Efficient Electrification Toolkit: Decision-Support Tools for Advancing Energy-Efficiency and Electrification in Buildings

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ABSTRACT

Electrification of building heating loads is one of the largest decarbonization opportunities for Ontario's public and private sector organizations. Many have set aggressive greenhouse gas (GHG) reduction targets, established timelines for their achievement, and are increasingly receiving funding (i.e., government incentives) to support their decarbonization efforts. However, an information and training needs assessment conducted by the Independent Electricity System Operator (IESO) in 2020 identified knowledge gaps and a lack of decision-support tools for building electrification projects as barriers for these organizations.

A series of workshops and research interviews were held with energy and facility managers to help understand their plans, timelines, and challenges related to decarbonization and electrification. Their feedback underscored a need for simple and flexible analytical tools to estimate energy savings, GHG emission reductions, and the energy cost implications of undertaking energy-efficiency and electrification projects.

In response, an "Efficient Electrification (Toolkit)" was developed as part of a suite of training and capability-building initiatives. The toolkit consists of simple calculators, building modelling templates using the Natural Resources Canada's RETScreen Expert platform, and financial pro forma. This paper explores how the toolkit supports building owners and managers in analyzing and understanding electrification opportunities – beginning with energy efficiency – to help reduce the costs associated with electrification efforts to meet their emission reduction objectives.

Introduction

The IESO works at the heart of Ontario's power system, delivering services across the province's electricity sector including: managing the power system in real-time, planning for the province's future energy needs, enabling conservation, and designing a more efficient marketplace to support the electricity sector.

For over a decade, the IESO has offered energy-efficiency programs and incentives in Ontario through its Save on Energy Conservation and Demand Management (CDM) frameworks. The 2021–2024 CDM framework offers programs like the Retrofit program, the Existing Building Commissioning (EBCx) program and the Strategic Energy Management (SEM) program. Ontario has saved over 17.3 TWh of electricity in the last decade through its Save on Energy programs and resources.

The IESO's Save on Energy CDM offerings also include a broad range of educational tools, resources, and training (capability building) programs to help energy professionals across Ontario build and enhance their competencies in energy efficiency and energy management practices. Capability building in the IESO's 2021–2024 CDM framework includes training and other types of support aimed at increasing the knowledge and skills of Ontario's energy

professionals, channel partners and decision makers in key sectors, leading to increased energy-efficiency across the province.

The 2021–2024 capability-building strategy takes a three-tiered approach to support participants at different levels of sophistication and experience. The three tiers are:

- Foundational: actionable guidance, basic knowledge, introductory training for sector participants with limited experience and/or resources.
- Specialized: higher level training resources tailored to key customer sectors and channels.
- Advanced: facilitation of an integrated approach to energy efficiency and decision-making for experienced organizations in priority sectors and channels, as defined by opportunity and need.

Education and training play an important role in mitigating the risks that investment in poorly planned projects and inefficient technologies will contribute to a larger increase in overall electricity load through building electrification. This ensures that electrification occurs in a way that manages both reliability of the electricity grid as well as costs of electrification projects and energy bills. As such, the Toolkit was designed to inform decision makers on how to plan their decarbonization projects in the most cost-effective way, while also ensuring maintaining reliability of the electricity grid.

Ontario's Electricity Grid

The long-term forecast of Ontario's electricity system is summarized in the IESO's Annual Planning Outlook (APO). The APO forecasts electricity demand, assesses the reliability of the electricity system and assesses supply to meet Ontario's energy needs by identifying future system needs and the factors that influence them while providing insights into what will be required to prepare for a reliable and affordable electricity future in Ontario. The 2022 APO covers the period from 2024 – 2043 and informs the development of actions in the IESO's 2023 Annual Acquisition Report (AAR), which translates planning and operational information into a series of acquisition requirements.

Historically, Ontario's grid-level demand[1] over the five-year period (2017 through 2021) has been mostly flat, ranging between 132 and 138 terawatt-hours (TWh), as shown in Figure 1.[2]

[1] Gross-level demand is the total demand for electricity services in Ontario prior to the impact of conservation (including programs and regulations), but including the effects of naturally occurring conservation (energy savings that occurs without the influence of incentives or education programs and regulations). Net-level demand is gross-level demand minus the impact of conservation. Grid-level demand is net-level demand minus the demand met by embedded resources. It is equal to the energy supplied by the bulk power system to wholesale customers and local distribution companies.

[2] Historical energy demand presented is actual observed demand based on actual weather and has not been weather normalized.

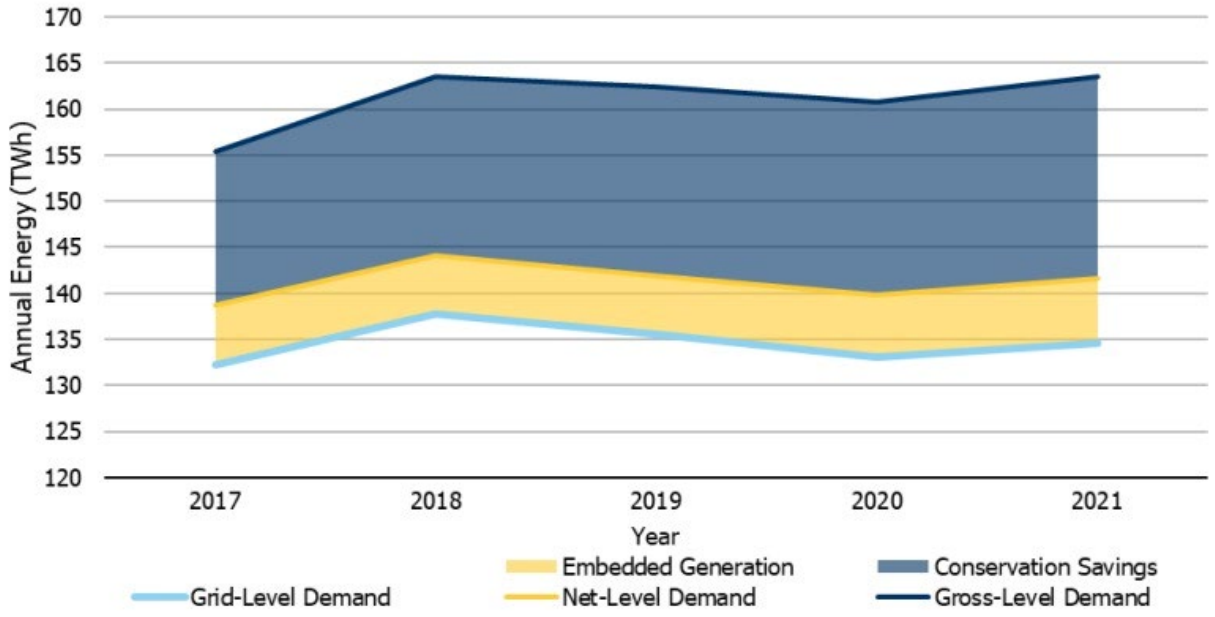

Figure 1. Historical energy demand

The 2022 APO projects an increase in electricity demand due to an emerging transformation of the economy, which is driven by climate change mitigation factors such as, fuel switching from carbon-based fuels to, electricity, as well as potential economic development and policy stimulus. Other factors that support the projected increase in electricity demand include stable electricity rates, increasing natural gas rates, and increasing GHG emissions costs over the outlook period.

In 2023, the total electricity demand in Ontario was at 137.1 TWh and the energy produced (delivered capacity) was made up of a diverse mix of resources, shown in Figure 2.[3]

[3] While capacity represents the maximum amount of electricity that the system can supply at any given time, the amount of energy produced varies. Most of the electricity produced in Ontario is generated at nuclear and hydro plants, which produce low levels of greenhouse gas emissions. For further information, please see the 2023 Year in Review.

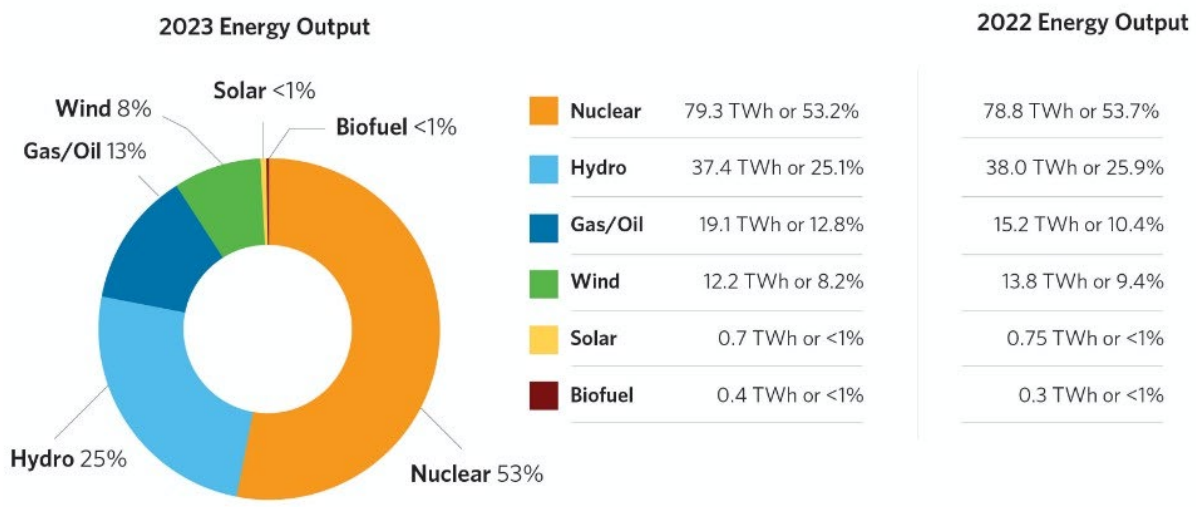

Figure 2: Total electricity output by source in 2023. Note: Due to rounding, percentages may not add to 100

In Ontario, summer capacity needs are typically higher than winter capacity needs due to summer peaks, influenced by air conditioning demands. However, electrification of heating is forecasted to result in a switch from summer to winter peaks in the mid-2030s.

In 2022, the IESO published the Pathways to Decarbonization, a report to the Ontario Minister of Energy to evaluate a moratorium on new natural gas generation in Ontario and to develop a pathway to zero emissions in the electricity sector. The Pathways to Decarbonization report illustrates how the electricity system would require an additional 69,000 MW of non-emitting supply and 5,000 MW in demand reduction from conservation to meet winter peaks, which are almost three times higher than what is experienced today.

Market Context

Public sector organizations – municipalities, colleges and universities, and hospitals – are leading the way on decarbonization and electrification in Ontario today. Important gains are also being made in the Class A commercial real estate and industrial sectors. Ontario regulation requires public organizations to maintain climate plans that align with the GHG emissions reduction goals of achieving a 37% reduction by 2030 and an 80% reduction by 2050 relative to 1990 levels.[4] Many public sector organizations have achieved, or are on track to achieve, their initial emissions reductions targets, most of which took effect between 2020 and 2022. Decarbonization of the electricity supply through the decommissioning of coal plants was a major contributor to these organizations' success, since emissions caused by electricity consumption are a key factor in calculating scope-2 emissions. These organizations also reported that they have further 2030 emissions reduction targets, which range from 30% to 80% emission reductions against a baseline year. These will be significantly more challenging to achieve than

[4] Government of Ontario, *Ontario's Climate Change Strategy*: https://docs.ontario.ca/documents/4928/climate-change-strategy-en.pdf

their initial targets, in part because the Ontario electricity system is nearly ninety percent emissions-free.[5]

Given natural gas heating is prevalent among these types of facilities and Ontario has a clean electricity system, electrification of Heating, Ventilation and Air Conditioning (HVAC) and vehicles presents the largest emissions-reduction opportunity for public sector organizations. Interviews with public sector organizations found that natural gas use represents as much as 80% of the many organizations' emissions portfolio-wide.

The IESO conducted individual and small-group interviews with more than 30 businesses, industry associations, public organizations, and other key stakeholders to better understand their current activities and challenges related to electrification. According to those interviews, most electrification activity that has been completed or is currently underway in public sector organizations in Ontario falls into one of four categories:

- Converting natural gas boilers to electric boilers in district heating systems: This is most common in colleges and universities with multiple buildings and one or more campuses.
- Replacing rooftop units (RTUs) and hydronic systems with air-source heat pumps (ASHP) in existing building retrofits: Municipalities reported the most activity converting from natural gas-fired RTUs to ASHP.
  ASHPs appear likely to be a high-volume measure for the municipal sector over the next one to five years. Municipalities consistently indicated that they had investigated replacing RTUs or hydronic heating systems with ASHPs and several have also considered ground-source heat pumps (GSHP). More than half had completed three or more projects replacing RTUs with ASHPs. Two municipalities indicated that ASHPs offer the best lifecycle cost for many projects, based on projected energy and carbon pricing.
- Installing GSHPs in new construction: One university indicated that all its new facilities will be heated with GSHPs going forward, and nearly half of all respondents (five) have installed or are in the process of developing GSHP projects in new buildings. Several municipalities and universities indicated that they had investigated installing GSHP as a retrofit measure, but none had gone forward with the projects.
- Electrifying vehicle fleets: More than half of respondents (six) noted that they are taking steps to electrify their vehicle fleets and add electric vehicle (EV) charging stations to their building portfolios. To date, these have been small purchases and demonstration projects, but one municipality indicated it plans to replace 300 vehicles over the next 10 years and expand charging stations.

The most significant barriers to decarbonization projects are project costs and electrical service limitations, though several municipalities indicated that city councils are increasingly willing to invest capital funds in projects to reduce emissions. Electrical service capacity or supply availability constraints are a widespread challenge: one in three interviewed organizations reported that they had been blocked from electrifying one or more pieces of equipment because

[5] Independent Electric System Operator, "Decarbonizing the Electricity Sector", 2023: https://www.ieso.ca/en/Powering-Tomorrow/2023/Decarbonizing-Ontarios-Electricity-Sector#:~:text=Today%2C%20Ontario's%20electricity%20system%20is,a%20significant%20and%20complex%20undertaking.

the electrical service at the building- or at the utility feeder-level could not support the additional load from new electric heating equipment.

Information and Training Needs

Because of Ontario's clean electricity system, electrifying natural gas heating in buildings is one of the largest opportunities for businesses and public sector organizations to reduce emissions. In this context, heat pumps are critical: electrifying building heating loads on a broad basis with less-efficient options such as baseboard heating and electric boilers would cause challenges for electricity supply and distribution. Widespread adoption of heat pumps is necessary to decarbonize building heating while managing new electrical load growth. But many heating and cooling contractors are unfamiliar with heat pumps and less likely to purchase or sell them over higher-emitting or less-efficient technologies, particularly in the residential sector.

Energy and facilities managers at public sector organizations identified several gaps in available information, tools and expertise that pose challenges to adoption of heat pumps, including:

- **Tools to understand the energy, cost, and carbon impacts of electrifying building heating systems.** Energy and facilities managers consistently indicated they did not have effective, easy-to-use tools to estimate the impacts of electrification projects. A few organizations had off-the-shelf energy analysis or modelling tools, but these were a poor fit for understanding and comparing electrification scenarios. Others had developed their own tools to analyze energy project outcomes, typically using Microsoft Excel, but these tools were limited in scope and usefulness. There was a need for a simple, easy-to-use tool to estimate approximate cost and carbon impacts for common project types that managers and finance teams could use to screen or sort potential projects to support capital and maintenance planning. There was also a need for a more powerful analysis tool capable of modelling the impacts of different electrification project scenarios to support the development of a detailed business case and inform sizing and design decisions.
- **Efficient building operations with heat pumps.** There is an information gap regarding changes in building operations that may be required to operate a building efficiently after a heat pump retrofit. Well-informed and effective building operations is important if Ontario is to achieve the energy savings and emissions reduction potential offered by heat pumps. Building managers and operators highlighted knowledge gaps including how to manage temperature setbacks to avoid engaging backup heating systems, balancing heating ramp-up times and peak demand periods, and equipment maintenance procedures.
- **Electrification constraints**. Building owners and managers face an information gap regarding the electrical service capacity at the building and feeder level. Electrification project developers need to know whether their building and the local distribution network has sufficient capacity to accommodate new loads ranging from 10 kW for ASHPs or EV charging in a small office building to 800 kW for an electrical boiler on a college campus to 6 MW for a new electrical arc furnace in a steel plant. Timing and cost are also key considerations. Is capacity available now and is it likely to be available in a few years?

How much will it cost to increase capacity for the building, and can the larger distribution system accommodate that?

The IESO's Save on Energy Training and Support Program was well-positioned in 2022 to address these needs through information, tools development, and training to support building owners in making informed electrification decisions. The IESO recognized that market and policy pressures were beginning to drive organizations across Ontario to consider electrification opportunities. The objective of this Training and Support Program initiative was to provide information and tools to enable those organizations to electrify their heating and operations in an energy-efficient manner.

The Efficient Electrification Toolkit

Recognizing the need for tools and information to support businesses and public organizations across Ontario in making informed decisions about electrification opportunities, the IESO developed the Efficient Electrification Toolkit. The Toolkit includes fact sheets, easy-to-use calculators to estimate cost and carbon impacts of electrification projects and building model templates to facilitate more detailed technical and financial analysis using the RETScreen Clean Energy Management Software platform[6]. The IESO's Save on Energy program also offered a series of webinars and workshops, as well as hands-on coaching and technical support, to help building owners and managers apply the new tools in developing electrification projects.

Fact Sheets

The Toolkit includes simple fact sheets to improve end user understanding about topics in building electrification, including how to compare the cost and carbon performance of different heating systems using common units, common constraints for building electrification projects such as electrical service limitations at the electrical panel, service entrance, or transformer, and heat pump performance across Ontario's different climate zones.

Easy-to-use calculators

The IESO developed two types of easy-to-use calculators based in Microsoft Excel to ensure that they are accessible to a wide range of users: Heat pump retrofit interactive fact sheets and a Simple lifecycle cost analysis tool.

Heat pump retrofit interactive fact sheets. These help the user to approximate the energy performance, cost and carbon impacts of retrofit projects that involve replacing an existing heating system with heat pumps. The fact sheets use a familiar "Did you know…" approach but allow the user to choose between different options for five different parameters, including where in the province their building is located, the fuel used by the existing heating system, the new equipment configuration, and the building's level of insulation. They also allow the user to select from sets of energy efficiency measures that will be implemented alongside the heating system

[6] RETScreen supports pre-feasibility and feasibility analysis of energy efficiency, renewable energy and electrification projects. RETScreen is developed and maintained by CANMET Energy, a division of Natural Resources Canada. Information about RETScreen is available at https://natural-resources.canada.ca/maps-tools-and-publications/tools/modelling-tools/retscreen/7465.

retrofit, including demand control ventilation, heat recovery, and air sealing. Additionally, the sheets involve a set of static assumptions regarding the building floor area, efficiency of the existing and proposed heating equipment, fuel costs, and project costs for heat pump and energy efficiency retrofits. Based on the options selected by the user, the interactive fact sheet generates a set of outcomes and financial metrics that include annual operating costs, carbon emissions impact, internal rate of return, net present value, and cost per ton of avoided emissions.

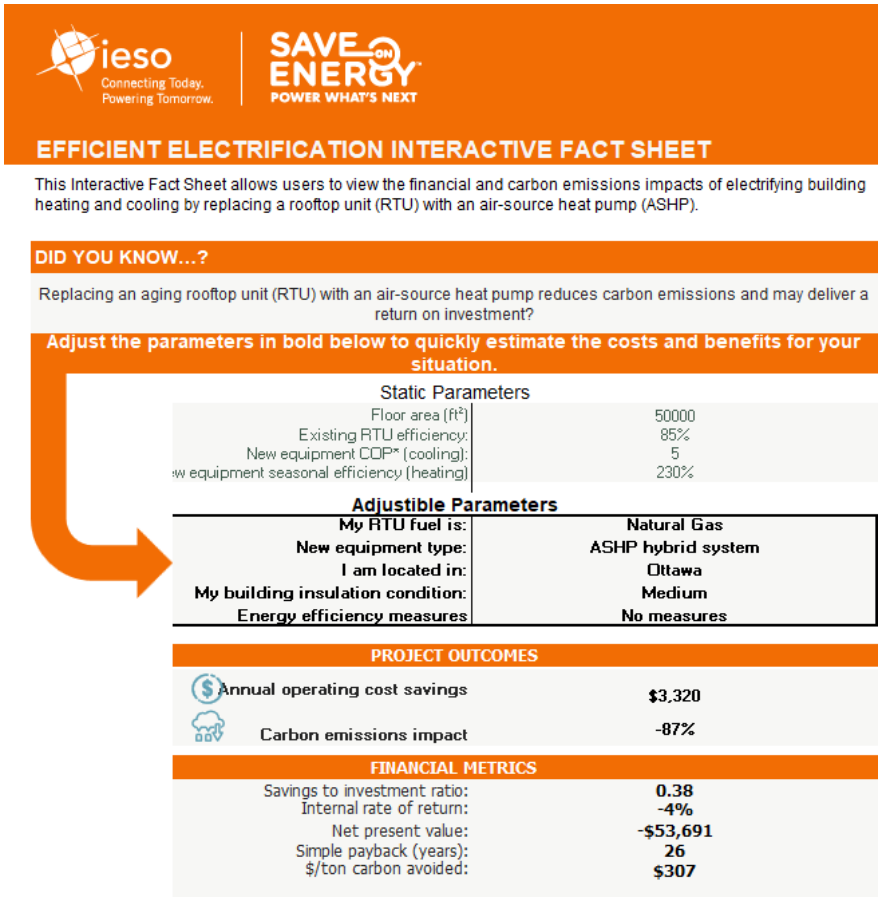

Figure 3. The Efficient Electrification Interactive Fact Sheet for Rooftop Unit-to-ASHP Retrofits

Each fact sheet relies on more than 300 individual simulations conducted in RETScreen and saved in the background, allowing users the benefit of sophisticated modelling tools and the familiarity and accessibility of MS Excel. The Toolkit includes one interactive fact sheet for a mid-rise office building replacing a RTU with ASHP; other interactive fact sheets are currently in development by the RETScreen team at CANMET Energy including replacing boilers in a multi-unit residential building.

Simple lifecycle cost analysis tool. Because natural gas is less expensive than electricity per unit of delivered energy in most parts of Ontario, it can be challenging to develop business cases for electrification projects based on simple payback. The IESO developed an easy-to-use, MS Excel-based calculator with which users can calculate and compare financial metrics including net present value, internal rate of return, and savings-to-investment ratio for base case and proposed case scenarios with a few simple inputs.

Advanced calculators. The Toolkit includes financial analysis and modelling tools to support facilities and energy professionals in conducting more detailed analyses of potential energy efficiency and electrification projects. Most of these tools rely on the RETScreen Clean Energy Management Software platform developed and maintained by Natural Resources Canada. RETScreen supports project planning, implementation, monitoring and reporting through a suite of modelling as well as performance and financial analysis capabilities. The IESO chose to use RETScreen as a key platform for the Toolkit because it offers an intermediate solution between simple, MS Excel-based calculators and professional energy modelling platforms such as CANQuest and EnergyPlus. Energy and facilities managers in Ontario are familiar with RETScreen and many already have access to the software.

Efficient Electrification Facility Archetypes. Energy and facilities managers from the public sector and commercial real estate sector indicated the need for modelling and analysis tools to support the initial steps of building electrification project development. These steps include estimating the building's heating and cooling load based on energy bills or modelled performance, matching the load to a proposed heating and cooling system (usually a heat pump), and analyzing the financial and carbon emissions impacts of the proposed retrofit. RETScreen offers all these capabilities, but the IESO found that many users lacked the expertise needed to connect the outputs of one step to the inputs for the next and were not able to use RETScreen to meet their need for a tool to support the development of detailed business cases for building electrification projects.

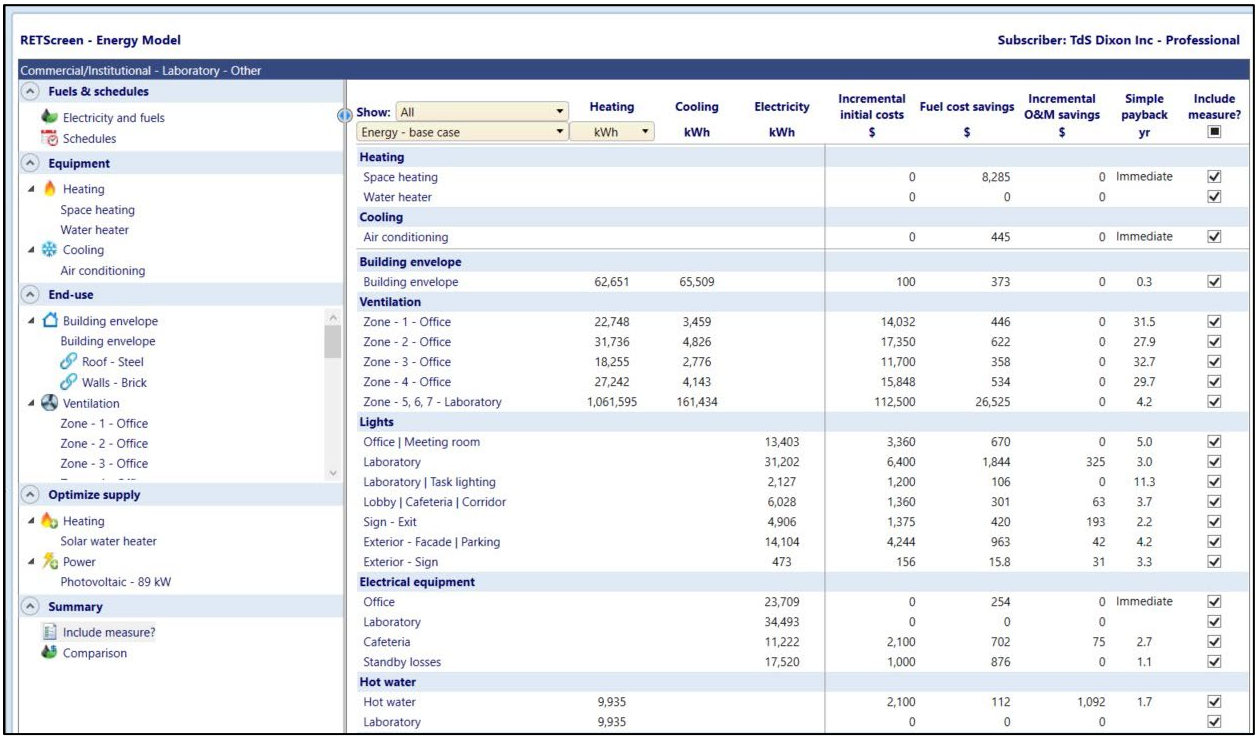

Figure 4. The Efficient Electrification RETScreen Archetype for Laboratory Buildings, Viewing/Updating Building Parameters in The Feasibility Model

To support users in applying RETScreen to building electrification projects, the IESO developed a set of facility archetype files that include many of the inputs needed to support electrification project analysis for a specific facility type, and detailed instructions to guide users in applying the archetypes to their project scenarios. Figures 4 and 5 show screenshots of the Feasibility Model and Power Heating/Cooling Model components of the Archetype for Laboratory Buildings. Each facility archetype file includes assumptions regarding the facility size, envelope, configuration (e.g., the recreation centre includes a pool and skating rink), as well as heating, cooling, and ventilation equipment. Experienced RETScreen users can customize all these factors to match their facility, while unpracticed users can rely on the assumptions to approximate their situation.

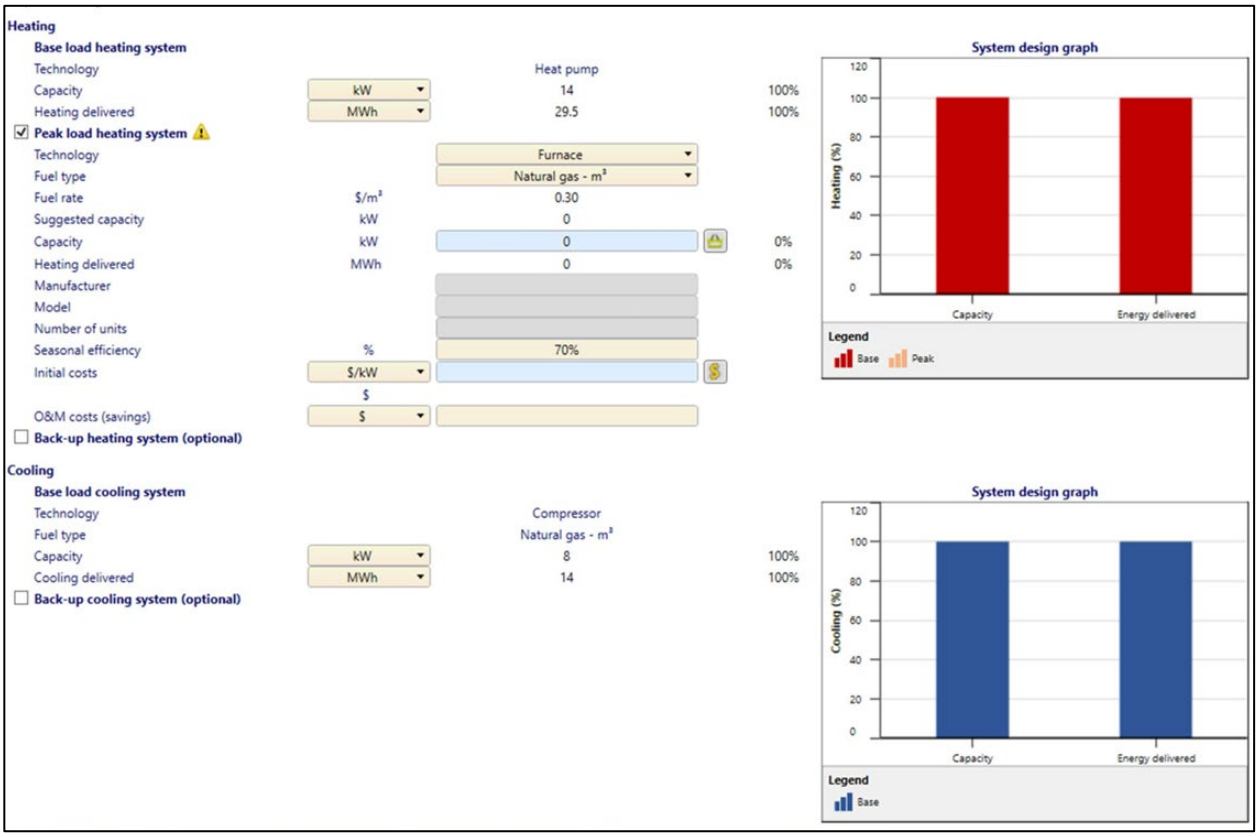

Figure 5: The Efficient Electrification RETScreen Archetype for Laboratory Buildings, Balancing the Primary and Back-up Heating Systems Using the Power-Heating-Cooling Model View

A key feature of the Efficient Electrification RETScreen Archetypes is the ability for the user to choose how to balance primary and back-up heating systems to optimize for the maximum emissions reduction at the lowest capital cost. Winter low temperatures in southern Ontario can reach -20ºF, but they are more often between 5ºF and 35ºF. Sizing the new electric heating system to serve the peak heating load at -20ºF will be significantly more expensive for most buildings than sizing the heating system to meet the load at 5ºF and relying on a back-up system for a few hours or days each year. By selecting different sizes for the primary heating equipment (usually a heat pump) and different heating system balance temperatures, users can easily understand what share of their total heating load will be served by the new primary heating system and what share will be served by the back-up system, and the cost and emissions implications of different configurations. For example, during usability testing with

municipalities, colleges, and universities, the IESO found that sizing a new heat pump to meet 80 percent of a facility's peak heating load would result in the heat pump delivering 95 to 98 percent of that building's heating load over a typical year. Reducing the size of the new heat pump to 50 percent of the facility's peak heating load resulted in the heat pump delivering 75 to 80 percent of annual heating load. By making this type of analysis fast and simple to perform, the Archetypes enable users to compare the capital cost and emissions outcomes of different sizing options for new electric heating systems.

Interviews showed that the public sector – municipalities, colleges, and universities, in particular – is leading the way in Ontario on building electrification as a retrofit opportunity. The IESO conducted detailed interviews with municipalities, colleges and universities and worked closely with four of these organizations to test and refine early versions of the facility archetypes. Based on user feedback the IESO also developed an initial set of four facility archetypes: office/classroom building, laboratory building, fire station, and community center/recreation center.

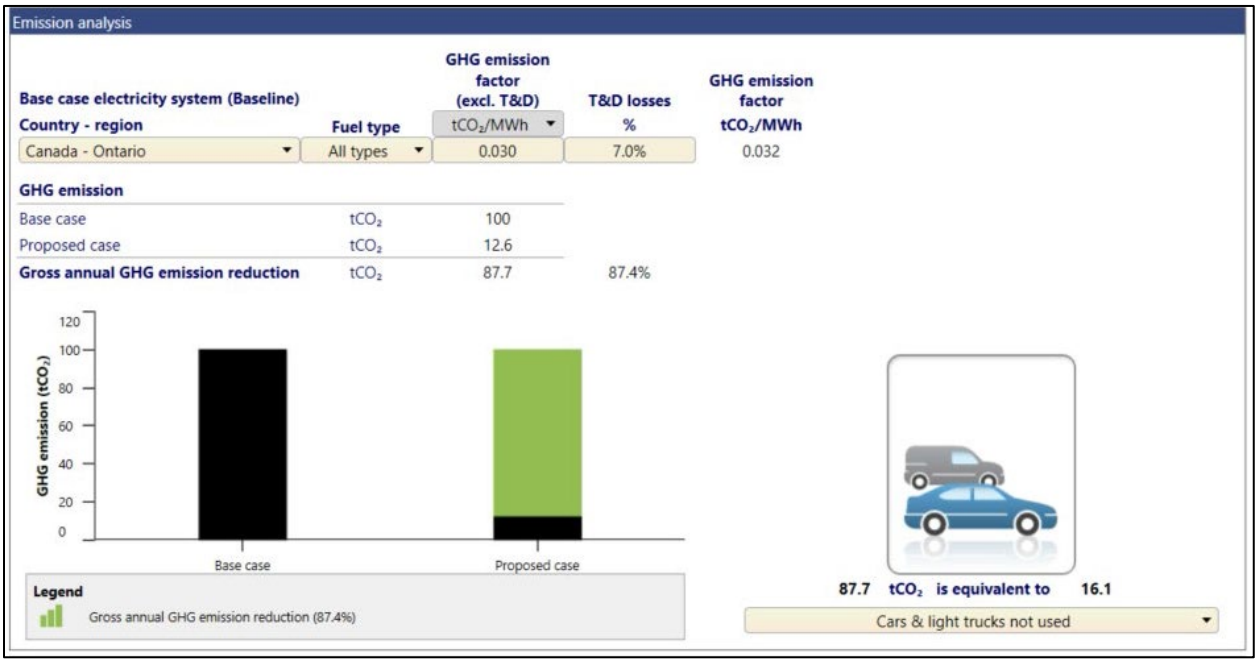

Figure 6. The Efficient Electrification RETScreen Archetype for Laboratory Buildings, GHG Emissions Outcomes View.

RETScreen Virtual Energy Analyzer. The IESO developed the Efficient Electrification RETScreen Archetypes in 2022. At that time RETScreen had the capability to analyze electrification project outcomes, but the level of expertise and time required were prohibitive for many users – the IESO's Save on Energy Efficiency Electrification Facility Archetypes addressed that need by populating many of the required inputs and providing clear instructions for users.

In October 2023, Natural Resources Canada released RETScreen version 9.1, which includes a new, built-in tool to support analysis of electrification and decarbonization projects. The Virtual Energy Analyzer is a set of facility archetypes – including office buildings, multi-unit residential buildings, retail, education and institutional buildings, industrial facilities and more – each with a detailed building model and a set of energy efficiency and electrification

measures that achieve a 30-40% or 80% reduction in that facility's Scope 1 and Scope 2 emissions. The Virtual Energy Analyzer guides users in identifying the most cost-effective opportunities to reduce emissions by providing easy-to-compare before-and-after results for energy performance, emissions, and operating costs. Facility archetypes are complete representations of a typical facility – they require no customization or modification by users – and users can modify many different parameters such as the building size and use, heating and cooling systems, envelope materials and construction, and location to better match their own facilities.

Efficient Electrification Toolkit Training. The IESO's Save on Energy program offered a series of webinars and remote workshops timed with the release of the Toolkit to support organizations and businesses across Ontario in applying the Toolkit to their project planning and development.

The training series began with an informational webinar discussing the basics of electrification projects, the important role of energy efficiency in improving project outcomes, and key electrical heating and cooling technologies and configurations for commercial and institutional buildings. Next, the IESO offered a workshop in which participants received hands-on instruction from expert coaches in how to apply the Efficient Electrification Facility Archetypes in RETScreen to their own buildings and projects. Subsequent workshops in the series provided instruction and coaching in how to use the RETScreen Virtual Energy Analyzer for electrification projects and how to conduct financial analysis and develop business cases for electrification projects.

In addition to public webinars and workshops, the IESO is providing focused training to specific sectors that have indicated a need for electrification project support, including public school boards and commercial real estate sector groups. The IESO's Save on Energy program has engaged with public agencies (school boards) and industry associations (real estate) to offer information, training and hands-on technical assistance to energy/sustainability and facilities managers planning or developing building electrification projects in schools and commercial buildings across Ontario.

Stakeholder Feedback and Next Steps

The IESO worked closely with a small group of municipalities and colleges to develop the Toolkit. Energy and facilities managers from these organizations tested early versions of the Interactive Fact Sheet and Efficient Electrification Facility Archetypes and provided feedback to improve the value and usability of the tools.

The Toolkit was developed to support organizations and businesses to identify and develop electrification and decarbonization projects in their early stages, prior to engaging an engineering consultant to develop the detail design. But testers consistently indicated that the Facility Archetypes are also valuable as a tool to support building owners having informed discussions with engineering consultants during the design stage. Some municipalities and universities with experience developing building electrification projects indicated that consultants had recommended one design – including equipment sizing and selection – for their project, and they as the client did not have the tools or expertise to analyze the design and offer feedback. Given this experience, some Toolkit testers particularly appreciated the ability to quickly assess the cost and emissions impacts of sizing the heat pump to meet less than one

hundred percent of a building's peak heating load, and to use those results as the basis for design discussions with engineering consultants.

During the development of the Toolkit, the City of Toronto approached the IESO to discuss collaboration opportunities to support building electrification and energy efficiency. The City of Toronto has ambitious energy and emissions objectives, including reducing GHG emissions by 50% by 2030 and achieving net zero emissions by 2040.[7] One component of the city's strategy to meet these objectives is to support local energy efficiency and decarbonization professionals that, in turn, will provide key expertise and services to the thousands of aging, mid-size, Class B and C buildings across the Greater Toronto Area. The City of Toronto engaged with the IESO to develop training workshops for energy professionals to help to apply the Toolkit in their work with building owners – these workshops will take place during spring and summer 2024.

The IESO expects to build on the public training series and the collaboration with the City of Toronto to continue to share the Toolkit with energy professionals and building owners across Ontario. The team also continues to develop additional Toolkit resources, including new Interactive Fact Sheets for a wider range of building and equipment scenarios and How-To capsule videos. By continuing to expand the Toolkit and share it with building owners, the IESO will support informed electrification project decision-making that integrates energy efficiency, reduces emissions and long-term operating costs, and maintains a reliable, affordable, and clean electricity system.

[7] City of Toronto, "TransformTO Net Zero Strategy", 2024: www.toronto.ca/services-payments/water-environment/environmentally-friendly-city-initiatives/transformto/.

References

City of Toronto, “TransformTO Net Zero Strategy”, 2024: www.toronto.ca/services-payments/water-environment/environmentally-friendly-city-initiatives/transformto/

Independent Electricity System Operator, “Annual Acquisition Report”, 2022: www.ieso.ca/en/Sector-Participants/Planning-and-Forecasting/Annual-Acquisition-Report

Independent Electricity System Operator, “Annual Planning Outlook Report”, 2022: www.ieso.ca/en/Sector-Participants/Planning-and-Forecasting/Annual-Planning-Outlook

Independent Electric System Operator, “Decarbonizing the Electricity Sector”, 2023: https://www.ieso.ca/en/Powering-Tomorrow/2023/Decarbonizing-Ontarios-Electricity-Sector#:~:text=Today%2C%20Ontario's%20electricity%20system%20is,a%20significant%20and%20complex%20undertaking

Independent Electricity System Operator, “Save on Energy Efficient Electrification Toolkit”, 2024: saveonenergy.ca/Training-and-Support/Commercial/Efficient-electrification#:~:text=The%20Efficient%20Electrification%20Toolkit%20is,configuration%2C%20energy%20needs%20and%20objectives.

Independent Electricity System Operator, “2023 Year in Review”, 2024: https://www.ieso.ca/Corporate-IESO/Media/Year-End-Data