

B-Y-E to C-H-P – How to Adapt C&I Programs when CHP incentives are not an option

Jake Fuller, EcoMetric Consulting

Jimmy Lu, CEM, IESO

Alice Herrera, CMVP, CEM, CEA, IESO

Salil Gogte, CMVP, CEM, EcoMetric Consulting

ABSTRACT

Combined heat and power projects (CHPs) have been a popular measure to incentivize in commercial and industrial energy efficiency programs over the past decade. While the electric savings potential of these systems is proven and clear, the emissions impacts of popular natural gas-powered CHPs are more complex.

Since 2016, the authors have conducted annual impact and process evaluations of a commercial and industrial (C&I) energy efficiency program in Ontario that has provided incentives for hundreds of engineering feasibility studies and projects to install natural gas-powered CHPs. A deeper dive into the emissions impacts of the program revealed that due to the low carbon intensity of Ontario's grid, natural gas-powered CHPs were net emitters of greenhouse gasses (GHGs) and not cost effective from the total resource cost test perspective.

A Ministerial Directive driven by Ontario's 2016-2020 Climate Action Plan eliminated the eligibility of fossil fuel-powered CHPs in mid-2018. As such, the province's biggest industrial program has had to pivot in order to continue serving the sector that favored natural gas-powered CHPs. The key advantage of this pivot was the decarbonization of the program in favor of projects focused on electric systems and created GHG emissions savings. The Independent Electricity System Operator's (IESO) newest framework is committed to decarbonization and shifting programs to focus on peak demand where recently fossil fuel generation has shifted towards mostly meeting peak demand. Findings from this research will help program administrators consider GHG impacts of behind-the-meter generation (BMG) projects and how to develop C&I programs that consider decarbonization goals.

Introduction

Since 2011, the Independent Electricity System Operator's (IESO)¹ Process and Systems Upgrades Program (PSUP) has been helping commercial and industrial customers with complex processes and systems in Ontario to identify and implement electric energy efficiency projects. PSUP provides incentives to these customers for engineering feasibility studies and project implementation to support this effort throughout the project life cycle.

Engineering feasibility studies are designed to support the successful design and implementation of complex capital-intensive energy savings projects in PSUP. Program participants leverage PSUP study incentives to contract an engineering firm to conduct in-depth analysis on project identification, potential savings, financial payback, and more. To ensure quality and accuracy of the studies, detailed applications and study proposals are required to be submitted by participants for the approval by the IESO. Each engineering feasibility study is technically reviewed by a third party contracted by the IESO. These third-party technical

¹ <https://www.ieso.ca/>

reviewers eventually reviews the implemented projects and develops the reported savings for projects once they are in service.

The IESO's incentive structure for the studies is designed to encourage the eventual implementation of PSUP projects, following these steps:

1. Incentive #1 covers 50% of the cost of the approved engineering feasibility study
2. Incentive #2 covers the balance of the cost of the study, payable upon confirmation of the project's in-service date

For a project to be eligible for a PSUP incentive, there must have been an engineering feasibility conducted through the program or the applicant must provide sufficient supporting documentation to prove the study minimum requirements have been met.²

To support the implementation of the capital-intensive, complex projects PSUP was designed to attract, the IESO provides a lucrative incentive which is the lowest amount of the following (IESO 2019):

- 70% of eligible costs³ of the project;
- the product of electricity savings multiplied by CA\$200/MWh, capped at 120% of the IESO-approved incentive amount;
- the amount that would provide a project payback for one year; and
- CA\$10,000,000 per project.

The project implementation incentive amount from the list above is reduced by the amount of the incentive paid by the IESO for the completion of the engineering feasibility study.

PSUP has been a long-standing program offering available to Ontario's commercial and industrial sector and remained popular throughout several Conservation and Demand Management (CDM) frameworks and program design changes. Its design has evolved to balance the organizational goals of reducing long-term energy costs and climate impacts with providing viable sustainability support to meet the needs of Ontario's commercial and industrial customers. The evaluation of PSUP and the rest of the IESO's Industrial Portfolio of programs began in 2016 under the 2015-2020 Conservation First Framework (CFF).

In 2017, a directive from the Minister of Energy (IESO 2017) made fossil fuel-powered behind the meter generation (BMG) projects ineligible for participation in IESO CDM programs beginning in July 2018. This directive was implemented to align conservation programs in Ontario with the province's 2016 to 2020 Climate Change Action Plan. The Climate Change Action Plan represented Ontario's five year plan to "fight climate change, reduce greenhouse gas pollution and transition to a low-carbon economy" (Ontario 2016). At the time of the directive, fossil fuel-powered Combined Heat and Power (CHP) projects were the main driver of electric savings in PSUP by a significant margin. As such, the IESO had to alter its program design and delivery to balance organizational goals of decarbonization and electric energy savings in the commercial and industrial sectors.

² Information on the minimum requirements for a PSUP Engineering Feasibility can be found in Appendix 2 of IESO's PSUP Program Requirements Document. <https://saveonenergy.ca/-/media/Files/SaveOnEnergy/Document-Archive/IF-Documents/PSUP-Program-Requirements-LT.ashx>

³ Eligible costs include capital expenses, connection costs for generation projects, diagnostic equipment and testing tools, data collection services, metering costs, professional and engineering services, travel, permits and license fees, environmental assessment costs, engineering feasibility study costs, and other reasonable costs approved by the IESO.

In March 2019, the IESO was directed by the Minister of Energy, Northern Development and Mines to discontinue CFF and centrally deliver energy efficiency programs in the 2019-2020 Interim Framework (IESO 2019). The order required a cost-effective wind down of the programs and allowed IESO-approved projects to be completed and incentives to be paid for customers. In July 2022, timelines to complete projects approved in the CFF were extended by the Minister in response to major delays caused by the COVID-19 pandemic (IESO 2020).

CHP Projects and PSUP

CHPs, also known as cogeneration, are systems that generate electricity and capture heat that is often wasted. This captured heat is leveraged to provide thermal energy for many energy intensive end uses such as industrial processes, water heating, and space heating. Two of the most common CHP systems are combustion turbines with heat recovery units and steam boilers with steam turbine (EPA 2021). The vast majority of combustion-powered CHPs are fueled by natural gas. Figure 1 shows a high-level diagram of a natural gas fueled combustion turbine with heat recovery unit.

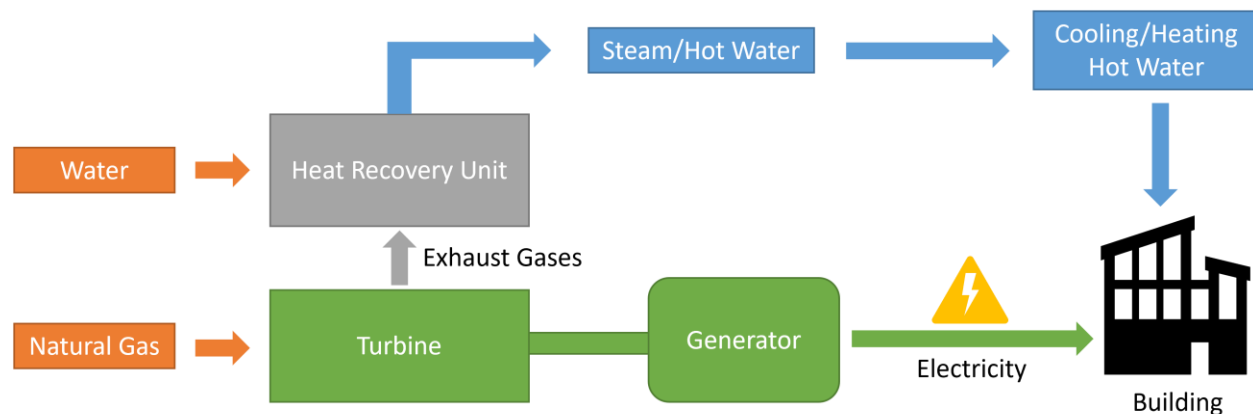


Figure 1. Combustion Turbine CHP.

Source: EcoMetric and United States Environmental Protection Agency.

CHP projects quickly became the most popular project in PSUP with the majority of applications for engineering studies and implementation submitted being focused on the BMG technology. Over the past decade, natural gas prices in Ontario have been low and supported the favorable economics of CHP investments that allow commercial and industrial customers to avoid higher costs of purchasing electricity from local distribution companies (LDCs). CHPs were also a great solution for Ontario's commercial and industrial sector which was made up thousands of buildings with significant electric and thermal needs such as multifamily residential, manufacturing, food and beverage, heavy industrial, and healthcare buildings.

In 2017, the last full year when fossil fuel-powered BMG projects were eligible for PSUP incentives, CHP projects accounted for 63% of all program applications received for engineering feasibility studies or project implementation. Applications for fossil fuel-powered CHP projects that were approved by the IESO before the directive made them ineligible in July 2018 were allowed to move forward through the implementation phase. Due to the size and cost of the systems many PSUP CHP projects took several years to progress through the implementation

and measurement and verification program phases. Figure 2 shows the net verified electric savings for PSUP by technology in the IESO's CFF.

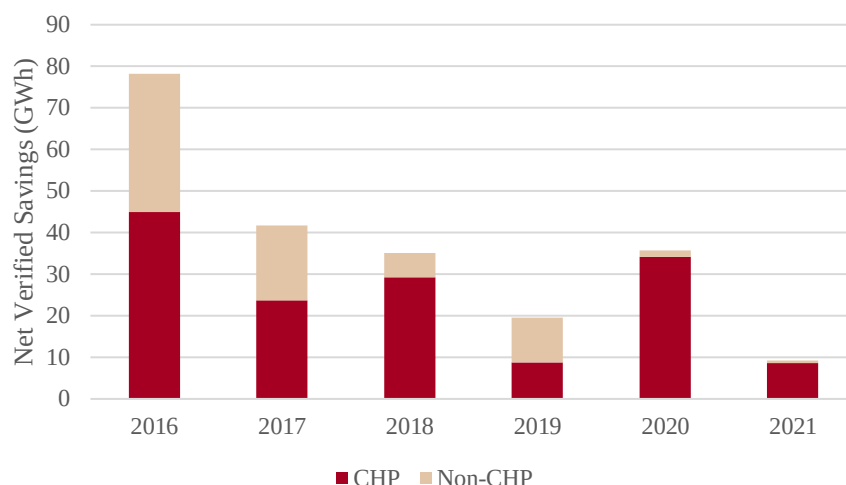


Figure 2. CFF PSUP Net Verified Electric Savings 2016-2021. 2021 data is preliminary.
Source: Program tracking data and evaluation team analysis.

Throughout the framework, CHPs have accounted for 68% of the net verified electric savings achieved in PSUP.⁴ These BMG projects were responsible for the majority of PSUP electric savings each year of the framework except for 2019, when they represented 45% of total savings. As the CFF wound down and stopped taking applications in 2019, the slower moving more capital-intensive CHP projects accounted for nearly all of PSUP savings in 2020 and 2021. The majority of the non-CHP electric savings in the CFF came through compressed air projects, efficient pumps and Variable Frequency Drives (VFDs), and industrial process changes.

Greenhouse Gas Impacts of CHPs

CHPs present an enticing opportunity for electric energy efficiency program administrators as they have the potential to empower customers to generate massive amounts of electric energy on site. However, the overall greenhouse gas (GHG) impacts of these systems can vary widely based on what is powering the CHP, as well as the composition of the electricity generated on the grid it is displacing. CHPs are often touted as emissions-reducing projects as they can generate electricity more efficiently than conventional power plants, but that is not always the case—especially in grids with a high percentage of renewable energy generation.

The vast majority of CHPs implemented through PSUP in the CFF were fueled by natural gas. These combustion turbine CHP projects resulted in net increases in natural gas consumption at the project level. Over the past decade, natural gas prices were relatively cheap in Ontario compared to other energy sources and supported favorable economics of investing in a CHP. Being a fossil fuel, natural gas has a high carbon intensity at roughly 490 gCO₂e/kWh (IPCC 2014)⁵. While the generation efficiencies of the CHP may reduce GHG emissions compared to a

⁴ Not including 2015

⁵ The carbon intensities from IPCC 2014 represent the global average of specific direct CO₂ emissions from power generation.

natural gas power plant, CHPs powered by natural gas have a much higher carbon intensity than electricity generated from renewable sources such as nuclear energy (12 gCO₂e/kWh) or hydropower (24 gCO₂e/kWh) (IPCC 2014).

Ontario's electric grid has a relatively low carbon intensity compared to the rest of North America and much of the world, relying more heavily on renewable energy sources to generate electricity such as nuclear energy and hydropower. Figure 3 shows the carbon intensity of electricity generation in Ontario along with a sample of countries from around the world in 2019. Ontario has a carbon intensity of 26 gCO₂e/kWh, compared to 132 in Canada and 383 in the United States. As depicted in Figure 4, Ontario's grid has had a low carbon intensity throughout the CFF, relying on nuclear and hydropower for more than 80% of electricity generation from 2016 through 2021.

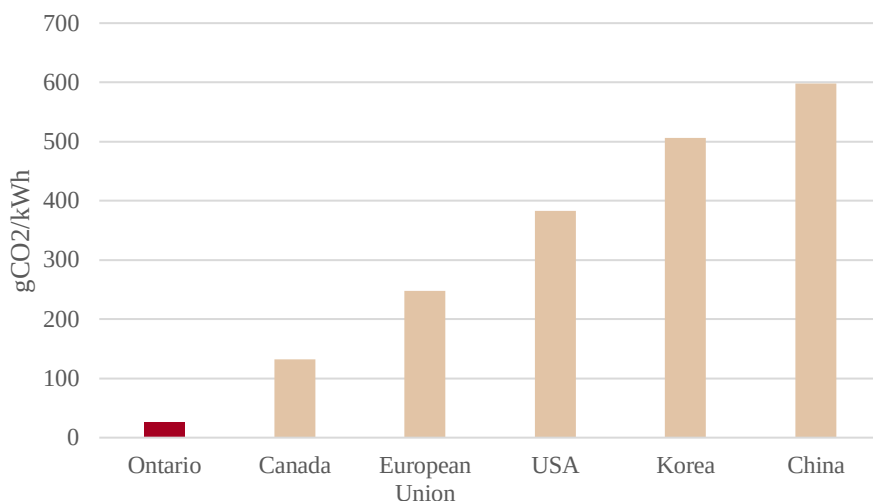


Figure 3. Carbon intensity of electricity generation 2019.
Source: IEA 2020 and IESO 2021

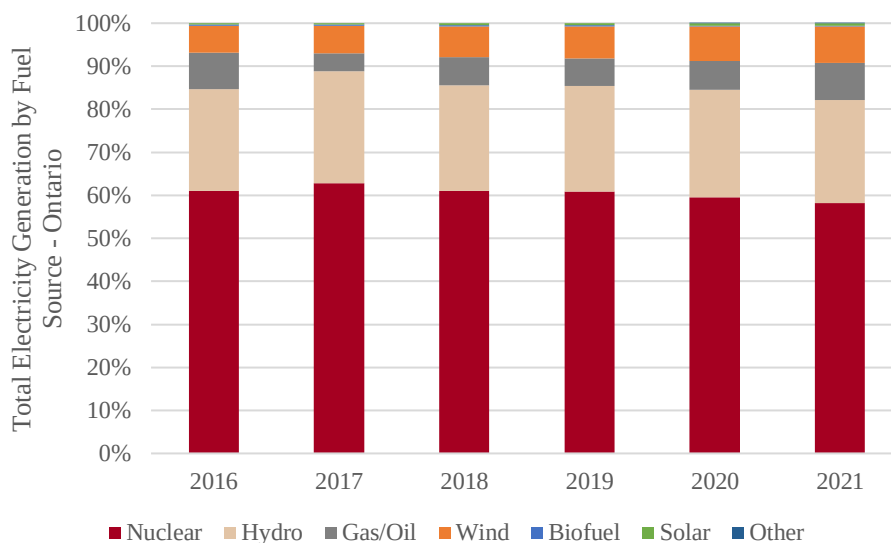


Figure 4. Ontario's total electricity generation by fuel source 2016-2021.
Source: IESO 2021

Due to the exceptionally low carbon intensity of Ontario's grid, natural gas-fueled CHPs were essentially displacing electricity generation from renewable sources with natural gas. The evaluation team dove deeper into the emissions impacts of these projects. The directive to wind down the CFF in a cost-effective manner impacted the evaluation team's ability to access project specific data and supporting documentation after program year (PY) 2017. However, as part of the PY2017 evaluation of PSUP, the evaluation team conducted an analysis of the greenhouse gas impacts of the prevalent CHPs.

The evaluation team estimated net GHG impacts for each project and program by utilizing measure-level energy savings load shapes based on metered data, natural gas consumption meter data, and emissions factors (EFs) provided by the IESO at the annual and hourly level and aggregated to the eight IESO peak periods as defined in the IESO Conservation and Demand Management Energy Efficiency Cost Effectiveness Tool. To provide an accurate estimate of the net natural gas consumption resulting from the installation of CHPs, the evaluation team considered both the consumption of the CHP unit and the avoided natural gas consumption of the pre-installation systems that now benefit from the CHPs thermal energy output.

In PY2017, the evaluation team evaluated 31 PSUP projects, of which natural gas-powered CHPs accounted for 18. The non-CHP projects included compressed air projects, chiller optimizations and upgrades, process specific optimizations, and efficient VFD and pump retrofits. Including the impacts from all projects evaluated, PSUP achieved 10,551 tons of GHG emissions savings in CO₂ equivalent from reduced electricity consumption in PY2017. Due to the low carbon intensity of Ontario's grid, the emissions savings from reduced electricity consumption is much lower than what is seen across the rest of North America.

However, due to the increased consumption of natural gas from CHPs, PSUP resulted in 14,342 tons of additional GHG emissions in CO₂ equivalent—resulting in a net emission increase of 3,790 tons. The natural gas consumption of the CHP turbines in these projects outweighed the natural gas savings of the existing systems displaced by the CHP's heat recovery unit. The emissions from this net increase in natural gas consumption outweighed the emissions savings from the avoided electricity the CHPs were generating. Examples of these existing systems that were include natural gas fired boilers for space heating and hot water and process-specific systems with heating loads. Of the 18 CHPs evaluated, only one had a net decrease in GHG emissions at the project level.

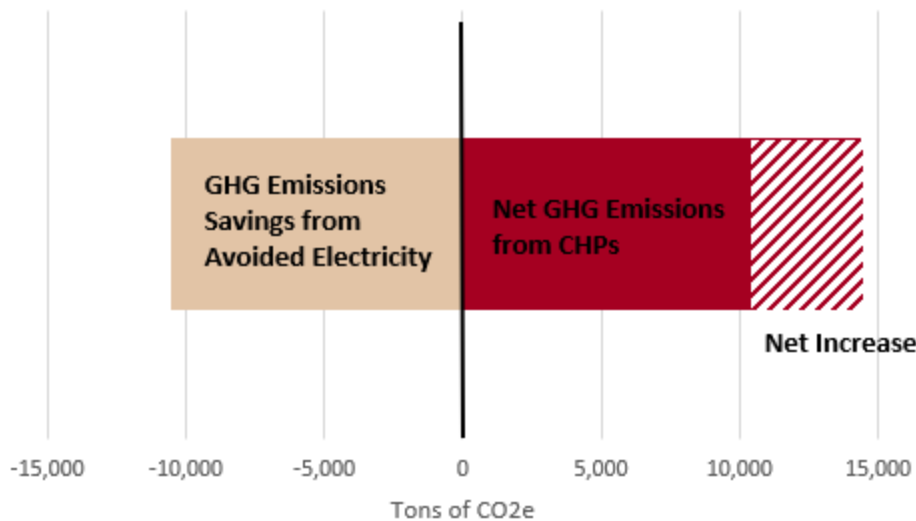


Figure 5. PY2017 PSUP GHG Emissions from CHPs.

Source: EcoMetric Evaluation Team

This increased consumption of natural gas by the CHPs also impacted the cost effectiveness of PSUP in CFF. In the cost effectiveness analysis of PSUP, the evaluation team accounted for net increased consumption of natural gas by CHPs as negative savings. As such, the avoided cost of natural gas was a negative benefit, or essentially a cost, from the total resource cost (TRC)⁶ test perspective. In PY2017, the same program year when the evaluation team conducted a deeper analysis of GHG impacts of CHPs, PSUP had a TRC ratio of 0.54 failing to meet the benefit/cost threshold of 1.0 under the test. The benefits from the avoided electricity were weighed down by over \$4M in lifetime natural gas costs of the CHPs. The effect of the increased natural gas consumption continued to weigh down the TRC ratio of PSUP throughout the CFF. The overall TRC ratio for PSUP was 0.68 combining all projects evaluated between 2015 and 2020. The impact of CHPs on PSUP's cost effectiveness had an influence on the minister's directive to remove them from the IESO's DSM framework, as the Ontario Energy Board (OEB) sets a TRC threshold of 1.0 for all DSM programs, except for those targeting low-income populations.

Considering the low carbon intensity of Ontario's grid, the net increase in GHG emissions by natural gas-powered CHPs was in contrast to market trends towards decarbonization. Aligned with the minister's directive, no incentives for fossil fuel-powered BMG projects have been provided by the IESO in the Interim Framework or the current 2021-2024 CDM Framework.

PSUP in the Interim Framework

The transition to the IESO's Interim Framework midway through 2019 represented the first time PSUP was delivered without fossil fuel-powered CHPs as an eligible measure. Unfortunately, this transition was quickly followed by the COVID-19 pandemic which wreaked

⁶ The TRC test perspective considers the benefits of avoided supply costs and the costs incurred by both the program administrator and participant. The IESO uses the TRC test to measure the cost effectiveness of their programs, with a benefit to cost ratio over 1.0 representing a cost effective program.

havoc on commercial and industrial operations, capital budgets, and engineering feasibility study and project implementation timelines. The pipeline of applications for studies and projects in PSUP remained relatively strong—totaling 150 applications between mid-2019 and 2020. However, turning those applications into verified savings was difficult in the face of the pandemic, with only six PSUP projects becoming in-service and ready for evaluation by March 2021.⁷

The shift away from fossil fuel-powered CHPs did not result in the end of applications for large cogeneration projects in PSUP. In fact, applications for waste heat and energy recovery projects totaled 297 GWh of potential energy savings in PSUP in the Interim Framework. The IESO focused on engineering studies for waste heat and energy recovery projects on heavy manufacturing buildings that produce massing amounts of waste heat such as steel and adhesive manufacturing. These CHP projects recover and leverage heat from existing processes to generate electricity without adding a fossil fuel-powered turbine.

Outside of these waste heat and energy recovery projects, the IESO focused on developing studies for non-CHP projects that were largely popular in CFF such as compressed air, efficient pumps and VFDs, and industrial process changes. Incentives for CHPs drove the multifamily residential sector participation in PSUP during the CFF and that segment largely did not participate in the Interim Framework once fossil fuel-powered CHPs were no longer eligible. As such, the IESO shifted its focus to Ontario's robust manufacturing sector where there is ample potential savings from non-CHP projects popular in the CFF.

One way the IESO was able to shift focus away from CHPs amongst their largest customers was by leveraging their unique Energy Manager program. The Energy Manager program subsidizes the salary of the energy managers and supports them with training and technical support to change the culture within the participating organizations and create opportunities for energy savings through both incented upgrades and non-incented actions. The energy managers are embedded in the participating organization as full-time employees and work to find energy savings, identify energy investments, secure incentives, and develop competitive advantages for the organizations they work in. The program requires minimum annual savings of 1,000 MWh, targeting larger facilities including industrial, commercial, and institutional buildings that can span multiple locations. To meet this goal energy managers drive projects through IESO programs, including PSUP.

Having an IESO-funded energy manager embedding in large industrial and commercial participants allows the IESO unique access to influence and drive non-CHP projects through PSUP. Energy managers attend IESO-funded trainings that provide high level energy efficiency resources, as well as more focused information on identifying and implementing non-CHP projects.

Participants with IESO-funded energy managers have 28 studies and projects currently under contract in PSUP in the Interim Framework totaling 50 GWh of estimated electric savings. The types of PSUP projects that are being led by IESO-funded energy managers are quite diverse and include waste heat recovery, efficient pump and VFD retrofits, compressed air optimizations and retrofits, and process-specific optimizations, to name a few.

Due to the difficulties of translating applications into completed projects and verified savings throughout the pandemic, PSUP achieved 4 GWh of net verified electric savings so far between 2019 and 2020. However, each of these projects resulted in avoided GHG emissions

⁷ For PSUP projects to be ready for review, they must be in-service, have at least a quarter of post-performance M&V data and be technically reviewed by a third party reviewer.

that totaled 453 tonnes CO₂e. The evaluation team is currently verifying savings for fourteen more PSUP projects with reported savings of 14.4 GWh as part of the 2021 Interim Framework evaluation.⁸

Broader Shifts Towards Decarbonization

Since 2005, Ontario's electricity grid has seen a significant decline in the GHG emissions produced and is forecasted to see significant changes in emissions generated into the future as shown in Figure 6.

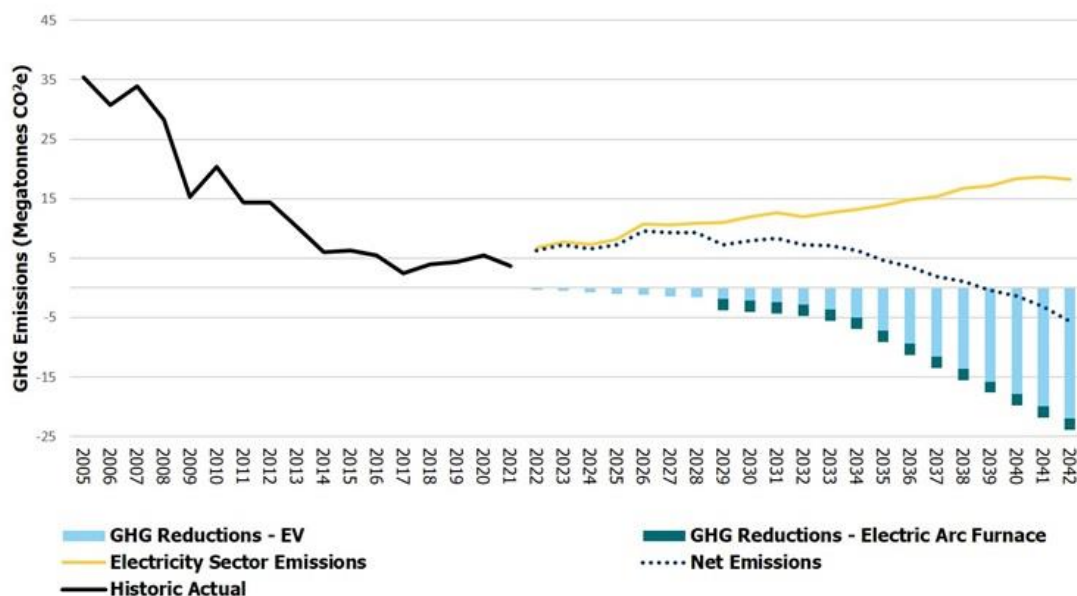


Figure 6. Ontario's historic and forecast electricity sector greenhouse gas emissions
Source: IESO 2021

As a result, the IESO has adapted and will continue to evolve its energy efficiency offerings to most effectively address provincial priorities and needs. Since Ontario's grid historically had fossil fuel generation on the margin during most of the day, this meant programs targeting energy savings were effective at also reducing emissions. More recently, fossil fuel generation has shifted towards mostly meeting peak demand. In response, IESO's energy efficiency programs are now targeting demand savings in order to reduce emissions and also defer infrastructure needs.

The current four-year energy efficiency framework focuses on achieving 440 MW in provincial peak demand reductions (and 2.7 TWh in electricity savings). Compared to the previous framework, current prescriptive programs have an increased emphasis on measures that produce peak demand savings such as refrigeration and non-lighting interventions. Performance-based programs now provide incentives based on demand reduction. For example, the current Energy Performance Program offers a \$50 incentive per kW reduced during summer peak. As sustainability becomes increasingly important to organizations, additional resources will be

⁸ 2021 verified savings for PSUP will be published in the PSUP Evaluation Report on IESO's website in September 2022. <https://www.ieso.ca/en/Sector-Participants/Energy-Efficiency/Evaluation-Measurement-and-Verification>

developed to assist program participants in connecting energy efficiency with their sustainability goals.

As the current framework unfolds, the IESO will deliver additional offerings that target demand reductions which also contribute to GHG reductions. The IESO will also leverage competitive mechanisms that provide the industry with flexibility on how to achieve demand reductions while also enhancing cost-effectiveness. One such initiative is the Industrial Energy Efficiency Program which allows organizations to submit energy efficiency incentive proposals with the highest ranked one being selected to receive funding. This has been an effective mechanism to acquire efficiency resources as demonstrated by the Energy Efficiency Auction Pilot which has secured 7.4 MW of winter peak demand reduction and 6.6 MW of summer peak demand reduction.

A significant decarbonization opportunity on the horizon is the electrification of both transportation and heating. As electrification occurs, emissions in those sectors will reduce but electricity demand will increase and keen attention is being paid to balancing and optimizing these priorities. IESO's energy efficiency programs will lessen the increase in demand electrification has on the grid. The IESO also is identifying opportunities to ensure electrification itself is efficient to further manage increases in demand. The IESO is currently undertaking a study to explore additional pathways to decarbonization that will lay the roadmap for future initiatives.

Lessons Learned

CHPs can offer an excellent opportunity for C&I energy efficiency programs to achieve significant electric savings. However, if C&I program administrators are committed to decarbonization, they should consider:

- The carbon intensity of electricity generation in their jurisdiction
- The eligible fuel types of incented CHPs and their carbon intensities
- Cost effectiveness impacts of increased natural gas consumption

Program administrators committed to decarbonization and creating GHG emissions savings should also consider including incentives for in-depth engineering feasibility studies in the program design. These studies serve multiple purposes including:

- Development of successful, well thought out projects that meet program goals
- Serve as an opportunity to encourage prospective participants to implement specific projects and measures that are most effective in meeting emissions goals
- Requiring participants to understand and quantify the economic benefits of avoided GHG emissions

In order to maintain successful commercial and industrial energy efficiency programs, administrators must remain flexible as the needs of the market and governmental policies change. The IESO provides a great example of this flexibility. PSUP went through a major shift between the CFF and Interim Framework. The IESO responded by leveraging the tools of engineering feasibility studies and funded energy managers to drive participation and savings in the program. In the latest framework, the IESO piloted an Energy Efficiency Auction to allow the C&I sector to drive the efficiency resources for peak demand reduction. Lessons learned

from this pilot have resulted in the development of a full program offering that allows organizations to submit energy efficiency incentive proposals.

References

EPA (United States Environmental Protection Agency). 2021. Combined Heat and Power (CHP) Partnership. (March 1, 2021). <https://www.epa.gov/chp>

Government of Ontario. 2016. Climate Change Action Plan (archived). <https://www.ontario.ca/page/climate-change-action-plan>

IESO (Independent Electricity System Operator). 2017. Amendments to Ministerial Directions Arising from the Long-Term Energy Plan 2017. (October 26, 2017). <https://www.ieso.ca/en/Corporate-IESO/Ministerial-Directives/Amendments-to-Ministerial-Directives-Arising-from-the-Long-Term-Energy-Plan-2017>

IESO (Independent Electricity System Operator). 2019. Discontinuation of the Conservation First Framework. (March 21, 2019). <https://www.ieso.ca/en/Corporate-IESO/Ministerial-Directives/Discontinuation-of-the-Conservation-First-Framework>

IESO (Independent Electricity System Operator). 2019. Interim Framework for the delivery of Energy Efficiency Programs. (March 21, 2019). <https://www.ieso.ca/en/Corporate-IESO/Ministerial-Directives/Interim-Framework-for-the-delivery-of-Energy-Efficiency-Programs>

IESO (Independent Electricity System Operator). 2020. Interim Framework for the delivery of Energy Efficiency Programs. (July 22, 2020). <https://www.ieso.ca/en/Corporate-IESO/Ministerial-Directives/Conservation-First-Framework-timelines-extension>

IESO (Independent Electricity System Operator). 2019. Program Requirements: Save on Energy Process & Systems Upgrades Program. Version 1.0. (May 1, 2019). <https://saveonenergy.ca/-/media/Files/SaveOnEnergy/Document-Archive/IF-Documents/PSUP-Program-Requirements-LT.ashx>

IESO (Independent Electricity System Operator). 2021. Power Data. <https://www.ieso.ca/power-data>

IESO (Independent Electricity System Operator). 2021. *Decarbonization and Ontario's Electricity System*. <https://www.ieso.ca/-/media/Files/IESO/Document-Library/gas-phase-out/Decarbonization-and-Ontarios-Electricity-System.ashx>

IESO (Independent Electricity System Operator). 2021. *Annual Planning Outlook in 7 graphs*. <https://www.ieso.ca/en/Powering-Tomorrow/2021/The-2021-APO-in-7-Graphs>

IPPC (Intergovernmental Panel on Climate Change). 2014. *Climate Change 2014: Mitigation of Climate Change*. “Currently Commercially Available Technologies: Emission Intensify of Electricity Table”. <https://www.ipcc.ch/report/ar5/wg3/>

IEA (International Energy Agency). 2020. *Development of CO2 emission intensity of electricity generation in selected countries, 2000-2020*. <https://www.iea.org/data-and-statistics/charts/development-of-co2-emission-intensity-of-electricity-generation-in-selected-countries-2000-2020>