A Case for Accelerating the Rollout of Small-scale, Combined Heat and Power (CHP) Projects Through a CHP Case Study

The Go Transit, Streetsville, Bus Maintenance Facility

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by David Baker

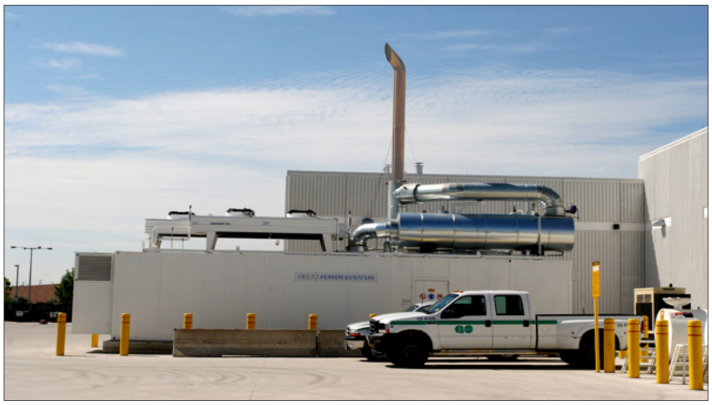
Ontario's local electric utilities need "billions and billions" of dollars in investment, and will be seeking higher prices to raise the money, says the head of the utilities' association as printed by the Toronto Star newspaper on November 14th, 2011. Jim Keech, chair of the Electricity Distributors Association, said utilities are under pressure to renew their systems on numerous fronts.[1]

It is our (the taxpayer's and ratepayer's) money, so we have to ask, could these "billions and billions of dollars" be spent more efficiently than is currently being contemplated? And, could we spend less to get more? The simple answer to both of these complex questions is, "Yes." However, when looking at the broad energy landscape these are particularly difficult questions when almost every solution is heavily resisted by diverse but important segments of our population. Every resident of Ontario, who follows the news, is acutely aware of the difficulties we face when the Ontario Power Authority (OPA) draws up plans for new gas or nuclear power plants. Plus, new transmission lines are fought inch-by-inch by landowners and local residents as new right-of-ways are sought out.

We must deal with these issues since most of our aging nuclear reactors will come to the end of their lives during the next five to ten years. Nobody will argue against the fact that Ontario's electrical infrastructure must continue to be modernized and maintained. But there is no simple, single answer as to how. This case study gives an example of a small-scale, distributed, natural gas **Combined Heat and Power (CHP) Plant** and suggests how this option can play a significant role in the solution to Ontario's energy dilemma.

THE MISSISSAUGA GO TRANSIT CHP PLANT IN STREETSVILLE

It happens that one of the most efficient uses of energy dollars is nestled behind the Mississauga Go Transit bus maintenance facility in Streetsville. Here there is a small-scale, inconspicuous **CHP Plant** that quietly goes about its business to provide electricity and heat to the massive structure that is used for maintenance for more than 200 buses, with two indoor, automated bus-washing stations, a paint shop and storage for 104 buses. Located at 6190 Mississauga Rd., the 281,122-sq.-ft. facility opened on March 3rd, 2009[2].



Left, 1.2 MW Go Transit CHP Plant with roof-mount heat exchange system; right, Go Transit Streetsville bus maintenance area.

Combined Heat and Power is the simultaneous production of electricity and heat using a single fuel such as natural gas. The heat produced from the electricity generation process is captured and used to produce steam or hot water that can then be used for industrial and commercial heating or cooling purposes, such as district energy systems. The dual output of CHP facility can make more efficient use of fuel than two separate facilities that each just produce just heat or electricity. Consequently a CHP facility can provide the same energy services with lower greenhouse gas emissions.

Overall efficiency can exceed 80 % — which means that 80 % of the energy can be captured as electricity or usable heat. At the moment CHP plays a small role in Ontario's Long Term Energy Plan[3] but it is fully capable of playing a much larger part.

The Go Transit Streetsville CHP Plant acts as an electricity generator and is part of a heating system that distributes heat through pipes beneath the cement floor. The heat produced is used to supplement the heating needs of the main bus facility, including space heating and snow melt. On the coldest days it requires approximately 1.5 Megawatts (MW) of heat per hour. Of that, the CHP system can provide 1.2 MW.

The Go Transit CHP system, with a nameplate capacity of 1.2 MW, is the size of a single shipping container. It delivers over 2.4 megawatts of combined electrical and thermal energy. Excess electricity is sold to the grid. Income and energy savings produce an estimated annual operating profit for Go (and therefore Ontario taxpayers) in excess of $120,000 annually[4]. Optimizing use of the recovered heat is the key to profitability.

The Go Transit CHP system, which complies with the CSA C282 standard, also provides emergency electricity backup during a blackout for this key transit facility. In the case of a blackout, even when the natural gas generator is not operating, the automation system picks up the drop in power and within a millisecond commands the UPS (Uninterruptible Power Supply) to instantly kick-in to support emergency lighting and other vital operating systems; followed by a 50 kW diesel generator that takes a few seconds to start; followed 20 seconds later by the natural gas generator, to provide 1200 kW of power.

Go Transit is in the process of building a second CHP system in Oshawa that is identical to the Streetsville site but with the addition of a chiller for air conditioning in summer. This becomes a complete end-to-end energy solution.

The Go Transit CHP system is a good example of small-scale **distributed energy production** fuelled by natural gas. Small-scale distributed energy production is generally defined as localized generation that produces less than 40 MW of combined energy output, in close proximity to the consumer(s) of the power. Examples of distributed energy also include wind, solar PV, and biomass power production. It is the antithesis of "centralized power" which is generally defined as large 400 MW to 5,000+ MW plants fuelled by uranium, coal or natural gas and located far from end users.

Some of the advantages of small-scale Distributed Energy over large, centralized power plants are:

- Reduced risk of a massive power outage over a wide region, therefore increased reliability of the overall grid;
- Reduced need to build more, unsightly and expensive transmission lines, often one of the most difficult parts of siting an energy plant (cost is between $240,000 and $2,000,000 per mile, installed excluding land fees);
- Significantly less cost for land (smaller footprint required for the power plant and no need for transmission line right-of-ways);
- No line loss – electricity that travels over transmission lines loses a significant percentage of power relative to distance travelled. Average annual line loss in Ontario is 7% and in rare cases during peak periods as much as 20% of the energy is lost. An average loss of 7% (approximately 9.94 TWh or $646,000,000[5] per annum) between the generator and the user is a significant financial loss to the consumer.
- Smaller carbon footprint using natural gas, wind and solar PV = less impact on the local environment;
- Faster, less complicated and less costly interconnection to the grid; and
- Uncomplicated commissioning process.

HIGHLIGHTS OF THE GO TRANSIT CHP PLANT

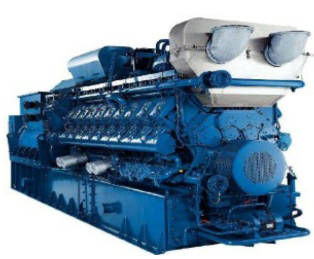
Operations – The CHP plant has been successfully operating at the GO Transit Streetsville facility since March, 2009. The system was installed and is operated by Buttcon Energy Inc. (BEI) using BEI's "Smart Generation" operating software developed by BEI[7]. Using internet based computer technology, the automation system is capable of remotely managing, monitoring and dispatching the generation control systems to create secure, reliable, and economic benefits for the site. This includes integrated wireless device (smartphone/pad) monitoring for remote alarm monitoring and system management. Although the system is fully automated, it still requires maintenance technicians to perform on-site repairs, warranty work and general maintenance.

The System – The backbone of the technology is the natural gas generator from Motoren-Werke Mannheim GmbH (MWM GmbH) or (Deutz) CHP series TCG 2020 V12 Natural Gas Engine. The fully automatic engine is capable of automatic starting and stopping, and produces rated power in parallel with the local utility for selling excess production to the grid. Basically it is a power plant in a box which includes the generator, oil cooler, after cooler, radiator, heat exchange system and all other necessary operating equipment. It is MOE and TSSA compliant.

Energy Production – The electricity produced on an average daily basis is 12 megawatt hours (MWh). The thermal energy produced on an average daily basis is 12 MWh in winter and 0 MWh in summer producing an average of 6 MWh daily on an annualized basis. The current configuration has no host for off-season heat. Future installations will include an absorption chiller that will provide 120 tons of facility cooling via the recovered heat.

Operating software – Go is capable of monitoring, in real-time, local weather conditions, building load requirements, gas prices, electricity prices and emission output to optimize the generator's real-time operating parameters. The system also monitors local utility gas and electricity rates, including time of use rates, then calculates the math. It will direct maximum power to the transit facility during peak periods when grid power is the most expensive and direct less power to the facility during off-peak periods when grid power is less expensive. In other words; the system turns itself on when the economics are good, in real time, and off when they are not.

CHP Specifications



TCG 2020 V12 Natural Gas Engine

- **Electric power:** **1200 kW**
- **Thermal output:** **1210 kW**
- **Electrical efficiency:** **43.1 %**
- **Thermal efficiency:** **43.5 %**
- **Combined efficiency:** **86.6 %**

Note: Caterpillar is in the process of acquiring MWM GmbH

Emissions & Risk – Although the plant is fuelled by natural gas, which isn't considered "green energy", it is considered "clean energy" as there are far less emissions than coal or diesel-powered generators. According to the Ontario Power Authority, the CO_2 emission rate for CHP is 80% less than that of a coal-fired generating station. There is also far less cost and accident risk than those associated with handling and storing nuclear fuel.

Heat Exchanger – The core of the heat recovery system includes the exhaust gas heat exchanger and engine cooling water heat exchanger, with booster pumps.

Capital Cost – The traditional method of evaluating the cost of a power plant is to compare the total installed capital cost against the nameplate capacity (which is listed as the maximum number of kilowatts that can be produced in one hour by the power plant). For instance, AECL submitted a bid to build new reactors at Darlington in 2009 at a cost of $26 billion for two 1200 MW reactors, or $10,800/kW[8].The capital cost for the Go facility was approximately $1.8m with a nameplate capacity of 1200 kW. When energy is added for the thermal component, the capital cost is below $1,500/kW which represents quite a low capital cost/kW for an energy plant. For example: on-shore wind turbines cost approximately $2,400/kW[9], solar PV approximately $5,000 -7,000/kW[10], nuclear $10,000+/kW and hydro $2,000 - 5,000/kW[11].

Enclosure – The generation system is contained in a rugged, self-contained,walk-in, sound attenuated, weatherproof enclosure that is the size and shape of a shipping container which is delivered to the site fully equipped.

Reports and Monitoring – The system is equipped with a full portfolio of on-line reporting tools. The unit is monitored in real time for safety, maintenance, production and security purposes which contributes to efficient maintenance cycles.

Security – The enclosure is equipped with a very secure, lock and key-pad entry system, internet and smart phone monitored fire & gas alarm system, intrusion detector, and web-cam monitoring system. The system will automatically shutdown in certain emergency or security situations and can also be shutdown remotely.

Noise – The bare system produces noise levels consistent with 60 db @ 50 ft. Once placed in the sound attenuated enclosure, noise is reduced to a point that it is no louder than that of a car idling close by.

Installation – The system is delivered in the self-contained enclosure as described above. Pre-installation includes the necessary gas delivery and coupling equipment and cement pad. Actual installation and commissioning time is between one and two weeks after delivery of the container. Because the system is prefabricated, engineering, construction and installation cost is greatly reduced compared to an on-site built system.

New Go CHP Plant – Construction is under way for the next CHP plant at the Go Transit, East Regional Bus Facility Maintenance & Storage Garage in Oshawa, with an added absorption chiller that will provide approximately 100 tons of chilling capacity for air conditioning in the summer.

LOCATION, LOCATION, LOCATION

Location is always an issue when situating a power plant. The ideal setting is to place it as close to the users as possible. Small-scale CHP units such as the Go Transit Streetsville plant are rated for residential and commercial use, meaning safety issues, noise and emissions are low enough to be located almost anywhere. For instance: A 1200 kW (1.2 MW) generator such as the Go Transit unit could provide all of the heat and power to sustain a residential development of up to 430 detached homes using a central heating system and micro-grid for the electrical distribution.

SCALABLE IN SIZE

Natural gas fuelled CHP plants are also scalable in size and are ideal to power individual commercial operations or to transmit electricity via micro-grids to slightly larger geographic areas. Micro-grids are now found in the oil and gas fields, resorts, commercial zones and sometimes small communities. As the need grows for more power over time, small systems can be scaled-up by daisy-chaining generators to increase output. Small-scale CHP systems range from a mere 1 kW (e.g. Honda micro-CHP unit for the home) to more 20 MW. There are centralized, large-scale CHP power plants that reach more than 400 MW in size such as the Sarnia CHP natural gas-fired 440 MW industrial cogeneration facility[12].

REDUNDANCY

On-site power production coupled to the grid means the two sources can supplement or back each other up. On-site redundant generators also back each other up, and packaged with a UPS are able to provide the virtual guarantee of a 100%, uninterrupted, commercial power supply for the end-user. This is vital for facilities such as hospitals, airports, and government buildings as well as EMS, data and communication centres. When redundant generators are not required to supply primary power, they can continue to operate to supply power to the grid to generate income as with the Go Transit case. In this way, not only do they virtually guarantee 100% power to the consumers they serve, they also pay for themselves over time.

DISASTER RELIEF – THE CHP COMPONENT

A small-scale CHP system can serve as a major component for a region's disaster response strategy if located in a central area of a community such as a high school or community centre. Gymnasiums or sports facilities are often used as an evacuation centres in the event of a disaster. Equipped with a CHP system, a school could serve as an off-grid, fully powered, emergency centre complete with central heat in winter and air conditioning in the summer. The same scenario would hold true for hospitals, data centres, government buildings, military and EMS facilities that are vital operating facilities and often need to operate beyond emergency power, or at full power in the case of disaster.

NATURAL GAS AS A STOP-GAP BETWEEN COAL / NUCLEAR AND RENEWABLES

Renewable sources such as wind and solar PV will become more economical over the next 20 years and storage of electricity will solve the problem of wind and solar PV's load swings. Uncertainty about the cost, timeline and safety of nuclear energy are issues that will slow growth or exclude nuclear power plant development completely over the next decade at least. Ultimately economics will be a key factor in the energy production method of choice. It is generally accepted that natural gas is the best-case scenario as a mid-term bridge between the fossil fuel/nuclear age and the emission-free renewable age. During this period natural gas will continue to be an increasingly important fuel in the energy generation mix. Localized distributed energy production eliminates the enormous cost of unsightly transmission lines and there is virtually no line loss. CHP almost doubles the efficiency (halves the cost) of fuel by producing 2 energy products rather than one… so what are we waiting for?

THE EVOLUTION FROM CENTRALIZED POWER TO DISTRIBUTED POWER HAS BEGUN

When contemplating the evolution from centralized power production to widespread, small-scale Distributed Energy Production one only needs to look back at the evolution of computers, the production of data and data movement. The onset of the digital age saw data created and stored in massive, main-frame computers that were afforded only by governments, universities and multinational corporations. The gatekeepers were opaque and information was shared by few. When the Internet era arrived, main-frame data was distributed to other main-frames via thick, high capacity, expensive, dedicated lines, but the amount of data was still quite limited and shared by few. The arrival of PCs revolutionized the computer industry and now they out-produce large-scale main-frames in terms of data production. PCs have not replaced main-frames and as a matter of fact, they work seamlessly together, each as an important component in data production, management and distribution.

The same evolutionary path is underway in the production and distribution of our energy. It is not a stretch to imagine small-scale power producers distributed throughout the province providing reliable, clean energy, to consumers that are located in close proximity to the source; mixed with power produced by large, centralized plants. Small-scale, distributed power is currently focused on wind and solar power producers. Small-scale CHP plants such as the GO Transit Streetsville facility could, and should, play a more important role.

ONTARIO'S CURRENT CHP PLAN

Currently, according to Ontario's Long Term Energy Plan[13], the total industrial CHP capacity in Ontario is estimated to be about 2,000 MW, or about 6 per cent of Ontario's installed generation capacity.

On November 23rd, 2010 the Minister of Energy directed the OPA to procure 1,000 MW of CHP projects, less the approximate 500 MW procured to date[14]. In response, the OPA has developed the Combined Heat and Power Standard Offer Program (CHPSOP)[15] to support efficient use of natural gas-fired electricity generating facilities that use CHP technology. The goal of CHPSOP is "to facilitate increased development of CHP facilities to a maximum capacity of 20 MW per project, connected to a Distribution System, and in an area where such generation can be effectively accommodated."

The OPA has allocated 150 MW of capacity for the Launch Period of CHPSOP. Five hundred MW of new CHP might be considered a slow and cautious roll-out toward CHP being accepted as a prominent player in the energy mix. There are no obvious physical or economic reasons why the speed of the CHP energy roll-out could not accelerate at a much faster pace to a much higher capacity, as has occurred in the renewable sector with wind and solar PV.

The Ontario Clean Air Alliance estimates[16] that Ontario's total industrial, commercial and institutional CHP potential is 11,400 to 16,500 MW. Why are we holding back? All that is required is for our energy regulators to remove the governor and step on the gas.

About the Author

David Baker served for over 3 decades as a senior executive in the television broadcast industry including as Senior Director of International Development for CHUM Television International and as Sr. VP International Development for Alliance Atlantis Communications. In 2008 he migrated into the clean energy industry. He served as President and CEO of Canadian Windfields Inc. and Dao Power Canada Inc. where he focused on the development of wind, solar PV and biomass renewable energy projects. As he continues to advance his commitment to the reduction of global warming, David currently operates a private consulting practise to assist companies to develop business plans, raise capital and launch clean energy projects in Canada, the US and Caribbean region.

ENDNOTES

1 Toronto Star, Tuesday, Nov. 15, 2011 and http://www.moneyville.ca/article/1086795--consumers-to-face-higher-power-price

2 http://www.mississauga.com/article/27967

3 Ontario's Long Term Energy Plan http://www.mei.gov.on.ca/en/pdf/MEI_LTEP_en.pdf

4 Estimate by Buttcon Energy Ltd.

5 Lost revenue for line-loss is based on the following calculation

Ontario MWh Average Consumption/hr	Hours/ Annum	Average Consumption MWh/Annum	Line Loss	MWh Lost/ Annum	Average Wholesale Price Paid/MWh	Line Loss Lost Revenue
13,800	8,760	142,000,000	7%	9,940,000	$65.0300	$646,398,200

Data Source: http://www.ieso.ca/imoweb/pubs/marketReports/monthly/2010dec.pdf

6 http://www.buttcon.com/energy/

7 http://www.thestar.com/article/665644

8 Based on my own budgeting of multiple projects

9 http://www.txchnologist.com/2011/declining-cost-per-watt-solar

10 Based on the cost to build the James Bay Project: http://jamesbayroad.com/hydro/index.html

11 http://www.powerauthority.on.ca/current-electricity-contracts/combined-heat-power

12 Ontario's Long Term Energy Plan, page 34-36.

13 http://www.powerauthority.on.ca/sites/default/files/page/CHPSOP%20-%20The%20Ontario%20Greenhouse%20Alliance.pdf

14 http://www.powerauthority.on.ca/combined-heat-power-standard-offer-program-chpsop

15 See the Ontario Clean Air Alliance's *Darlington Re-Build Consumer Protection Plan* report at http://www.cleanairalliance.org/files/active/0/darlington.pdf.

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