75 megawatts of electricity. This capacity is more than sufficient to meet the day-to-day operating needs of the hospitals, even during summer and winter months when cooling and heating demands are at their peak. As these facilities produce excess power, BAHT will sell the surplus to Horizon Utilities' primary electrical grid and to McMaster University for certain buildings on the campus. In total, the cogeneration projects will save Hamilton Health Sciences a minimum of $1 million each year, and the potential for greater savings exists.

There are also other benefits of cogeneration, particularly within a hospital setting. Cogeneration provides the sites with a stable and clean power supply, which will help protect staff, patients and equipment from both power loss and power surges.

These cogeneration facilities also provide infrastructure that can be used by neighbouring buildings if a situation arises where it makes sense to tap into an alternative source of power. Since Hamilton Health Sciences' facilities are located at three very different points within the city, opportunities for the hospital to supply power to new or existing buildings could easily come up as the city continues to grow and develop. Hamilton Health Sciences already supplies power to some buildings at McMaster University, and each year, representatives from the two organizations renegotiate a campus energy plan.

From an environmental standpoint, cogeneration also makes good sense. Although natural gas is used to power the engines, most of the energy is recoverable, which means there is little waste and pollution. "By improving fuel efficiency and burning less fossil fuel (which will reduce greenhouse gas emissions), we also reduce air pollution. Coal-fired power plants, found in many provinces are an example. These are major sources of both particulate pollution and greenhouse gases. Replacing them with natural gas co-generation facilities or renewable energy sources such as wind power would greatly reduce emissions of both types of pollutants and improve public health" (Suzuki 2002).

Despite the relatively low penetration of cogeneration facilities in Canada, environmental groups, government officials and others recognize the value and potential of this technology to help reduce demand on traditional energy-producing systems and as an environmentally friendly alternative.

As good corporate citizens with a particular interest in protecting health, hospitals have a vested interest in pursuing alternative technologies that will reduce harmful emissions. Hospitals also need to partner with individuals and organizations at many different levels, including municipal, provincial and even national, to lead by example and provide essential and sometimes life-saving resources, particularly during times of crisis. Through its cogeneration project, Hamilton Health Sciences is helping to eliminate pressure on the area's electricity grid and is well positioned to supply power to other critical resources and services in an emergency situation in which traditional power sources have been lost or compromised. Hamilton Health Sciences' experience offers one example of how hospitals can, and should, take an active role in energy production and conservation. HQ

References

Cogen Europe. 2001. *A Guide to Cogeneration.* Brussels, Belgium: Author.

Duncan, D. 2004. *Remarks at the Ontario Energy Association Energy Management/DSM Management Forum and Trade Show.* Toronto, ON. Retrieved November 15, 2006. <http://www.energy.gov.on.ca/index.cfm?fuseaction=media.speeches&speech=26042004>.

Hydro One. 2006. *About Hydro One Networks. Quick Facts.* Toronto: Hydro One. Retrieved December 4, 2006. <http://www.hydroonenetworks.com/en/about/quick_facts/>.

Independent Electricity System Operator. 2003. *Blackout 2003. Sequence of Events*. Toronto: Author. Retrieved November 15, 2006. <http://www.theimo.com/imoweb/EmergencyPrep/blackout2003/default.asp#Sequence>.

Strickland, C. and J. Nyboer. 2002. *Cogeneration Potential in Canada Phase 2.* Ottawa: Natural Resources Canada.

Suzuki, D. 2002. "Medicare Reform: Expanding the Health Care Debate." *Canadian Medical Association Journal* 166(13): 1678–79.

WWF-Canada, Greenpeace Canada, Pembina Institute for Appropriate Development, Sierra Club of Canada, Ontario Clean Air Alliance and the David Suzuki Foundation. 2006. *Put Some Energy Into a Smart, Green Strategy 2006.* Gatineau, QC: Pembina Institute.

About the Authors

William B. MacLeod is the vice-president of Research and Corporate Development at Hamilton Health Sciences. He plays an integral role in physical planning and redevelopment projects and also served as president of the Bay Area Health Trust, an arm's-length entity created to develop revenue-generating opportunities for Hamilton Health Sciences. Revenues from these projects, which include the hospital's cogeneration facilities, will be used for investment in capital equipment for the hospitals.

Murray T. Martin is the president and chief executive officer of Hamilton Health Sciences. With more than 30 years of experience in healthcare administration, Mr. Martin is committed to contributing to the development and sustainability of Canada's healthcare system.