Market impact of a conservation incentive program for combined heat and power projects

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ABSTRACT

Combined heat and power (CHP) is considered an energy efficiency measure under the Ontario energy conservation programs. Once operational, the CHP system displaces electricity that would otherwise be supplied to the host facility by the electricity grid. Since the start of Ontario's industrial electricity conservation programs in 2010, CHP projects have comprised a significant portion of the applications and the electricity savings projected to be achieved. One of the results of the increase in CHP project activity was the creation and involvement of various stakeholders with interest in the conservation programs, including government agencies, manufacturers, consultants and utilities.

This paper reviews Ontario's conservation program data to analyze the impacts of the eligibility of CHP Projects. The paper uses program data to show the impact of CHP projects on the conservation program performance and electricity savings. Subsequently, the paper identifies the various stakeholders involved and provides insights into the impacts on each stakeholder. In addition, estimates are made on the revenue generation and job creation as a result of program participation based on project costs. Where possible, stakeholder feedback are included. The results offer insight and lessons learnt to other jurisdictions seeking to develop similar programs and understand the impacts.

Background

In 2010, the Independent Electricity System Operator (IESO)[1] for the province of Ontario, Canada, began launching the latest version of their industrial incentive programs. Funded by ratepayer dollars, the first program was targeted at industrial customers (transmission connected customers) who were directly connected to the transmission grid without interconnection through a local distribution company (LDC). A similar program was soon made available to commercial and industrial customers of the LDCs (distribution connected customers). At the core of the programs are mechanisms to provide incentives for engineering studies and retrofit projects.

For study incentives, the amount of funding available to program participants is dependent on the program in which they are enrolled and the type of study being completed. The program rules require that the studies include an estimate of the electricity savings that would be achieved through the implementation of an eligible measure, and a cost estimate for its installation. The study incentive applications are subject to a third party technical review of the study proposal and the prospective energy conservation measures.

Study incentives are available for a Preliminary Engineering Study (PES) and Detailed Engineering Study (DES). A PES is meant to provide the program participant with a high-level

[1] http://www.ieso.ca/

study of potential electricity savings measures that can be implemented at their facility. Guidelines within the program rules required that the PES have an accuracy of +/-30% on the electricity savings and +/-50% on the capital cost of the measure. For a PES, the incentive amount is limited to the cost of the study up to $10,000[2] for distribution connected customers and up to $20,000 for transmission connected customers.

A DES is a more comprehensive investigation of the potential measure. The program rules require that the electricity savings are calculated to an accuracy of +/-10% and +/-25% for the capital cost of the measure. A DES typically involves metering, data collection and more accurate modelling methods than a PES. Because of the additional effort required, a DES is eligible for greater incentive funding. For distribution connected customers, the DES incentive is limited to a maximum of $50,000. For transmission connected customers, there is no monetary limit to the DES incentive, however, the study incentive amount and scope are reviewed to provide some certainty that they are appropriate when compared to the prospective project.

Finally, incentives are also available for implemented projects. Participants can apply for subsidies to cover a portion of the eligible costs to implement the project. A rigorous technical review process functions to evaluate the project prior to implementation. It, provides reassurance that the project meets the eligibility requirements of the programs rules, and that there is a well-defined measurement and verification (M&V) process that will validate the electricity savings of the installed measure. The dollar amount available for incentives for each project is limited to the minimum amount determined by one of three calculations. The first calculates the incentive to be the dollar amount required to bring the project to a 1-year payback. The second rule limits the incentive amount to 40% of the eligible project cost[3]. The last rule limits the incentive amount to $200/MWh of contracted annualized electricity savings. For transmission connected customers, the rate is more generous at $230/MWh.

Conservation Combined Heat and Power and Waste Energy Recovery

Certain behind-the-meter generation (BMG) projects are eligible as conservation measures. BMG projects involve the generation of electricity that serve the host facility only and cannot export electricity to the grid. These projects are limited to 20 MW for transmission connected customers and 10 MW for distribution connected customers.

In the context of the IESO incentive programs, there are specific definitions for the BMG project types called Conservation Combined Heat and Power (CCHP) projects and Waste Energy Recovery (WER) projects.

CCHP is defined as the “simultaneous production of electrical and thermal energy where both forms of energy are productively and efficiently used within the Facility and/or its processes” (IESO 2015). In addition, the program rules state that the CCHP project must “use natural gas or propane as its sole fuel, unless otherwise approved in writing by the IESO”. The majority of BMG applications made through the incentive programs involve the use of an internal combustion engine (ICE) or gas turbine (GT) as the prime mover, which uses natural gas

[2] All costs are in Canadian Dollars, unless otherwise stated.
[3] 70% for projects other than cogeneration (CHP) systems. For instance, a chiller system upgrade can be eligible for an incentive amount up to 70% of the project’s capital costs.

as fuel to drive a generator to produce electricity. An example of a typical CCHP system is illustrated in Figure 1.

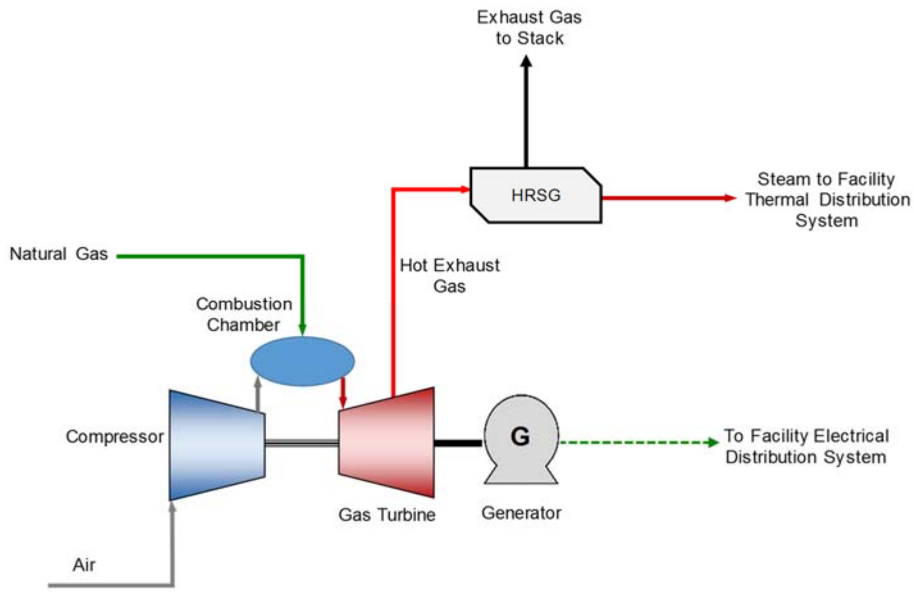

Figure 1. Illustration of an example CCHP system with a gas turbine prime mover

For the IESO incentive programs, WER "means the generation of electricity primarily from heat or fuel that is a waste by-product of the Facility" (IESO 2015). WER projects are considered more favorable since the electricity is derived from waste energy, such as by-product steam, landfill gas, biogas, etc. For example, WER can involve recovering heat from an exhaust gas flow of a blast furnace, or using waste biomass as a fuel to produce steam for a steam turbine generator.

Program Eligibility and Total System Efficiency

Initially, incentive applications for studies and projects involving CCHP generation required explicit permission from the IESO prior to acceptance into the programs. Efficiency improvement projects, such as the installation of variable frequency drives, equipment upgrades, and WER projects did not require explicit permission.

When generating electricity and heat using separate (and stand-alone) systems, a total efficiency of 55% is achievable. The total efficiency of 55% is based on using natural gas to generated power and heat at 40% (IEA 2008) and 80% efficiencies, respectively. The program rules considered CHP systems as an electricity (energy in general) conservation measure. The program required that the CCHP projects must be "designed and operated in a manner that the CCHP project achieves a minimum annual Total System Efficiency of 65%" (IESO 2015). The Total System Efficiency (TSE) is a measure of how effectively the system is able to generate useful thermal and electrical energy from the fuel. This requirement helps to ensure that the electricity that is derived from the CCHP, is generated in a manner that improves the overall efficiency for the facility when electricity and thermal loads are considered. The 65% minimum

TSE ensures a minimum of 10% efficiency improvement, which results in improved economics for the host facilities (which explains the difference between 65% and 55% discussed earlier).

In addition, as shown in Figure 2, the majority of electricity in Ontario is derived from nuclear (61%) and hydroelectric power plants (24%). As a result, the greenhouse gas emissions (GHG) of the Ontario electricity grid is as low as 40 g-CO2e/kWh (MOE 2013). Most of the CCHP projects within the incentive program use natural gas as a fuel source, which results in some level of GHG emissions.

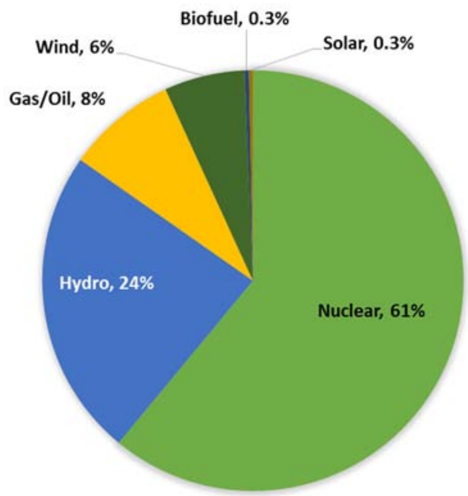

Figure 2: Share of various fuel sources in Ontario's total electricity generation in 2016 (IESO 2017)

Popularity of CCHP in the Incentive Programs

From the onset of the programs, it was clear that CCHP was a technology that participants and LDCs were interested in implementing. For the program participants, natural gas prices were relatively low, and the cost to generate electricity from a CCHP system was less than the cost of purchasing electricity from the grid. For the utilities, the CCHP projects had the potential to be more cost effective since these projects were expected to result in high electricity savings for fewer ratepayer dollars. Furthermore, on a per project basis, the potential electricity savings associated with a single CCHP project was greater than most other efficiency measures.

Since the incentive programs inception in 2010, hundreds of DES and PES applications have been submitted covering all eligible measures. Studies of CCHP systems account for 34% of these proposed studies. Similarly, 65% of all project incentive applications involve CCHP. The popularity of CCHP in the incentive program is further illustrated in figures 3 and 4. Figure 3 shows the proportion of CCHP projects as a percentage of the total electricity savings of the program to date based on project incentive applications. Figure 4 shows the percentage of incentive budget spent on CCHP studies and projects compared to the total incentives spent.

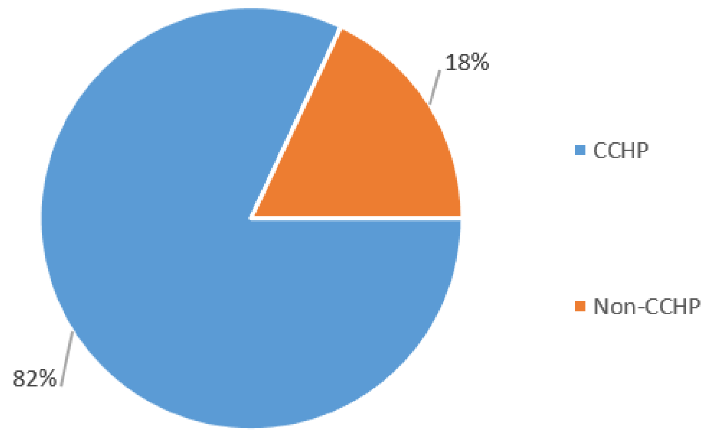

Figure 3. Electricity savings of CCHP as a percentage of electricity savings for all installed projects.

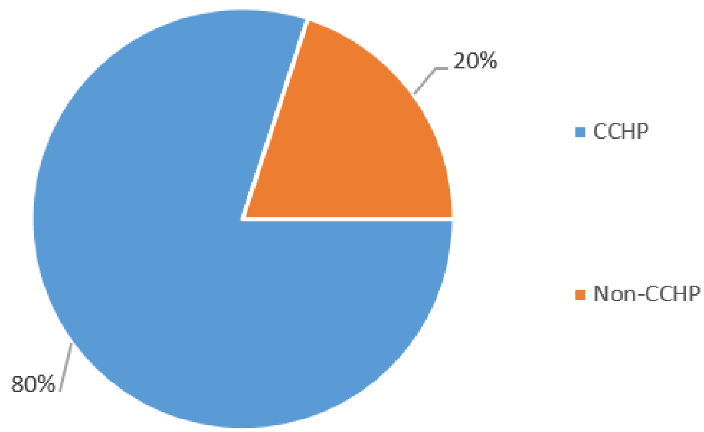

Figure 4. CCHP Incentives as a percentage of the total incentives provided.

Figure 5 shows how the number of new CCHP applications increased over the life of the program. It is clear there has been an increasing interest CCHP in the program.

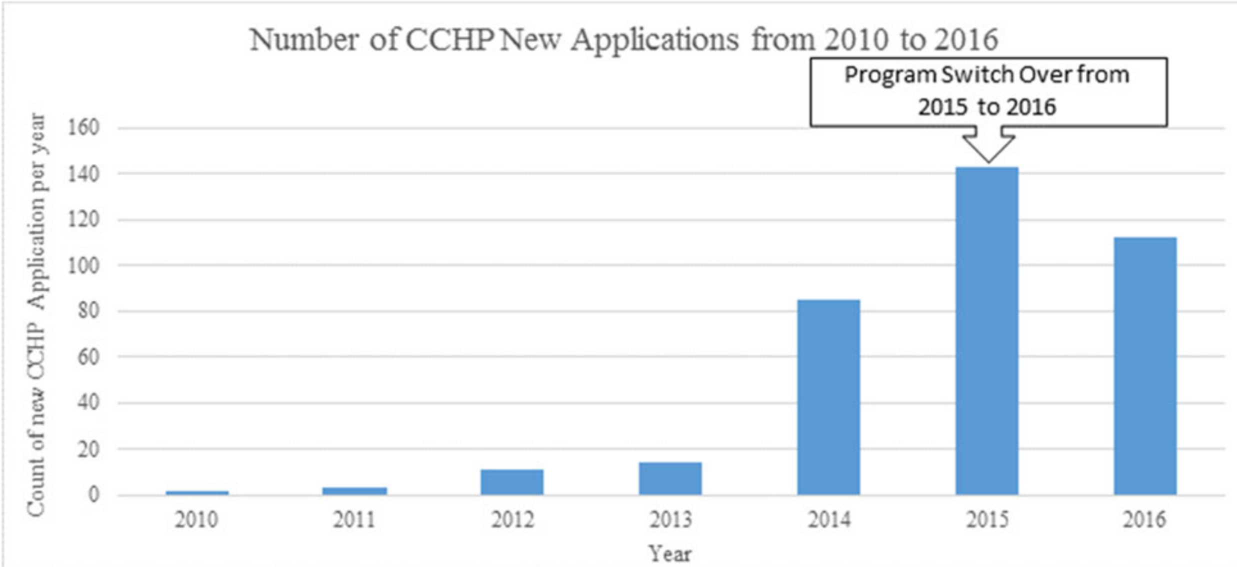

Figure 5. Number of CCHP Applications from 2010 to 2016.

CCHP Installation by Sector

Historically, CCHP technology were predominantly installed in industrial facilities. Not surprisingly, a sizable portion of the applications made through the IESO programs are from industries such as food and beverage, agriculture, consumer products and chemicals. In general, industrial facilities have the sizable electrical and thermal loads to make the installation of a CCHP system economically feasible. The CCHP system's generated electricity will typically displace a significant portion of the facility's electrical load. In the industrial facility, the thermal energy derived from the CCHP system will typically be used to offset the existing boilers by recovering heat for steam and/or hot water generation. In some applications, the exhaust air is used to pre-heat combustion air in manufacturing processes.

Hospitals also submitted a significant number of the applications. Most hospitals require larger boilers because of their significant thermal loads for steam and hot water for space heating, domestic water, kitchen loads, and sterilization. The heat produced by the CCHP system is able to supplement the thermal requirements of the boilers. A fair number of nursing homes, which are ideal candidates for CCHP much like hospitals, have participated in the program, but on a smaller scale.

An interesting development from the programs is the high proportion of applications from the multi-use residential building (MURB) sector (see Figure 6). Incentive applications from the MURB sector account for 39% of all applications made for studies and projects.

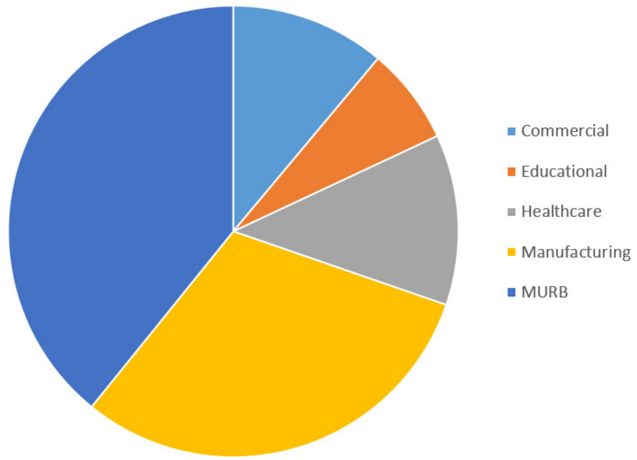

Figure 6. Applications by sector graphic

The high volume of applications from the MURB sector can be attributed to several reasons. First, smaller CCHP systems (as small as 19 kW) have become more widely available and are better suited for MURBs. Secondly, facility owners and program participants in the MURB sector are open to longer payback or longer return on investment than a typical industrial facility (see Figure 6). Most industrial facilities are interested in projects with paybacks of three years or shorter. For this reason, industrial customers are more likely to invest in projects that increase production, rather than in energy efficiency upgrades. MURBs have limited means by which to increase their profit and have shown that they are open to implementing projects with paybacks that exceed 10 years and longer.

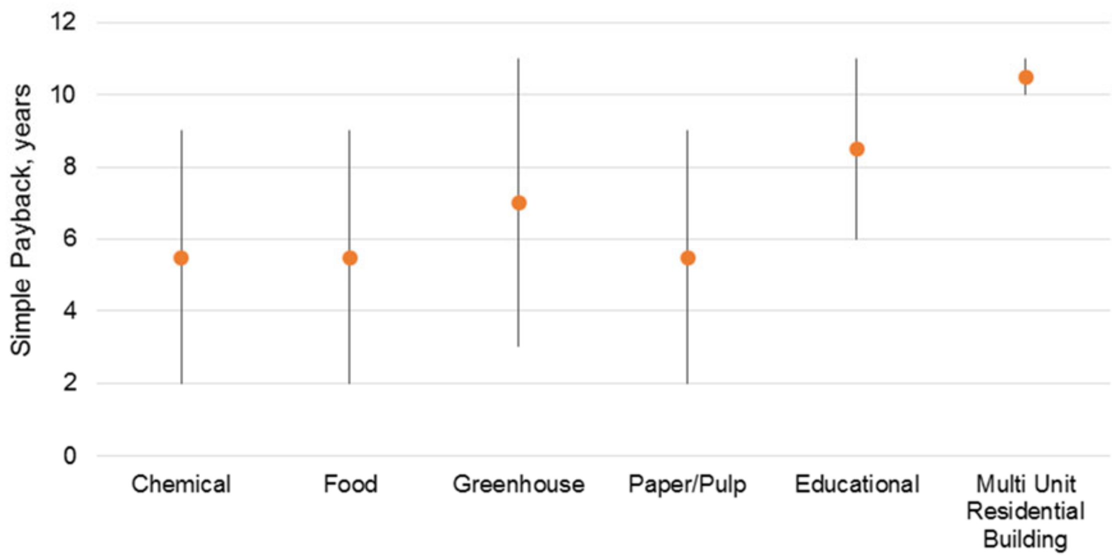

Figure 6. Simple payback of BMG projects for various facility types (Navigant 2016).

Because the program rules dictate that the project must operate with an annual total system efficiency of 65% or greater, most MURB projects are limited by the facility’s thermal load. The CCHP systems are capable of operating at all times to offset the facility's electrical load; however, in order to meet the 65% total system efficiency, the CCHP system must be turned down to limit the unused thermal output. While the colder winter months offer opportunities for the CCHP thermal loads to offset heating loads, summers thermal load are typically limited to domestic hot water heating. In MURBs and other facilities, program participants have explored the option of installing chillers for air conditioning in the summer months. The use of chillers in these situations will add to the capital cost of the project and introduce additional equipment that will incur additional costs to maintain.

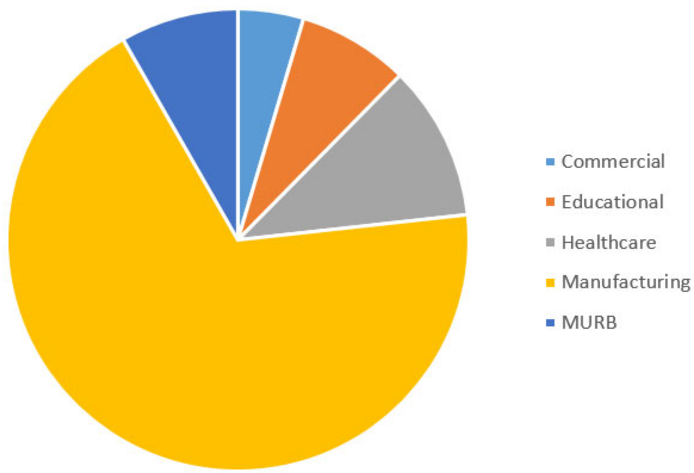

Figure 7. A breakdown of CCHP electricity savings (MWh per year) by sector

Table 1 provides a summary of the installed and contracted BMG projects initiated by the IESO conservation programs based on the prime-mover of the CCHP system. As Table 1 suggests, the majority of the projects have (or will have) a TSE greater than 65%, which reveals the available potential of CCHP systems for improved energy efficiency. Systems that use gas turbines as their prime-mover are mostly installed in manufacturing plants, where there is a great demand for low pressure steam.

Table 1. Summary of installed and contracted BMG projects

CHP Technology	Share of Total Installed/Contracted, %	Share of Total Electricity Savings, %	Efficiency, %	Simple Payback with Incentive, years
Gas turbine	23%	67%	72%	4.0
ICE	71%	33%	71%	9.4
Microturbine	5%	1%	63%	12.3

In almost all cases, CCHP package costs (prime-more plus heat recovery system) account for nearly 50% of the total capital costs of the project. Civil, mechanical, and electrical costs vary between 25 to 35% of the capital costs, and the rest are related to project management and commissioning. The utility interconnection costs vary for each case, as in some facilities the need to upgrade the transformers and switchboards.

CCHP incentives and industry stakeholders

The high volume of CCHP applications that have been submitted through the IESO incentive programs has impacted many stakeholders. Consultants, contractors, equipment vendors and manufacturers have all benefited from the increase in popularity of CCHP system due to the incentive programs. A small sample of equipment vendors and consultants were surveyed to gain insight into their experiences with the CCHP incentive program. Respondents were asked how strongly they agreed or disagreed with the statement that CCHP incentive programs have increased their business. All consultants and responded that they either agree or strongly agree.

Based on program data, a total of 45 unique consultants have been involved with studies for the CCHP program with the majority qualifying as a small or medium business. This amounts to approximately $8 million in engineering consulting fees and over 50,000 in engineering man-hours in CCHP studies since the inception of the incentive program.

Thus far, 16 CCHP projects have been completed and installed, and over 50 others have been contracted and are in the installation phase. A breakdown of the installed and contracted projects based on sector is given in Table 2.

Table 2. Breakdown of installed or contracted BMG projects by sector

Sector	Percentage of installed or contracted projects, %
Commercial	23%
Industrial	41%
MURB	36%

Typically, engineering consultants are also involved with detailed design of projects after the project incentive application is approved. Estimates of the engineering efforts suggest that these 16 projects totaled approximately $40 million in consulting fees and an estimated 260,000 engineering man-hours. Installation costs associated with these 16 CCHP systems were reviewed and it was estimated that approximately $20 million in construction labor fees were paid amounting to approximately 240,000 man-hours.

Looking forward at project incentive application volumes and studies in progress that can convert to projects, it is conceivable that engineering consulting fees can amount to more than $400 million and more than 2.5 million man-hours by the end of the current program cycle in 2020. This assumes that all projects with incentive applications are installed. Extrapolating for construction labor, it is estimated that the CCHP applications can result in $260 million in labor fees and 3 million man-hours by the end of the program cycle.

Equipment vendor are also seeing the benefits of the incentive program. Similar analysis of major equipment capital cost suggests that the CCHP incentive program can have a hand in approximately $500 million in equipment sales by the end of the program cycle.

Future considerations

In 2016, the incentive programs allowed for third party participation in behind-the-meter generation applications. By allowing participation by a third party, ownership of the project is not limited to the customers of the LDC. This change allows for alternative financing options for generation projects with the intent of increasing program participation by removing potential capital cost barriers as companies look for ways to fund projects.

While undoubtedly CCHP incentive programs have contributed towards the province's conservation targets, challenges exist which can potentially hamper the amount of CCHP installed through the conservation programs. A cap and trade program was initiated in Ontario in 2017 which will likely result in additional costs imposed on the natural gas that fuel the CCHP systems (MOECC 2016). In doing so, the projects will have longer payback periods and become less attractive for facilities looking to implement a CCHP system.

In addition, the base load electricity in Ontario is generated from nuclear power plants and hydroelectric sources. Both sources are relatively clean and contribute very little to GHG emissions. Electricity is also generated at natural gas plants as needed to balance the electrical demand. The natural gas plants will generate GHG emissions, however, when viewed on the whole, Ontario's electricity grid can be considered relatively clean. However, as most CCHP systems consume natural gas, they will emit GHGs (Branker, Hosseini and Dicion 2017). While small by comparison, increased GHG emissions contravenes other government intiatives to reduced GHGs so it is conceivable that in the future, CCHP systems will be limited or eliminated from the conservation incentive programs.

Conclusions

Ontario's IESO has shown great leadership in the implementation of electricity (and to some extent, energy) conservation programs, since 2010. The IESO's conservation programs provide considerable incentives to residential, commercial, institutional, and industrial facilities for their energy efficiency and conservation projects.

Among many energy conservation measures, conservation combined heat and power (CCHP) systems have gained considerable interest due to many benefits that they can offer to the facilities and also the province of Ontario. For effective implementation of these systems, the IESO's program rules set the minimum eligibility requirements for the CCHP projects, among which is a minimum TSE of 65%.

Since the beginning of the conservation programs, a considerable number of applications have been reviewed by the IESO, and so far 16 projects have been installed and fully commissioned. Another 50 projects have been contracted and are awaiting final commissioning.

The majority of the applications are received for multi-unit residential buildings, where there is interest for increased reliability from the local electricity distribution grid. However, several issues including high payback periods, and the challenge with meeting a TSE of 65% (or higher) have prevented the MURBs from full implementation of all the applications.

The manufacturing sector, so far, has the highest installed CCHP systems within the program, which is a testimony to the many benefits of these systems for the host facilities.

The conservation program has also influenced the improved employment within the energy and CHP industry, by involving vendors, contractors, consultants, and technical reviewers in the implementation process.

Acknowledgements

The authors acknowledge inputs from other CLEAResult team members who assisted with getting survey and analysis results and for the input of the respondents.

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