TowerWise

Case Study:

Combined Heat and Power Installation on Senator David Croll Apartments

1. Executive Summary

The Senator David Croll Apartments is a 44-year-old, 19-storey rental apartment complex owned and managed by Toronto Community Housing (TCH). The building includes retail operations on its ground floor, including a 24-hour supermarket.

Faced with an aging diesel-fuelled emergency power system, TCH saw an opportunity to make the system cleaner and more robust while also benefitting from provincial programs supporting on-site electricity generation. In partnership with Toronto Hydro, TCH installed a natural gas fired combined heat and power (CHP) system to serve both as an emergency power source and to help meet the building's needs for electricity and domestic hot water.

Incremental Project Cost over Generator Replacement	$1,130,000
Electricity Generated in 2010	970,000 kWh
	38% of total building electricity demand
Annual Energy Cost Savings	Less than $10,000
Payback without Incentives	30 years+
Payback with CHPSOP (if available to 341 Bloor in future)	10-13 years
Net Annual Greenhouse Gas Emissions with CHP	+48 Tonnes

CHP systems capture the waste heat from the engine that spins an electrical generator and use this heat for space or water heating. As a result, they can have energy efficiencies of more than 80 percent. This compares with 60 percent energy efficiency of a standalone natural gas-fired combined cycle power plant, which can lose up to another 10 percent of produced energy through transmission losses. From a power system perspective, CHP systems can offset the need for new centralized generation and transmission capacity and reduce pressure on the aging downtown Toronto distribution grid.

By opting for CHP, TCH also ensured that the building could remain fully functional during a blackout, rather than just core emergency power loads remaining operational. Standard emergency power systems are designed to allow for a safe building evacuation; as such they only provide adequate power for emergency lighting and other critical systems. With the CHP system, the buildings' elderly tenants can remain in their suites during a blackout with no loss of functionality. As well, a blackout represented a major risk for the building's supermarket tenant, which would likely face costly spoilage in such an event.

The system has performed well and produced cost savings for TCH since its commissioning in 2009. However, a number of factors have limited the return on investment and environmental benefits from the project.

First, delays in the development of the province's Standard Offer Program for CHP led TCH to enroll the building in the less lucrative Demand Response 3 program instead. This has weakened the business case for the system. Furthermore, due to grid constraints and other factors, it was not possible to connect the system to the provincial electricity grid and, therefore, all the power the system produces is used on site. This may affect the project's eligibility for the Standard Offer Program in future.

Second, as a result of the building's reduced heating demand for the domestic hot water system in the summer, the CHP system cannot be economically operated in the summer months. Given that both the price and the carbon content of electricity tend to be highest in summer, this limits both the economic and the environmental benefits of the system.

Finally, the maintenance costs associated with the CHP system are significant and consume a large share of the revenue/cost-savings.

Future CHP projects should be able to achieve stronger economic and environmental benefits by qualifying for the CHP Standard Offer Program and incorporating thermal storage or tri-generation to facilitate year round system use.

2. Project Description and Rationale

The Senator David Croll Apartments is a 19-storey apartment complex built in 1968. It is currently owned and operated by the Toronto Community Housing (TCH). Toronto Hydro approached TCH to use the 326-unit building as a pilot project for installation of Canada's first rooftop combined heat and power (CHP) system.

The system was designed and installed by Toronto Hydro. Unlike most CHP systems, the TCH pilot system was installed on the building's roof for proximity to existing boilers, which involved lifting a 40 foot-long container to the top of the 19 storey building.

The project was timely as TCH needed to replace the building's existing emergency diesel generators. A reliable source of emergency power was required to keep the building operational both for the residential tenants, many of whom are elderly, and the commercial tenants, which include a 24-hour grocery store where there is a high risk of stock spoilage during a blackout. As the CSA Standard 282-05 was amended in 2006 to allow for off-site fuel supply for emergency power systems, natural gas could be used instead of diesel (Canadian Consulting Engineer 2007).

A CHP system could therefore be used with the existing natural gas supply to provide a robust source of baseload electricity from an on-site generator. The waste heat from this process could then be transferred to domestic hot water (DHW) storage through a heat exchanger. Benefits of CHP include a local source of power that avoids significant transmission losses and increased operational efficiency over conventional electricity generation. Furthermore, by helping to reduce peak demand, CHP systems can help to prevent or postpone the need for future investment in a new transmission corridor into the City of Toronto.

CHP Container Lift

3. Design and Installation

The TCH pilot CHP system was designed to meet the emergency power loads and electricity base loads for the building so that, ideally, only peak load electricity would be purchased from the local utility. Actual system performance is described in the following section.

Design of a CHP system must take into account both the heating and electrical loads of the building. Balancing these loads is essential for an efficient and cost-effective system because maximizing electrical production at all times will result in periods of excessive heat production necessitating heat dumping (Ontario Clean Air Alliance 2008). Ideally, a CHP system used for DHW should be sized to meet the majority of the hot water demand during sustained operation, without overheating the storage tanks and requiring heat dumping. Three years worth of electricity and gas consumption data – from 2006 to 2008 – was used to determine the appropriate system size for the building.

A natural gas engine with a total system efficiency of 83 percent, an electrical output of 335kW and a thermal output of 1.4MMBTU was selected. The particular model used was selected in part because it was the quietest, lowest emission engine on the market at the time. The engine and generator, along with the heat recovery equipment and controls, are housed in a 40 foot steel container. The design team, which included Toronto Hydro, DDACE and HH Angus, opted to install the container on the roof of the building so that it was close to the boilers and could exhaust directly. The most significant challenge of the entire project was hoisting the container up to the roof. On Jan. 5, 2008, part of Bloor Street was blocked off while the largest crane in Ontario performed the lift.

The system was not commissioned until over a year later, in July 2009, due to delays associated with the original plan to connect the generating equipment to the electrical grid. In the end, the project was commissioned without the grid connection.

Two existing natural gas boilers were left in operation, but only one is required to meet the residual DHW load not met by the waste heat from the CHP system.

4. Project Performance

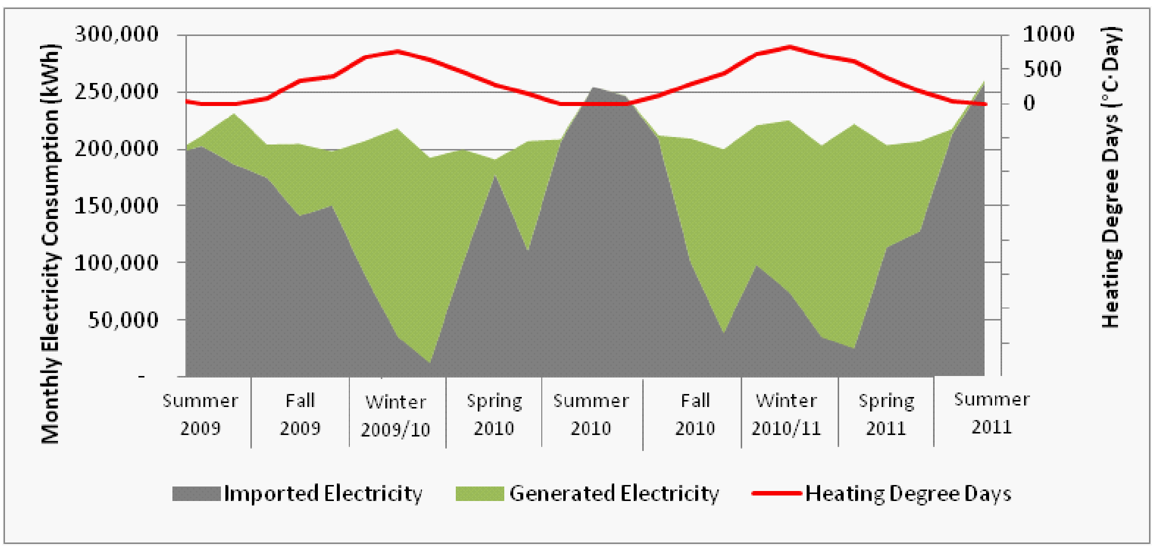
CHP system operation is determined by a number of factors including the cost to generate electricity, the generator operating time and the building's requirement for heat.

For economical performance, the CHP system operator must take into account the cost of generating electricity on-site versus purchasing electricity from the grid. The difference in these costs is known as the "spark gap". The plant at the Senator David Croll Apartments uses a controller system supplied by Toronto Hydro to monitor the real-time prices of electricity and natural gas to determine when it is profitable to operate the system. If it is not economically viable to generate electricity for more than 15 minutes at a time, the CHP system will shut down.

Another consideration for optimal system performance is the number of starts and stops that the engine experiences because "steady-state operation" is ideal for maximum efficiency. Excessive starts and stops also shorten the lifecycle of the equipment. Though the spark gap is an important driver of system operation, price volatility cannot be allowed to override minimum operating times required for efficient generation. For example, on a particularly volatile day, the algorithm which controls the system may switch the engine on and off a few times, but each time it will operate for a minimum of 15 minutes. This is to ensure that the system has warmed up and is operating at the optimal temperature for a minimum period of time before shutting down again (Graovac 2011a). The system has switched on and off about 840 times in the two years since commissioning, which is considered acceptable by the operator.

The building's need for heat also dictates system operation. Generation during periods where no heat is needed will necessitate dumping of the resulting waste heat. This correlation is shown in Figure 1, where generation typically takes place during periods of colder weather as shown by the heating degree day peaks.

Figure 1: Electricity Load Profile with Heating Degree Days



Generation tapers off in the shoulder seasons even though there may still be heat demand in the building, presumably because electricity prices are typically not as high as they are in winter. The minimal generation in summer is because the building does not require much heat. However, high electricity rates (especially on peak demand days) sometimes make it economical to switch the engine on for short periods.

Figure 2 shows CHP electricity production on a typical winter day. No other improvements to the building were undertaken before the installation of the CHP system, so the overall electricity load profile has not changed since the installation of the CHP system. The difference now is that when the building has significant heating demands, the CHP system can help to meet these while generating almost all of the electricity needed to

Figure 2: Typical Winter Operation

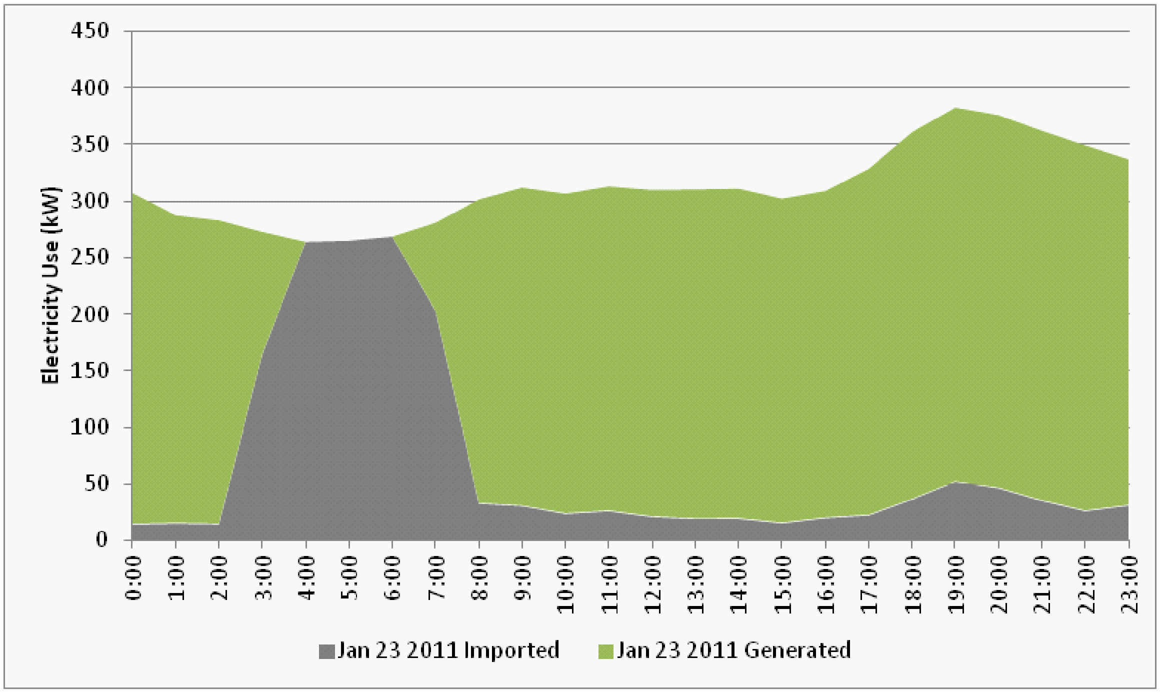
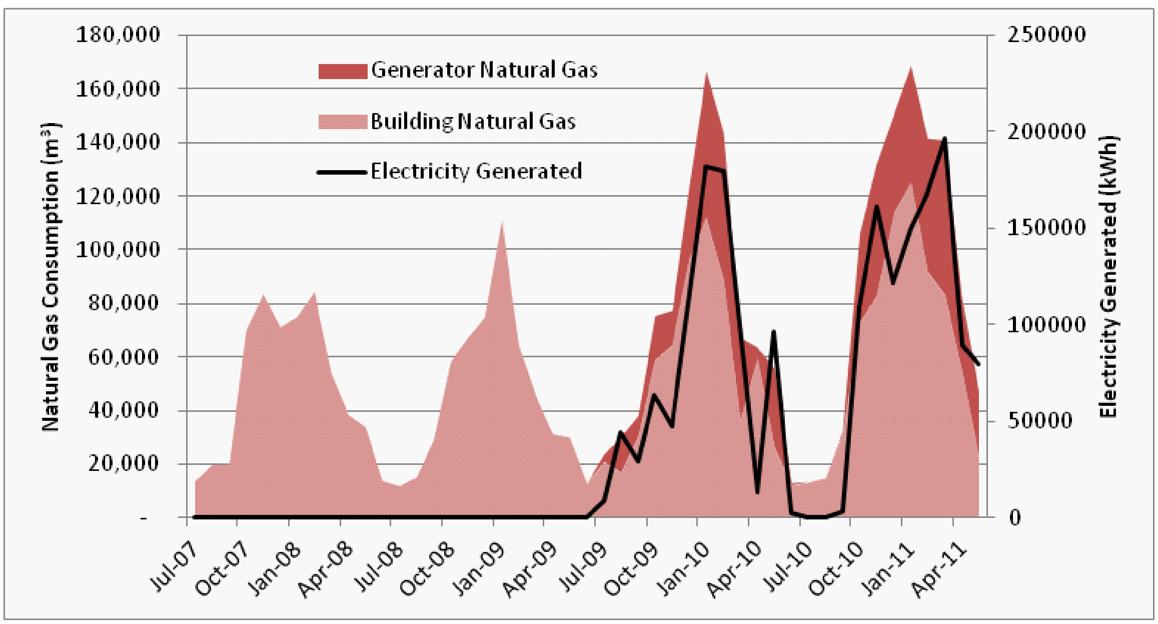


Figure 3: Natural Gas Use Profile before and after CHP installation



operate the building. (Toronto Hydro requires a minimum grid supplied electricity draw of 100kVA at all times to ensure network reliability.)

Figure 3 illustrates the building's natural gas usage, before and after installation of the CHP system, in comparison to on-site electricity generation. Of course, on-site generation has increased the building's natural gas consumption. But while the CHP system now accounts for a large portion of the building's natural gas demand, some of that increased demand is offset by gas no longer being consumed by boilers (replaced by waste heat from CHP).

The CO_2 emissions produced by the on-site natural gas combustion engine are compared with the avoided CO_2 emissions from on-site electrical generation as shown in Table 1. The CO_2 emission factors used are as follows:

- Electricity from the grid: 0.187kg/kWh (TAF)
- Natural gas in a conventional boiler: 1.879kg/m^3 (TAF)
- Emissions factor for the CHP engine: 0.54kg/kWh (Graovac 2011e)

Table 1: Estimated CO_2 emission for 2010 with and without CHP

2010 Energy Use		Without CHP	With CHP	Net CO_2 Emissions
Electricity Imported	kWh	2,535,000	1,532,000	-188
	Tonnes of CO_2	474	286	
Electricity Generated by CHP	kWh	-	1,000,000	+540
	Tonnes of CO_2	-	540	
Natural Gas (Boilers)	m^3	545,000	383,000	-304
	Tonnes of CO_2	1,024	720	
GHG Emission Balance				**+48**

Note: 296,000 m^3 of natural gas is required by the CHP to generate the 1,000MWh of electricity. The resulting emissions from this combustion process are determined by using the CHP engine emissions factor above. An efficiency of 65% was assumed for the boilers in the "Without CHP" scenario.

The CO_2 emissions associated with CHP operation in 2010 were slightly higher than the combined emissions resulting from the equivalent kilowatt-hours of electricity drawn from the grid and the equivalent thermal kilowatt-hours generated in a conventional boiler.

5. Maintenance

The TCH CHP pilot has a service and maintenance contract for the CHP system with Toronto Hydro at an annual cost of approximately $40,000 (based on 2010 operating hours), which includes a fixed annual amount of $21,210 and a variable portion of $4.51/operating hour. In addition to this routine service, the system is visually inspected every working day to ensure everything is functioning. Major servicing costs will likely be incurred about every 15 years (Graovac 2011b).

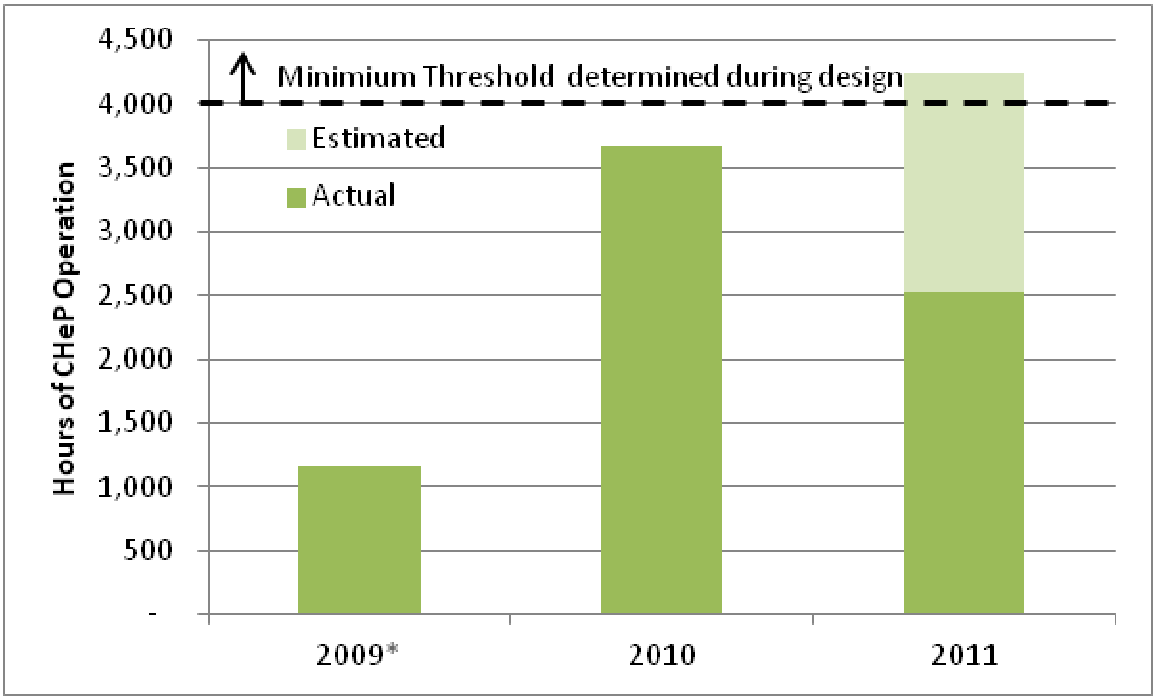
6. Project Cost and Revenue

The capital cost of the project was budgeted at $1,225,000 but came in 8.5 percent over budget at $1,329,300 including change orders and a 10 percent mark-up applied to change orders. There were a few reasons for the budget overruns, including the equipment lift to the building rooftop and associated road closure as well as protection requirements that were required by Toronto Hydro when it was anticipated that the system would be connected to the grid.

Funding for the project was provided by a number of sources. Natural Resources Canada (NRCan) covered 50 percent of the project cost with the agreement that TCH would share the savings. Enbridge, Toronto Hydro and the Toronto Atmospheric Fund also contributed funding to offset the capital and planning costs of the project.The number of annual operating hours drives both cost (natural gas and maintenance) and revenue (avoided grid-supplied electricity costs and incentive payments) for the system. The minimum projected operation time for the system, as determined during design by Toronto Hydro, was 4000-5000 hours. The "ideal" running time of 5980 hours per year was determined based on the best internal rate of return considering energy prices, heating loads and equipment efficiency (Graovac 2011a). The actual system operation hours are shown in Figure 4.

At the time of writing, the 2011 operating hours were 15 percent greater than for the same months in 2010, so based on this performance, the system is capable of meeting the minimum threshold for economic operation determined at the design phase of the project. However, the number of operating hours could actually decrease now that the building participates in the OPA's Demand Response 3 (DR3) program. This is because payments under DR3 are based on the differential between the building's typical demand during peak periods and the amount this demand can be reduced via activation of the CHP system. See below for a more detailed explanation of the DR3 program. The system currently draws revenue from two sources: electricity cost savings and revenue from enrolment in the DR3 program. In future, it may be able to draw revenue from the OPA's CHP Standard Offer Program.

Figure 4: Hours of CHP Operation



Note: The system was commissioned in July 2009 so 2009 includes less than half a year of operating hours.

Energy Cost Savings

To calculate the energy cost savings of the project, we must take the total projected energy cost without the CHP system and subtract the total actual energy cost with the CHP system plus the cost of CHP maintenance.

These energy costs can be divided into two parts: natural gas usage and electricity usage. Natural gas cost savings are equivalent to the gas usage offset by waste heat from the CHP system, less the gas used to generate electricity. This actually resulted in a negative savings (additional cost due to increased gas use to run generator) of -$34,000 in 2010. To determine gas savings, we factored in gas prices, conventional boiler efficiency – assumed to be 65 percent efficiency – and heating degree days, to determine the gas that would otherwise be required for water heating in the absence of the waste heat from the CHP system.

On the electricity side, cost savings are represented by the monthly kWh reduction in grid-supplied electricity plus payments received through the DR3 demand response program. To calculate savings, we used a cost of 7.9 ¢/kWh as any building with generating equipment is still required to pay the debt retirement charge (0.7 ¢/kWh) to the Ontario Electricity Financial Corporation (Graovac 2011d). The combined savings and DR3 payments amounted to approximately $78,000 in 2010.

After factoring in maintenance costs, the resulting net annual benefit from energy cost savings alone is less than $10,000 and is highly sensitive to changes in energy prices and maintenance costs.

Combined Heat and Power Standard Offer Program

The TCH pilot CHP system was initially designed to take advantage of the OPA`s CHP Standard Offer Program, originally announced in 2007 but not launched until 2011. If the system were enrolled in the the Standard Offer Program, TCH would have a 20-year contract that pays it $28,900 per MW of installed capacity per month (OPA 2011a) as compensation for having its plant available to supply electricity to the Ontario electricity system. For existing buildings such the Senator David Croll Apartments, where aging electrical infrastructure makes it difficult to export electricity, the OPA can, on a case by case basis, allow a displacement contract as opposed to an export contract (Simpson 2011). This is also known as a “Behind-the-Meter Facility” (OPA 2011b).

The revenue earned through electricity exports from the system is then deducted from the monthly standard payment to calculate the monthly net payment. (In the case of a behind-the-meter facility like the Senator David Croll Apartments, the electricity cost savings from self generation are deducted from the standard payment).

Based on its system capacity, the projected CHP Standard Offer Program revenue for the TCH pilot would be about $113,000 per year (Zhang 2011a). The net revenue from assumed market electricity sales are based on the performance of the OPA’s modelled CHP plant, characterized by a deemed heat rate and variable operating costs, in conjunction with the prevailing daily natural gas prices and hourly Ontario electricity prices for the specified month. The CHP plant must be available to generate electricity at all times but does not necessarily have to be operated at the same schedule as the OPA’s modelled plant, typically about 2200 hours.

The actual net revenues from market electricity sales will differ from those that are assumed in determining the contract settlement payment and would be based on the TCH pilot system’s actual heat rate, costs, and operating times (Yahoda 2011) compared to those of the “model” CHP plant. Essentially, if the TCH plant is more efficient than the model plant, it will earn more net revenue. However, any increase in electricity sales revenue will be deducted from the standard monthly payment. This reduction in the guaranteed revenue has been estimated at $10,000-15,000 per year maximum (Graovac 2011c).

Unfortunately, due to the delays in the OPA launching the CHP Standard Offer Program, TCH chose to enroll in the less lucrative DR3 Program instead. It will reassess the potential for enrolling in the Standard Offer Program when its DR3 contract expires (systems cannot be simultaneously enrolled in both programs).

Demand Response (DR3)

The DR3 program is designed to relieve pressure on Ontario's generation and distribution systems during periods of peak electricity demand. It pays large energy users (or a group of energy users brought together by an aggregator) to be ready to reduce their electricity demand for a certain number of contracted hours each year (e.g., 100 or 200 hours). Under DR3, use of "embedded generation" (e.g., a CHP system) is considered another way of reducing demand for grid-supplied electricity.

However, while enrolment in DR3 is a valuable revenue source for TCH pilot thanks to payments received for both "availability" (system available to generate power in peak periods) and "utilization" (system generating power in peak periods), it also results in a disincentive to operate the system in non-mandated periods when electricity demand is high. This is because the DR3 payments are based on the differential between baseline grid-supplied electricity usage in peak periods by the building and the amount by which the system can reduce this demand when operating. To maximize this gap, the operator would likely keep the system idle during peak periods unless there is a call from the Ontario Power Authority to activate the system. Given that peak demand (and DR3 activation) occurs most often in the summer when CHP operation is least economical due to a low building heat load, this may be less of an obstacle than it first appears.

As a system with less than 5 MW of capacity, the TCH CHP system had to be enrolled in the DR3 through an aggregator, in this case the City of Toronto. Participation requires that the building be ready to reduce its demand for grid-supplied power at certain times of the day for a four-hour block in response to a notice issued by the OPA, typically one day in advance. TCH has enrolled in the program for a three-year term starting in August 2011. This contract requires 100 standby hours and, historically, 30-40 actual operating hours (Lundchild 2011). Payments are calculated at $92 per MW for availability and $200 per MWh for actual activation. Annual DR3 revenue for Bloor Street is expected to be around $24,000.

7. Financial Analysis

In order to conduct a financial analysis of this project, a number of assumptions must be made about the future operation of the system. For example, there is uncertainty about the number of annual operating hours and utility rates as well as what OPA incentive programs (if any) the system will be enrolled in after its current DR3 contract expires.

For the purposes of this analysis, annual operating hours equal operating hours from 2010 (3661 hours). However, this would be reduced to 2000 hours under the rules for DR3 participation (Graovac 2011d) and 2200 hours under CHP Standard Offer Program.

Given the volatility of gas prices, we assume that gas prices will remain flat through the 15-year projected period while including both a high and a low price scenario for electricity. The low scenario is based on no electricity price increase during the period, while the high scenario includes a 9 percent annual increase from 2012 for the following three years and then flat prices for the remainder of the period (as projected in the province's long-term electricity plan).

The simple payback and return on investment (ROI) of the CHP installation are based on the cash flow diagram presented in Figure 5 showing capital expenditure, maintenance costs and natural gas costs as negative cash flows and electricity cost savings as positive cash flows.

Figure 5: Cash Flow Diagram

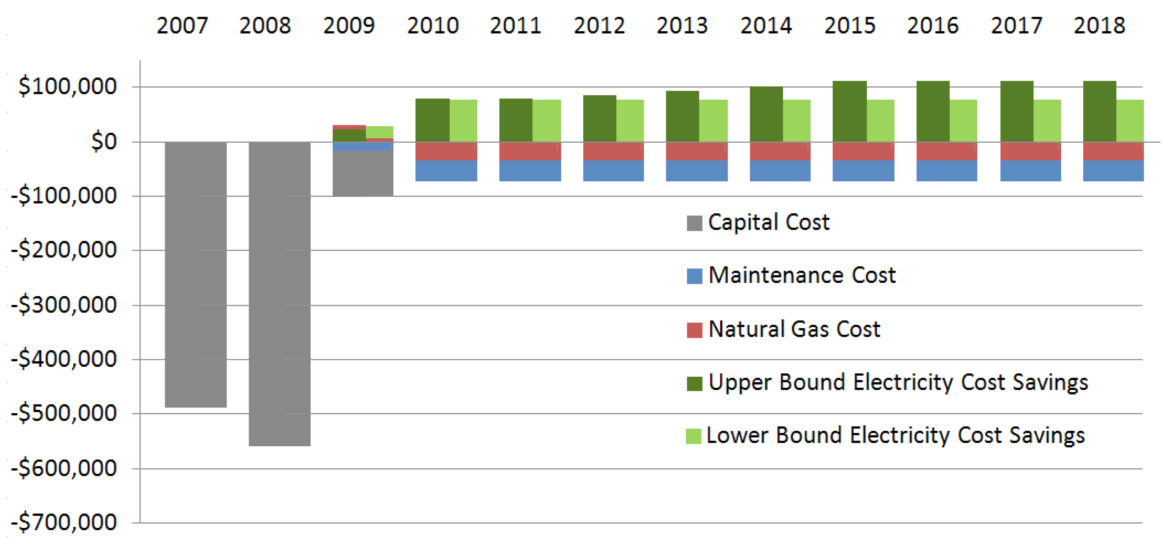


Table 2 shows the simple payback and return on investment (ROI) for the first 15 years following the installation of the CHP system. Note that the 15-year performance period begins in 2009, the last year that costs were incurred for the system and the first year that energy cost savings were generated. As the system was only commissioned mid-way through 2009, the measures in the table below will be conservative.

As well as the two electricity price scenarios, Table 2 includes projections that take into account revenue from the OPA DR3 and the Standard Offer Programs. Only under Standard Offer Program and high electricity prices does the system become economic, illustrating the importance of these support payments that recognize the wider benefits of such systems (avoided transmission losses, reduced pressure on the distribution system, reduced need for additional transmission capacity, reduced peak demand, avoided new generation capacity).

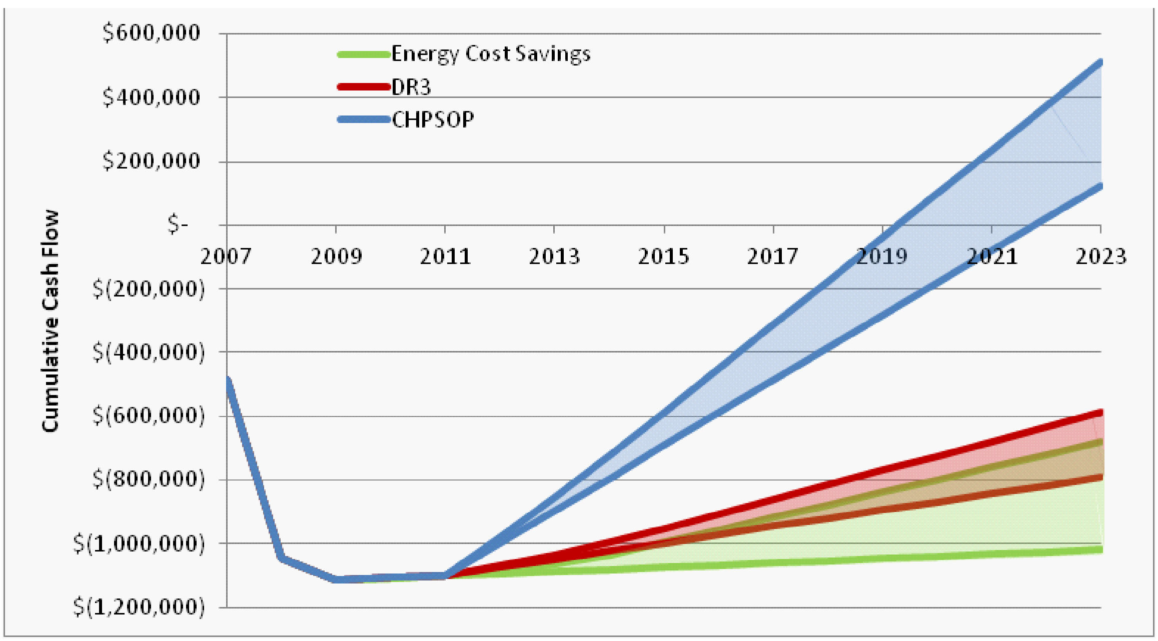
Table 2: With Standard Offer Revenue

Scenario		Estimated Annual Revenue from OPA	Simple Payback	15 year ROI (Est.)
Energy Cost Savings Alone	Upper	-	31 years	-60%
	Lower		>50 years	-90%
With DR3 Revenue	Upper	$24,000	27 years	-52%
	Lower		45 years	-70%
With CHPSOP Revenue	Upper	$113,000	10 years	46%
	Lower		13 years	12%

Though not shown here, no scenario generated a positive net present value during the 15 year performance period.

To demonstrate the influence of the OPA incentive programs, Figure 6 shows a cumulative cash flow diagram which includes a performance envelope for energy cost savings alone, the DR3 scenario and the Standard Offer Program scenario. All scenarios assume OPA program revenue begins in 2012.

Figure 6: Cumulative Cash Flow Diagram



When cumulative cash flows reach the horizontal axis, the net benefit begins to exceed the capital cost expenditure (note that this does not include the time value of money).

8. Lessons Learned

For other properties looking at a CHP system, the TCH pilot project participants recommend a detailed planning process involving the local utility and the OPA to avoid any unforeseen challenges during installation and commissioning, such as the one-year delay that was experienced by TCH as they struggled to address grid connection issues.

It is also important to note that the contract capacity for the CHP system is not necessarily the same as the rated capacity. The TCH system has a rated capacity of 335kW system, but a contract capacity of approximately 300kW and an average operating capacity of about 260kW. Pre-project revenue estimates must be based on the appropriate capacity (e.g, operating capacity not rated capacity). Also, the more efficient the CHP unit, the better the returns are likely to be. Maintenance costs, which can be fairly substantial, must also be factored in.

The de-carbonization of Ontario's electricity mix means that embedded gas-fired generation could actually have higher greenhouse gas emissions than grid-supplied electricity. However, this will be much less true in peak periods, when the province still relies heavily on fossil fuel generation. That is because CHP generation is substantially more efficient than using large natural gas generating plants and transmitting power.

Unfortunately, peak demand usually occurs on hot summer days when building heat load is low and it is uneconomic to run the CHP system without incentives. Incorporation of thermal energy storage or tri-generation to provide cooling through an absorption chiller could help address this problem and give the system greater economic and climate benefits.

9. Conclusions

Toronto Community Housing Corporation (TCH) has been an innovator and leader in energy efficiency and renewable energy, regularly exploring and integrating advanced energy systems in its building portfolio. The pilot CHP installation at TCH's Senator David Croll Apartments faced significant challenges and has produced some important knowledge outcomes that can be useful to public and private proponents considering this technology.

The CHP system currently supplies almost 40 percent of the building's electricity each year, has the capability to maintain complete functionality during a blackout, and provides a much cleaner source of back-up power.

While this particular project does not demonstrate a strong business case, analysis of the planning, installation, operation and financing elements provides insights on how to significantly strengthen the business case for subsequent applications, specifically:

- Ensure CHP system size is matched to building heating load
- Plan for summer use of excess heat (such as tri-generation or thermal storage)
- Reduce maintenance costs
- Ensure a grid connection is feasible in order to facilitate participation in the OPA's CHP Standard Offer Program

Adoption of de-centralized energy has been hampered by barriers to grid connection and lack of clear pricing arrangements, and this case was no exception. This pilot project illustrates the critical importance of effective incentive and procurement program design, as well as the need for clarity regarding program eligibility requirements and operating rules to allow project initiators the confidence to properly design and deploy cost-effective systems.

Overall, CHP offers flexible, de-centralized power generation with a wide range of local benefits including avoided transmission losses, reduced need for additional transmission and generation capacity, reduced peak demand, and perhaps most importantly, reductions of the constraints on the local power grid. Unfortunately, the current CHP Standard Offer Program does not provide clarity, and requires operators to undertake a full system design and submit a detailed application without confidence that their project will be accepted into the program. This uncertainty, along with grid connection issues, is likely to limit investment in CHP projects in the near term.

Acknowledgements

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References

Canadian Consulting Engineer. 2007, May 1. What's New.... [Online] Available: http://www.canadianconsultingengineer.com/news/what-s-new/1000212818/

Ontario Clean Air Alliance. 2008. Towers of Power. [Online] Available: http://www.health-power.ca/chpmultiresweb.pdf

Ontario Power Authority. 2009, May 8. Program Rules. [Online] Available: http://archive.powerauthority.on.ca/Page.asp?PageID=1212&SiteNodeID=314

Ontario Power Authority. 2011a, May 2. Combined Heat and Power (CHP) Standard Offer Program. [Online] Available: http://www.powerauthority.on.ca/sites/default/files/page/CHPSOP%20Rules.pdf

Ontario Power Authority. 2011b, June 15. Appendix 1 – Standard Definitions. [Online] Available: http://www.powerauthority.on.ca/sites/default/files/page/CHPSOP%20Standard%20Definitions_0.pdf

D. Graovac. 2011a, Sept 8. Toronto Hydro-Electric System Limited [personal communication, email]

D. Graovac. 2011b, Sept 28. Toronto Hydro-Electric System Limited [personal communication, email]

D. Graovac. 2011c, Sept 29. Toronto Hydro-Electric System Limited [personal communication, phone call]

D. Graovac. 2011e, Oct 6. Toronto Hydro-Electric System Limited [personal communication, email]

D. Graovac. 2011d, Dec 1. Toronto Hydro-Electric System Limited [personal communication, phone call]

E. Lundchild. 2011, Oct 2. Ontario Power Authority [personal communication]

J. Simpson. 2011, Aug 30. Toronto Hydro [personal communication]

D. Yahoda. 2011, Sept 29. Ontario Power Authority [personal communication]

F. Zhang. 2011a, Nov 14. Toronto Community Housing Corporation [personal communication, email]

F. Zhang. 2011b, Nov 25. Toronto Community Housing Corporation [personal communication, meeting]

Glossary

Equivalent Carbon Dioxide (CO_2e) – A measure used to compare the emissions from various greenhouse gases based upon their global warming potential. For example, the global warming potential for methane over 100 years is 21. This means that emissions of one metric ton of methane are equivalent to emissions of 21 metric tons of carbon dioxide. (Source: Organisation for Economic Co-operation and Development)

Heating Degree Day (HDD) – Represents the amount of heating energy required during the heating season. It is measured by the difference between the base temperature of 18°C and the mean temperature for a particular day. (Source: Natural Resources Canada)

Heat Exchanger – A device used to transfer heat from one fluid to another across a barrier which does not allow the two fluids to come into direct contact. (Source: The Renewable Energy Resource Centre)

Internal Rate of Return (IRR) – The discount rate at which the net present value of all cash flows from a particular project is equal to zero. The IRR can be used to compare several projects under consideration. If all other factors are equal among the various projects, the project with the highest IRR would likely be selected first. (Source: Investopedia)

Net Present Value (NPV) – The difference between the present value of the cash inflows and the present value of the cash outflows which can be used to analyze the profitability of a project. (Source: Investopedia)

Return on Investment (ROI) – The benefit of an investment, or gain from investment minus cost of investment, is divided by the cost of the investment. This ratio or percentage is used to show the efficiency of the investment. (Source: Investopedia)

Simple Payback – The length of time in years required to cover the cost of a project. It is calculated by dividing the cost of the project by the annual cash inflows. (Source: Investopedia)

Weather Normalization – A mathematical process that adjusts actual energy usage so that it represents energy typically used in an average year for the same location. This accounts for weather differences from year to year that may result in abnormally high or low energy consumption. (Source: ENERGY STAR)

www.TowerWise.ca

TAF's TowerWise program works with high-rise owners and managers to reduce energy use and emissions from apartment towers and condominiums. TowerWise provides unbiased advice and assistance to help high-rise owners make their buildings more comfortable and less polluting. To get involved with the TowerWise program, contact Lyle Jones at ljones@tafund.org, 416-393-6370

Toronto Atmospheric Fund

The Toronto Atmospheric Fund (TAF) has been sparking action on climate, air pollution and energy use in Toronto for 20 years. Internationally recognized for its innovative and effective programs, TAF has helped the City save millions on energy costs and helped citizens to live greener lives in healthier communities. TAF relies exclusively on income from its own endowment and investments from program partners for its operations. For more information, visit www.toronto.ca/taf

Toronto Community Housing

Toronto Community Housing is the largest social housing provider in Canada and the second largest in North America. It is home to about 164,000 low and moderate-income tenants in 58,500 households, including seniors, families, singles, refugees, recent immigrants to Canada and people with special needs.