LONG SAULT ARENA GHG REDUCTION PATHWAY FEASIBILITY STUDY – FINAL REPORT

Abstract

This report has been completed for the Township of South Stormont as part of the 'Long Sault Arena GHG Reduction Pathway Feasibility Study'.

Created for the Township of South Stormont
June 13th, 2023

Created By: Next Energy Development Group Inc.

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Long Sault Arena GHG Reduction Pathway Feasibility Study
Completed for: Corporation of the Township of South Stormont
Completed by: Next Energy Development Group Inc.
June 13th, 2023

Executive Summary

Project Summary and Recommendations

Next Energy Development Group Inc. has been contracted to complete the Long Sault Arena GHG Reduction Pathway Feasibility Study for the Township of South Stormont. This report quantifies the technical and financial feasibility of performing a deep energy retrofit on the Long Sault Arena via the development of a 20-year plan for the facility with the goal of achieving net-zero operation. Additionally, this report is intended to provide the Township and all other interested parties with guidance and insight on how to: achieve cost-effective deep energy retrofits, increase environmental stewardship, improve efficiencies, and reduce energy consumption, GHG emissions, and energy related operating costs.

This report quantified four deep energy retrofit pathways which would allow the Township to achieve net-zero operations at the Long Sault Arena. Each Pathway includes a variety of energy conservation and emission reduction measures targeted towards reaching the goal of net-zero operation. Additionally, three of the four pathways include a proposed rooftop photovoltaic system with on-site battery storage. Rooftop solar generation with on-site battery storage was selected as a focal point of these Pathways in order to: transition to renewable generation, capitalize on the available solar resource, aid in the potential for full site electrification, capitalize on Hydro One's Net Metering program, and advance the opportunity for the Township to use the facility as an emergency shelter.

In-line with the Township's established environmental and financial goals, it is recommended that the Township continue to pursue measures that will allow the Long Sault Arena to operate as efficiently as possible, minimizing operating costs, consumption, and greenhouse gas emissions.

Should funding become available, it is recommended that the Township pursue Pathway #2 – GICB / Optimize Existing. This Pathway is recommended as, if implemented, it would provide the Township with the plans to: achieve a substantial decrease in operating greenhouse gas emissions reductions (47.5%), achieve net-zero operation through the purchase of carbon offsets, improve efficiencies and environmental stewardship, and provide energy security for the local community. This Pathway would allow the Township to meet all of these goals all while addressing the short- and long-term needs of the facility in a cost-effective manner. This selected Pathway is the most cost-effective solution for the Township; by maximizing the financial benefits of this project, the Township would increase available funding as it continues to target ways to further reduce costs, consumption, and emissions across the entire municipal fleet.

It is further recommended that the Township look to pursue a green building certification such as Zero Carbon Building (ZCB) or Leadership in Energy and Environmental Design (LEED), to garner the recognition that comes with the certification and promote environmental stewardship to the local and neighbouring communities.

At the time of writing this report, substantial funding opportunities exist through various government programs to offset the financial requirements of implementing the selected GHG reduction pathway, and/or select energy efficiency upgrades identified in this report. In February 2023 the

Township applied to Infrastructure Canada’s Green and Inclusive Community Buildings program in hopes of receiving up to 80% of eligible project costs for all ECMs included in the application. Further funding is available through the Federation of Canadian Municipality’s ‘Green Municipal Fund’ should the Township look to proceed with implementing the identified pathway. Additional retrofit rebates are available on a component specific nature through various utility providers.

Should the Township experience budget constraints related to this project, it is recommended that the Township closely examine the financial viability of individual energy conservation measures to maximize GHG emission reductions within the available budget. Additionally, it is recommended that this report is referenced when replacing end-of-life equipment to identify and pursue energy efficient replacement options.

Table 1 below summarizes the key financial, energy, and GHG considerations for each analyzed Pathway.

Table 1 - Summary of GHG reduction pathways

Pathway	Total Construction Costs	Incentives and Grants	Annual Energy Costs (Year 1)	Annual Cost Savings	Annual Energy Consumption [GJ]	Annual Energy Savings	Annual GHG Emissions	Annual GHG Emissions Reduction	NPV	IRR
P1 - Like-for-Similar	$1,345,339.13	$19,833.00	$112,962.75	11.9%	3,196.56	8.00%	93,755.98	3.2%	-$824,801.85	-4.0%
P2 - GICB / Optimize Existing	$2,809,784.13	$2,176,306.65	$103,374.96	17.1%	2,594.80	25.30%	50,883.71	47.5%	$1,513,290.25	17.8%
P3 -Full Electrification	$3,842,407.81	$2,362,427.75	$144,631.11	-23.0%	2,660.56	23.40%	10,386.66	99.9%	$1,072,432.85	11.8%
P4 - Full Electrification - Five Year Short Term Deep Retrofit	$3,804,907.81	$2,355,927.75	$144,631.11	-23.0%	2,660.56	23.40%	10,386.66	99.9%	$825,464.64	9.5%

Annual GHG emission reductions in Table 1 above include all means of avoided emissions, less the purchase of carbon credits. For all Pathways, the purchase of carbon credits is included to achieve net-zero operation.

Overall Assessment of Energy Benchmarking and Performance

Historical utility data from the baseline period of 2017 through 2019 was used to quantify a baseline year, and generate a calibrated energy model. A summary of annual consumption can be seen in Table 2 below.

Table 2 - Summary of Energy Consumption

	Electricity [kWh]	Variance from Calibrated Model	Natural Gas [m^3]	Variance from Calibrated Model
2017	530,640.00	1%	42,886.42	0%
2018	518,172.00	-1%	39,114.22	-9%
2019	519,600.00	-1%	42,012.41	-2%
Baseline	522,804.00	0%	41,337.68	-4%
Calibrated	524,999.00	N/A	42,791.84	N/A

Using this data, two key building performance metrics were quantified for the Long Sault Arena. These metrics are as follows:

1) Energy Use Intensity (EUI) – Represents the total energy consumed within a specific period, typically a year, relative to the building's or facility's size or function [GJ/m^2]

2) Greenhouse Gas Intensity (GHGI) – Represents the total amount of greenhouse gas emissions within a specific period, typically a year, relative to the building's size or function [$ekgCO_2/m^2$]

Figure 1 below shows these metrics for each year of the baseline period, the baseline year used for model calibration, and the resulting output of the calibrated whole-building energy model.

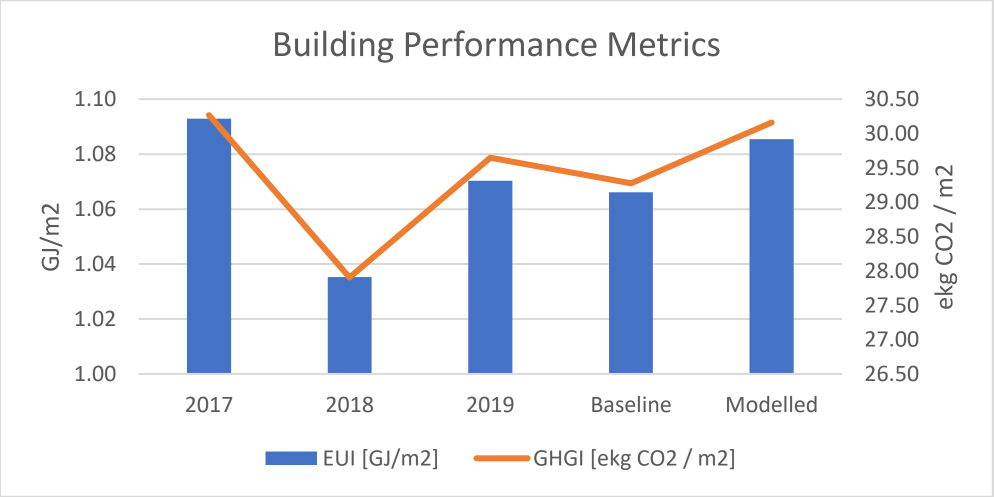

Figure 1 - Building Performance Metrics

b) Methodology Summary

To quantify the existing energy profile of the facility, an energy assessment was conducted consistent with ASHRAE Level II guidelines established by the ASHRAE 211 Standard for Commercial Building Energy Audits. The results of this audit have been incorporated into this report.

As part of the Township's application to Infrastructure Canada's Green and Inclusive Community Buildings (GICB) program, an energy model of the facility was generated using RETScreen Expert and calibrated to within 5% of annual utility consumption. Next, an energy model of the facility was generated using DesignBuilder and again calibrated against annual utility consumption ensuring adherence to the ASHRAE 14 energy modelling standards.

Once a thorough understanding of the facility and its operations was available, a forward projection of the facility was undertaken to fully quantify and gain a deeper understanding of the future of the facility over the study period. Information found was used to quantify maintenance requirements and cost estimates over the 20-year study period, as well as cost estimates for energy efficient alternatives to components requiring replacement over the same period, not considered in the initial energy audit. All cost estimates were completed to a CIQS Class C level capital estimate (+/- 25%).

With a clear understanding of the facility, its operations, and its future, a variety of retrofit pathways for the facility were considered, and four pathways were selected for further analysis. The selected pathways were then analyzed using DesignBuilder software to predict the overall performance of the facility at the end of the applicable pathways retrofit period.

This study was completed ensuring to incorporate stakeholder engagement throughout, to allow for project deliverables to be used in-line with additional funding programs targeting the same objectives, and to be flexible to future changes of the facility such as operational changes or facility expansion.

Rates and Assumptions

The utility rates used throughout this report to create a financial baseline consumption model and evaluate the energy efficiency measures were calculated as an average of the rates over the three-year baseline period of 2017-2019, based on the applicable billing structure at the facility. Electricity is billed through Hydro One under the 'General Service Demand' rate class. Natural gas and water are billed through Enbridge Gas, and the Township of South Stormont, respectively.

Electricity Consumption [\$/kWh]	0.1258
Electricity Demand [\$/kW] (2020)	23.83
Blended Electricity Cost (Pre-Tax) [\$/kWh]	0.1957
Natural Gas Consumption [\$/m^3]	0.3475
Water Consumption [\$/m^3]	3.004

Annual escalation factors of 5.9% and 7% annually were used for the price of electricity and natural gas, respectively.

Greenhouse gas emissions factors and other considerations used through this report are as follows:

- GHG Emission Factors:
  - Electricity: 0.028 g/kWh (Ontario Grid)[1]
  - Natural Gas: 1921 g CO_2/m^3 (Ontario)[1]
- Other:
  - Discount rate: 5%
  - Carbon Offset Cost (average) \$20/tonne $C0_2$

Contents

Introduction

Background

Next Energy Development Group Inc. was contracted by the Corporation of the Township of South Stormont to serve as the primary consultants tasked with completing the 'Long Sault Arena GHG Reduction Pathway Feasibility Study'. The Long Sault Arena, located at 60 Mille Roches Rd, Long Sault, ON K0C 1P0, is an approximately 3,200 m^2 space primarily built in 1994, consisting of: an NHL-sized ice pad, 6 changerooms, referee room, music room, John Cleary meeting room, canteen, maintenance rooms, and office space for Township Recreational staff.

The objectives of this study were to: conduct an energy audit of the Long Sault Arena, develop a calibrated energy model of the facility, and quantify at least two 'pathways' which would allow the arena to experience a 50% reduction in greenhouse gas (GHG) emissions within 10 years, and an 80% GHG reduction within 20 years when compared to baseline consumption. The net-objective was to target a pathway to net-zero operation at the facility.

This report outlines the processes taken to achieve the above objectives, as well as the results. In addition to quantifying the deep energy retrofit potential at the Long Sault Arena, this report is intended to provide the Township and all other interested parties with guidance and insight into how to achieve cost effective deep energy retrofits, reduce GHG emissions, and increase environmental stewardship. This report and its contents were generated using replicable processes based on industry best practices and standards, as well as generous contributions from various Township staff and industry professionals.

Why Pursue Energy and Carbon Efficiency?

Climate change refers to long-term shifts in global weather patterns and temperature caused primarily by human activities, particularly the release of greenhouse gases into the atmosphere. One of the key contributors to anthropogenic climate change is the excessive emission of carbon dioxide (CO_2) and other greenhouse gases from burning fossil fuels. As the world grapples with the urgent need to address this global challenge, carbon efficiency has emerged as a critical strategy. Carbon efficiency focuses on reducing carbon emissions and maximizing the effectiveness of energy use through various measures such as energy conservation, renewable energy adoption, and technological advancements. By improving carbon efficiency, societies can mitigate the impacts of climate change, promote sustainable development, and pave the way for a cleaner and more resilient future.

The Government of Canada recognizes the importance of investing in energy efficiency for several compelling reasons. Firstly, energy efficiency measures play a vital role in addressing climate change and reducing greenhouse gas emissions. As a country committed to international climate agreements, such as the Paris Agreement, Canada aims to meet its emission reduction targets and contribute to global efforts to combat climate change. Investing in energy efficiency enables Canada to minimize its carbon footprint, mitigate the impacts of climate change, and demonstrate leadership in sustainable development.

Secondly, energy efficiency offers significant economic benefits. By improving energy efficiency across sectors, Canada can reduce energy consumption and associated costs for businesses, industries, and households. This not only enhances the competitiveness of Canadian businesses but also fosters innovation, job creation, and economic growth. Energy efficiency measures create opportunities for the development of clean technologies, renewable energy sources, and the green economy, positioning Canada at the forefront of the transition to a low-carbon future.

Furthermore, investing in energy efficiency contributes to improved energy security. By reducing energy demand and optimizing resource use, Canada can decrease its dependence on imported energy sources and enhance domestic energy resilience. Energy efficiency measures help diversify the energy mix, promote renewable energy integration, and strengthen the country's ability to withstand energy disruptions and fluctuations in global energy markets.

Lastly, investing in energy efficiency aligns with Canada's commitment to promoting sustainable development and fostering healthier communities. Energy-efficient buildings, transportation systems, and industrial processes lead to reduced emissions, improved air quality, and enhanced public health outcomes. Energy-efficient infrastructure and practices also create more comfortable, affordable, and environmentally friendly living and working environments for Canadians.

Considering these factors, Canada recognizes that investing in energy efficiency is not only crucial for environmental protection and climate action but also brings about economic advantages, energy security, and improved quality of life for its citizens.

Acknowledgements

Next Energy Development Group Inc. would like to acknowledge and thank the Township of South Stormont, applicable members of municipal and facility staff, and relevant stakeholders including relevant vendors and members of the community for their invaluable insight into the status, operations, and ideas for the future of the Long Sault Arena.

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Methodology

This section provides an overview of the methodologies used throughout this study to collect, analyze, and model data, and to quantify and validate the financial viability and environmental impact of potential energy conservation measures and GHG reduction pathways.

Where possible, the study team aimed to use validated, repeatable processes such that this study may be replicated by other members of the global community to provide maximum global benefits. An example of this is the use of and adherence to various ASHRAE standards.

ASHRAE standards are a set of guidelines and practices developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) that cover a broad range of topics related to building systems and environmental control. ASHRAE standards are developed through a consensus process that involves input from experts in the field, including engineers, architects, researchers, and other building professionals.

ASHRAE standards are intended to provide best practices, guidelines, and technical specifications for the design, installation, operation, and maintenance of building systems and equipment. They cover a wide range of topics, including heating, ventilation, air conditioning, refrigeration, indoor air quality, energy efficiency, building envelope, and sustainability.

Separately, stakeholder engagement was a vital aspect of this project. As such, it was conducted at various stages throughout the project development to obtain feedback from applicable members of Township staff, consultants, suppliers, and other relevant stakeholders so as to ensure the most accurate, most applicable results.

This study was used to quantify deliverables for the Township's application to Infrastructure Canada's Green and Inclusive Community Buildings (GICB) program, an additional funding stream which will aid the Township in improving efficiencies, reducing GHG emissions, reducing operating costs, and improving environmental stewardship at the Long Sault Arena. The study was designed to ensure flexibility to future changes of the facility, such as operational changes or facility expansion.

More information on assessment methodologies can be found below, and in Appendices A and B.

Site Visit, Data Collection, and Document Review

To quantify the existing energy profile of the facility, an energy assessment was conducted consistent with ASHRAE Level II guidelines established by the ASHRAE 211 Standard for Commercial Building Energy Audits. The preliminary site visit and interviews were conducted on July 7th, 2022, by lead auditor Malik Taha, and associate auditor Sean Mitchinson. A number of supplemental site visits have since been conducted for minor data collection.

This audit included a review of all available information, documentation, drawings, and reports regarding the facility including but not limited to:

- Building Drawings from Substantial Constructions (mechanical, electrical, construction)
  - 1993 Renovation/Addition
  - 2009 Change Room Addition
  - 2013 Flat-Roof Reroofing
- Utility Data
  - Electricity (Hydro One)
  - Natural Gas (Enbridge Gas)
  - Water (Township of South Stormont)
- Township of South Stormont Reports
  - 2019 Energy Conservation and Demand Management (CDM) Plan
  - 2020 Parks and Recreation Master Plan
- Third Party Reports
  - Building Condition Assessment – Long Sault Arena - Draft (version available 6/1/2023) ('SLBC-Inc.)
- Daily weather data from NASA and correlated to long-term data from the same source
- Various quotes, estimates, and invoices provided to the Township, consultants, or for similar retrofits

Energy Modelling and Simulation

Energy modeling is a process of creating a mathematical or computer-based representation of a system or a building to simulate and analyze its energy performance. It involves collecting data on energy consumption, building materials, equipment, and occupant behavior, and then using that data to create a virtual model of the system or building.

The purpose of energy modeling is to assess and optimize energy use and costs, as well as to improve the energy efficiency and sustainability of buildings or systems. By analyzing the energy consumption patterns and predicting the performance of different design scenarios, energy modeling can help architects, engineers, and policymakers make informed decisions about energy-efficient design, renewable energy integration, and energy management strategies.

Energy modeling is commonly used in the design and construction of new buildings, as well as in retrofitting and upgrading existing buildings. The accuracy and reliability of energy modeling depend on the quality of the data, assumptions, and algorithms used in the model.

As part of the Township's application to the GICB program, an energy model of the facility was generated using RETScreen Expert and calibrated to within 5% of annual utility consumption. RETScreen Expert is a comprehensive clean energy management software developed by Natural Resources Canada (NRCan) to help professionals evaluate the energy production, savings, and financial viability of various renewable energy and energy-efficient technologies. It provides a platform for analyzing and optimizing renewable energy and energy efficiency projects and is widely used by energy professionals, engineers, and project developers worldwide.

As part of the requirement set by the Community Buildings Retrofit program, through which this study was completed, the energy model submitted must ensure adherence to the ASHRAE 14 Standard for Measurement of Energy, Demand, and Water Savings. The ASHRAE 14 standard requires an hourly building energy model that simulates the performance of a building on an hourly basis. Unfortunately, at of the time of writing this report RETScreen Expert does not adhere to the ASHRAE 14 standards as input data is used to produce an annual generation model, among other reasons.

There are however benefits to using hourly generation modelling; hourly generation modelling is necessary to capture the dynamic behavior of the building and its systems, including heating, cooling, ventilation, lighting, and other energy-related components. Hourly models can provide a more detailed and accurate representation of the building's energy use and can capture the impact of time-varying factors such as occupancy patterns, weather conditions, and equipment schedules. Hourly generation modelling also provide insight into peak demand charges, and changes to peak demand profiles which are likely to result from the electrification of heating equipment.

DesignBuilder was selected as the appropriate hourly energy modelling software for final reporting. DesignBuilder is a building performance simulation software tool that is used to model, analyze, and optimize the energy performance of buildings. It is a user-friendly software platform that allows architects, engineers, and energy consultants to create detailed models of buildings and simulate their energy performance using a variety of parameters and inputs. DesignBuilder offers a range of features and tools that allow users to assess and optimize the energy performance of buildings. These features include detailed weather data, customizable HVAC systems, energy modeling of building envelope and thermal mass, daylighting analysis, and thermal comfort analysis. DesignBuilder also includes an integrated EnergyPlus simulation engine, which provides accurate and reliable energy simulations for a wide range of building types and systems.

Development of Retrofit Pathways

With a thorough understanding of the facility and its operations a forward projection of the facility was undertaken to fully quantify and gain a deeper understanding of the future of the facility over the 20-year study period. This forward projection was completed using input from relevant members of municipal staff, data from the Township's 2019 PRMP report, completion of a Building Condition Assessment (BCA), and input from relevant suppliers such as the ice plant maintenance and typical HVAC providers. Information found was used to quantify maintenance requirements and cost estimates over the 20-year study period, as well as cost estimates for energy efficient alternatives to components requiring replacement over the same period, not considered in the initial energy audit.

With a clear understanding of the facility, its operations, and its future operating plan, a variety of retrofit pathways for the facility were considered. Through collaboration of the entire study team, four pathways were selected for further analysis, such as life cycle costs analysis (LCCA) and further energy modelling using DesignBuilder. This additional analysis and modelling allowed the study team to predict the post-retrofit overall performance of the facility for each pathway.

Opinions of Probable Cost/Cost Estimates

All cost estimating was completed to a CIQS Class C level capital estimate standard. Cost estimates for all general facility maintenance and all non- or negligible energy consuming equipment was completed through the third-party Building Condition Assessment, with a contingency of 15% included in all costs.

For equipment consuming significant amounts of energy, the focus of this report, when possible, cost estimating was completed using estimates from local suppliers. This was done to ensure adherence to pricing available in the region, and to draw on the knowledge of suppliers with a history working with the facility. As the region often experiences shortages with the availability of local suppliers, the study team elected to use estimates from the region where possible to ensure adherence to regional pricing and availability. Additionally, by collaborating with contracted and frequent suppliers of the Township, the study team was able to draw on the knowledge of these suppliers who have a history of and a strong understanding of the facility. At the current level of design and cost estimating, this supplier knowledge allowed the study team to quantify unknown obstacles which may have been overlooked if industry standard estimates were used.

It is recommended that should the Township look to implement any ECMs identified in this report, where possible contracts are awarded via a competitive RFQ/RFP process.

Lifecycle Cost Analysis

Life cycle cost analysis (LCCA) is a financial analysis technique used to evaluate the total cost of owning and operating a building or infrastructure project over its entire life cycle, including construction, operation, maintenance, and disposal. LCCA considers all relevant costs and benefits over the life of the project and considers the time value of money, inflation, and other financial factors and design considerations. The purpose of LCCA is to help decision-makers compare different options for building or infrastructure projects and select the option that provides the lowest total cost over the life of the project.

When completing deep energy retrofits over a 20-year period, there will be incremental capital costs and utility savings seen as retrofits are completed through each applicable year of the project's life cycle as required. Although high level project scheduling has been proposed, at this stage a detailed project implementation schedule cannot be assumed for LCCA purposes. As such, for the purposes of all LCCAs included in this report, utility savings are assumed to be uniform throughout the 20 year project period, based on the results of the applicable measure analyses and modelling for each pathway. Any exceptions to this strategy will be documented in the applicable pathway.

All life cycle cost analyses completed as part of this report accounted for the following considerations:

- Capital costs (hard and soft costs)
- Operation and maintenance costs (O&M)
- Anticipated cost of energy and carbon
    - Annual escalation rates applied to each utility
- Available external funding (grants, incentives, rebates, etc)
- GHG Emissions Reductions
- Discount Rate of 5%

LCCAs were completed for each recommended Pathway providing the total project Net Present Value (NPV) and Internal Rate of Return (IRR). From a strictly financial perspective, the Pathway would with the highest NPV and IRR would generally be considered the strongest option.

LCCAs were completed for this report assuming that the Township's pending GICB application is approved, and the Township moves forward with a successful application into the Federation of Canadian Municipalities' 'Community Buildings Retrofit – Capital Project'.

Additionally, for funding sources which provide funding through both grant and loan portions, only the grant portions are included in the financial modelling due to limited information on these loans. Quantifying the repayment of loans would require exact information not available at this time such as exact interest rates, amortization schedules, exact retrofit schedules, debt-equity ratios, and more. As such, funding opportunities for which funding is provided in the form of a loan have not been included in life cycle cost analyses within this report. This report is flexible to incorporating financial implications of these loans at such a time when the loans have been fully quantified.

Additionally, as will be mentioned in a later section of this report various incentives/rebates are available through applicable utility providers and LDCs. As these incentives are often model dependent, and thus outside of the scope of this report, these incentives were not quantified in this report. Should the Township look to implement any ECMs, once the exact model is selected it will be cross-referenced against available incentives through applicable programs.

Net-Zero Carbon Building Operations

Net-zero carbon building operations refers to the operation of a building in a manner that results in net zero carbon dioxide equivalent emissions. It means that the building's net emissions are balanced by avoided emissions resulting from exported low-carbon power or carbon offsets, resulting in zero net carbon emissions.

For the Long Sault Arena, the net emissions would equal direct emissions from the combustion of fossil fuels on-site, plus the indirect emissions associated with electricity consumption. To achieve net-zero, these net emissions would need to be equaled by the amount of low-carbon power exported and/or carbon offsets purchased. Any renewable energy generated and consumed on-site reduces on-site electricity consumption and is thus already accounted for in calculations.

To purse net-zero carbon building operations, building operators may look to: improve energy efficiencies, transition to renewable energy generation, incorporate on-site energy storage, continuously monitor and optimize building performance, and purchase carbon offsets.

Carbon offsets are a mechanism used to compensate for or offset GHG emissions generated from one source by supporting projects that reduce or remove emissions elsewhere. They are a way to take responsibility for the carbon footprint of an individual, organization, or event by investing in activities that have a positive environmental impact. By investing in carbon offsets, individuals, organizations, or events can take proactive steps to compensate for their emissions and support projects that contribute to global emissions reduction efforts. Carbon offsets are not a substitute for reducing emissions at the source or implementing sustainable practices, but they provide a mechanism to address emissions that cannot be eliminated in the short term.

It's important to note that the quality and effectiveness of carbon offsets can vary. Carbon offsets are certified and verified by recognized standards or programs to ensure the credibility and integrity of the projects and associated carbon offsets. Choosing reputable certification standards and thoroughly researching offset projects are essential to ensure that the offsets have a real and measurable impact in reducing or removing greenhouse gas emissions. Carbon offsets were priced at an average of \$20/tonne CO_2.

Green Building Certification Standards

Green building certifications are a recognized way to quantify and compare the energy performance of a facility. Numerous green building certifications exist today, such as the Zero Carbon Building (ZCB), Leadership in Energy and Environmental Design (LEED), or International Standards, should the Township choose to pursue certification of building performance. Choosing to achieve green building certification can come with many benefits such as: environmental sustainability, energy and cost savings, enhanced indoor environment quality, market value and competitive advantage, regulatory and incentive support, regional and global recognition, and being a part of driving the industry forward.

Although each green building certification is different, the majority have similar goals and procedures. Many green building certifications provide a framework for designing, constructing, operating, and certifying building that are environmentally sustainable and energy efficient. They can provide a means to assess the carbon emissions of buildings and promote the design and operation of highly energy-efficient and low-carbon buildings. Available for both new construction and major retrofits, green building certifications aims to drive the transition to a low-carbon future and mitigate the impacts of buildings on climate change.

By achieving a green building certification at the Long Sault Arena, the Township of South Stormont would demonstrate their commitment to sustainability and contribute to Canada's efforts to reduce greenhouse gas emissions.

Incentive and Project Funding Opportunities

Electricity Incentives

Various electricity incentives are available through the SaveOnEnergy program, with rates specified based on the relevant retrofit. Incentives are available for retrofits including lighting, HVAC, and manufacturing and other equipment. As these incentives are often model dependent, and thus outside of the scope of this report, these incentives were not quantified in this report. Should the Township look to implement any ECMs, once the exact model is selected it will be cross-referenced against available incentives through the SaveOnEnergy Program.

Additionally, the Ontario Electricity Rebate (OER) should be noted. The OER provides an 11.7% rebate to Ontario electricity consumers who consume less than 250 MWh annually, and/or have an annual average monthly peak demand of less than 50 kW. This incentive appears to be decreasing, as during the 2020 pre-feasibility analysis of this arena the OER was at 17%, reduced effective November 1, 2022.

Natural Gas Incentives

Various rebates and/or incentives are available through Enbridge Gas, with rates specified based on the relevant retrofit. Incentives are available for retrofits including space heating, ventilation, and hot water. As these incentives are often model dependent, and thus outside of the scope of this report, these incentives were not quantified in this report. Should the Township look to implement any ECMs, once the exact model is selected it will be cross-referenced against available incentives through Enbridge Gas.

Community Buildings Retrofit

The Township of South Stormont has elected to apply to the Federation of Canadian Municipalities 'Green Municipal Fund – Community Buildings Retrofit – GHG Reduction Pathway Feasibility Study' funding program. This application was successful, and the FCM has committed to funding 80%, or $56,000.00, of the $70,000.00 study costs.

This primary requirement of this study is to identify, quantify, and outline at least two 'GHG Reduction Pathways' that the Township of South Stormont may use as a reference to reduce GHG emissions at the Long Sault Arena by at least 50% within 10 years, and by at least 80% within 20 years, compared to the current or baseline performance of the building. The net goal of this study is to aim for net-zero operation of the Long Sault Arena.

Upon completion of this study, the municipality may elect to move forward to the GMF's 'Community Buildings Retrofit – GHG Reduction Pathway Capital Projects', which is again funded through the FCM. This funding stream will fund up to the lesser of 80% of eligible project costs or $5 million per project, with the FCM's funding contribution dispersed 25% as a grant, and 75% as a low-interest loan.

This funding stream allows for stacking with other provincial and federal funding programs up to 100% of eligible project costs.

Green and Inclusive Community Buildings

This Township of South Stormont has elected to apply to Infrastructure Canada's GICB program with the objective of implementing the ECMs identified as 'Phase 1' in this report to reduce the energy consumption, costs, and emissions associated with the operations of the Long Sault Arena, while extending the useful life of the building, and creating a positive impact for the local community including underserved populations.

This program is a competitive funding stream established to provide funding to, among others, municipally owned facilities that provide publicly accessible community services to communities in an area with underserved populations experiencing higher needs, with services that demonstrably service these populations. The program aims to advance the Government's climate priorities by improving energy efficiency, reducing GHG emissions, and enhancing the climate resilience of community buildings.

Among the numerous requirements of the GICB program is that retrofit projects must achieve a minimum of 10% energy savings (ideally greater than 25%) and must not lead to an increase in the building's operational GHG emissions.

This funding stream allows for stacking with other provincial and federal funding programs up to 100% of eligible project costs.

Future Funding Opportunities

As discussed previously in this report, there are number reasons why the Government of Canada is, and will continue to offer grants, rebates, incentives, and funding programs targeting energy conservation and GHG emission reduction. As such, it is recommended that the Township continue to monitor these opportunities as they become available.

Existing Conditions

General Facility Information

The Long Sault Arena is an approximately 3,200 m^2 space built in 1994, consisting of: an NHL-sized ice pad, 6 changerooms, referee room, music room, John Cleary meeting room, canteen, maintenance rooms, and office space for Township Recreational staff. The original shell of the building for the lobby, and changerooms 1 to 4 is from the original 1967 construction. This area was significantly renovated in 1993 when additions including the front offices and meeting room were added. During this 1993 renovation the roof of the arena structure was replaced as well. In 2009, another addition was added to the facility for changerooms 5 and 6. Furthermore, the original 1967 building, including the lobby area and original changerooms, but not including the arena, was re-roofed in 2013. Finally, various updates to the facility were implemented ranging from building envelope, mechanical, and electrical equipment upgrades in the years to follow.

A space function analysis was performed on the facility, dividing the building into applicable 'zones' based on HVAC systems, lighting systems, space-use, and operating hours. The list of zones used for this analysis can be found in Table 3 below.

Table 3 - Summary of Long Sault Arena 'zones'

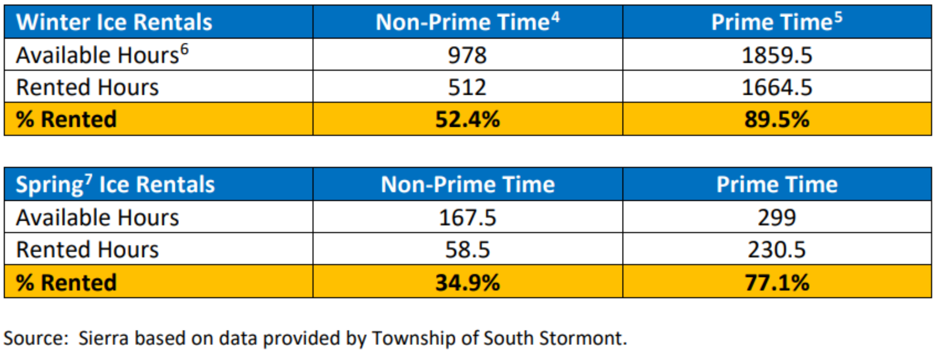
Zone #	Zone Name	Spaces Included
1	General Building	Lobby, corridors, canteen, washrooms.
2	Original Changerooms	Changerooms 1, 2, 3, and 4, and applicable washrooms
3	Washrooms	Lobby Public Washrooms
4	Offices	Municipal Recreation Office
5	Media Room	John C. Cleary Media Room
6	New Addition	2009 Changeroom Addition (Changerooms 5 and 6), and applicable washrooms
7	Arena	Arena
8	Spectators	Spectator seating
9	Zamboni Room	Zamboni Room
10	Compressor Room	Compressor Room
11	Sound Room	Sound Room

Facility Occupancy Schedule

The Long Sault Arena operates on a year-round basis providing many publicly available services, split primarily by season. During the fall, winter, and spring, the facility offers: adult and youth hockey, adult and youth figure skating, public skating, stick-and-puck, and a meeting space. During the summer months the facility offers a space for shuffleboard, conventions, youth summer school, an indoor-space for many summer camps and other activities operating on the grounds, as well as summer sports such as lacrosse and ball hockey.

The Township of South Stormont released their 'Parks and Recreation Master Plan' (PRMP) in January 2021, and an update to the associated 'Parks and Recreation Master Plan Background Report' in November 2020. This PRMP report was established as a guide to municipal planning in the sector over the next 10 years.

This background report provides the summary of ice rental statistics during the ice season from September 1st to May 7th, seen in Figure 2 below.



Winter Ice Rentals	Non-Prime Time[4]	Prime Time[5]
Available Hours[6]	978	1859.5
Rented Hours	512	1664.5
% Rented	**52.4%**	**89.5%**

Spring[7] Ice Rentals	Non-Prime Time	Prime Time
Available Hours	167.5	299
Rented Hours	58.5	230.5
% Rented	**34.9%**	**77.1%**

Source: Sierra based on data provided by Township of South Stormont.

Figure 2 - Long Sault Arena ice rental statistics

For the purposes of this assessment, prime-time ice is categorized as Monday to Friday from 4:30pm to 11:00pm and all day (8:00am to 11:00pm) on Saturday and Sunday. Per this report, winter is defined as September 1st – March 30th, and Spring is defined as March 31st – May 7th.

This background report also provides the summary of dry floor rental statistics during the dry floor season from May 8th to August 31st, seen in Figure 3 below.

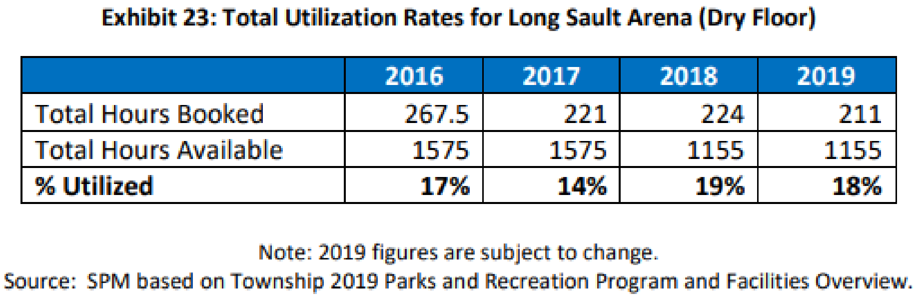


Exhibit 23: Total Utilization Rates for Long Sault Arena (Dry Floor)

	2016	2017	2018	2019
Total Hours Booked	267.5	221	224	211
Total Hours Available	1575	1575	1155	1155
% Utilized	**17%**	**14%**	**19%**	**18%**

Note: 2019 figures are subject to change.
Source: SPM based on Township 2019 Parks and Recreation Program and Facilities Overview.

Figure 3 - Long Sault Arena dry floor rental statistics

Year-round the facility hosts a municipal office space with around 10 full-time equivalent employees. A rough approximation on the weekly visitors to the facility was provided by the building operator, estimating around 4,100 weekly visitors during the ice-rental season, and around 750 weekly visitors in the off-season.

Building Envelope

Exterior Roof – Arena

Exterior roofing for the facility is comprised of three separate roofing systems: (1) the gabled arena roof over the ice slab space and associated maintenance rooms, (2) the flat roof over the general building including the facility lobby, changerooms, washrooms, offices, and media room, and (3) the flat roof over the 2009 addition.

The exterior roofing (1) for the arena space and associated maintenance rooms is made up of metal roofing panels, 6” insulation and a low emissivity ceiling as per the provided drawings. The Long Sault Arena facility staff have reported numerous leaks in the structure. This roof was installed in 1994 and is at its end-of-life so the municipality is pursuing opportunities for replacement.

All flat roofing, (2) and (3), is constructed as a 2-ply modified bitumen roofing system. Roofing for the 2009 changeroom addition (3) was completed in 2009, and all other flat roofing was redone in 2013.

Exterior Walls

There are five types of exterior walls at the Long Sault Arena: (1) walls for the general building including the facility lobby, original changerooms, and offices (2) the media room, (3) the 2009 addition of change rooms 5 and 6, (4) the lower-portion of the arena walls, including the ice slab space and associated maintenance rooms, and (5) the upper-portion of the arena walls, including the ice slab space and associated maintenance rooms.

From available drawings the walls are comprised of:

(1) Concrete block with internal foam insulation and a polystyrene exterior insulation finishing system, faced with brick
(2) Concrete block with a polystyrene exterior insulation finishing system, faced with brick
(3) Concrete block with polyisocyanurate insulation, faced with brick
(4) Metal cladding over 2.5” of insulation sealed against concrete blocks.
(5) Metal cladding with R-20 batt insulation sealed with a metal liner over solid framing

Exterior Windows and Doors

Exterior windows were visually inspected to be double-paned casement or fixed windows. The main entrance doors are vestibule glass sliding doors, while the remaining emergency exit doors were visually inspected to be hollow metal framed. There is also an insulated garage door operated by an electric motor. All doors and windows are considered to be in good condition.

Mechanical Systems

Process Equipment

The ice plant refrigeration system at the Long Sault Arena has a rated cooling load of 70 tonnes. This ice plant operates through the use of an ammonia cycle, a brine cycle, and a condenser. The brine cycle, driven by a brine pump, circulates brine through a series of pipes underneath the ice bearing concrete slabs to remove heat, freezing and maintaining the ice. The brine pump circulates the heated brine through a chiller heat exchange where heat is transferred to an ammonia cycle, thus cooling the brine before it re-enters the slab. This ammonia cycle is driven by two compressors and allows heat to be removed from the brine system via the previously mentioned chiller heat exchanger, then exhausted using a rooftop condenser. A cold-pump is used to supply water to the condenser, and a jacket-cooling pump cycles glycol through a heat exchanger to cool the compressors. Table 4 below shows a summary of the ice plant equipment at the Long Sault Arena.

Table 4 - Ice plant equipment schedule at Long Sault Arena

Description	Manufacturer	Model	Qty	Location	Installed	Condition
Compressor	MYCOM	N6WA	2	Chiller Room	1993	Poor
Motor #1	TECHTOP	GRA0504F-01	1	Chiller Room	2022	Poor
Motor #2	VENTPAK	HKH62	1	Chiller Room	N/A	Good
Chiller	Alfa Laval	MK15-BWFD	1	Chiller Room	2016	Good
Surge Drum	CIMCO	N/A	1	Chiller Room	2016	Good
Cold Pump	CIMCO	6X4X10	1	Chiller Room	2010	Good
Jacket Cooling Pump	ARMSTRONG	1.5X1.5X8 4380	1	Chiller Room	2015	Good
Condenser	Baltimore	Air Coil VC1-100	1	North-East Wall on Scaffolding	2009	Poor
Brine Pump	N/A	N/A	1	Chiller Room	2022	Good
Ice Resurfacer	Zamboni	446	1	Zamboni Room	2022	Good

Thermometers are stationed at key points in both the ammonia and brine cycles, and in the ice slab itself. A CIMCO seasonal controller is used to allow for precision control of the operating hours of the ice plant equipment. Ice slab temperatures are maintained at 20 C during low-volume hours, and 18 C during high-volume hours per facility staff.

The two compressors are operated with a 90 second delay to avoid excessive ramp-up charges. From reviewing the municipality's available recordings of daily compressor run hours, including data from 2017 through 2019, a daily average of 10 compressor run hours was found.

A natural gas-fired ice resurfacer is used to resurface the ice slab. The Township replaced the existing Zamboni model 445 with a Zamboni model 446 in August of 2022, in-line with end-of-life replacement. The 446 model features a 2.4 L / 59 HP at 2,500 RPM four-cylinder liquid cooled engine.

Heating, Ventilation, and Air Conditioning

The core heating and cooling loads of the building are met by a combination of multiple components, each supplying heating/cooling for their specified zones. A summary of the HVAC equipment found in the Long Sault Arena can be seen in Table 5 below.

Table 5 - Summary of HVAC equipment at the Long Sault Arena

Heating							
Component	**Zone**	**Manufacturer**	**Model Number**	**Capacity**	**Energy Source**	**Efficiency**	**Quantity**
AHU-1 (Air Handling Unit)	1, 2, 3	Engineered Air	DJ-40	400,000 BTU	Gas	78%	1
Spectator Radiant Heaters	8	ecoSchwank	ecoSchwank 13	50,000 BTU	Gas	N/A	6
Gas Space Heater	9	N/A	N/A	~ 80,000 BTU	Gas	~ 80%	1
Electric Space Heater	10	N/A	N/A	5 kW	Electricity	100%	1
Furnace-1	4	Keeprite	N9MSE0601 410A	60,000 BTU	Gas	96.7%	1

Furnace-2 w/ Heat Recovery Ventilator	5, 11	Keeprite	G9MXE1202422A1	120,000 BTU	Gas	97.5%	1
In-Floor Heating	6	Well-Mclain	Ultra 80 NG series 3-UE serial 550201310	80,000 BTU	Gas	~93%	1
Cooling							
Component	**Zone**	**Manufacturer**	**Model Number**	**Capacity**	**Energy Source**	**COP**	**Quantity**
AC-1	4	ICP	CA5018QKB1	1.5 RT	Electricity	2	1
AC-2	5	ICP	CA5542QKA1	3.5 RT	Electricity	2	1
Ventilation							
Component	**Zone**	**Manufacturer**	**Model Number**	**CFM**	**Motor HP**	**Year**	**Quantity**
Furnace-1 Exhaust Fan	4	Keeprite	N9MSE0601410A	385	0.5	2014	1
Furnace-2 Exhaust Fan	5, 11	Keeprite	G9MXE1202422A1	385	1	2014	1
AHU-1 Exhaust Fan	1, 2, 3	N/A	N/A	N/A	N/A	1994	1
Arena Exhaust Fans	7	Penn Ventilator Co., Inc.	N/A	4,677	0.5	1994	2
Spectator Exhaust Fans	9	N/A	N/A	N/A	N/A	N/A	2

F4, F8	1, 2, 3, 4, 5	Penn Ventilator Co., Inc.	N/A	500	0.25	1994	2
F6, F7, F13	1, 2, 3, 4, 5	Penn Ventilator Co., Inc.	N/A	100	N/A	1994	3
F11	1, 2, 3, 4, 5	Penn Ventilator Co., Inc.	N/A	385	0.14	1994	1

Information found in this table was identified through visual inspection of accessible components, and information available through drawings, quotes, and other relevant data.

As can be seen in Table 5 above, an air handling unit is used to provide heat to the general building including the lobby, corridors, washrooms, and changerooms 1 to 4. These spaces are not air-conditioned during cooling months. There are two high-efficiency furnaces, one to serve the municipal recreation office, and one to serve the media and sound rooms. The latter furnace is equipped with a heat recovery ventilator. The municipal office and media room are each cooled by separate rooftop air-conditioning units, and use the furnace fans and ductwork for their applicable rooms. The Zamboni and compressor rooms are heated by a natural gas space heater estimated at 80,000 BTU, and a 5 kW electric space heater, respectively. The spectator seating section is heated by 6 natural gas radiant space heaters, and finally the 2009 new addition is heated by a natural gas in-floor hydronic system.

All heating systems are controlled by digital thermostats. The building operator has confirmed that thermostats are not adjusted adhering to any particular schedule. It was confirmed during site visitations that washroom ventilation is automatically turned on with the lights, which are controlled by motion sensors.

Table 6 below is an estimate on hours of operation of these spectator radiant heating units, provided by the building operator.

Table 6 - Building operator's estimate of operational hours of space heating units

Zone	**Estimated Hours of Operation**							
	Sept	Oct	Nov	Dec	Jan	Feb	March	April
Spectator Seating	N/A	N/A	50hrs	80hrs	110hrs	110hrs	30hrs	N/A
Zamboni Room	N/A	90/hrs	240hrs	480hrs	480hrs	480hrs	200hrs	N/A
Compressor Room	N/A	N/A	12hrs	60hrs	60hrs	60hrs	12hrs	N/A

These units are turned on only upon request when temperatures are less than 0 C. These radiant heaters can be controlled in halves, allowing controllable heating of the spectator seating. No timers are utilized due to operational issues, as confirmed by facility staff.

At the time of the writing of this report, the in-floor hydronic heating system for the 2009 new addition has reached its end-of-life. It is proposed by the Township's HVAC provider to replace this with a like-for-like model before the start of the 2023-24 ice season.

It is generally understood that the Long Sault Arena is in adherence with applicable ventilation standards such as ASHRAE 62.1. All proposed retrofit measures that may have an impact on ventilation and applicable standards will be analyzed to ensure adherence to the ASHRAE 62.1 standards.

Building Controls

The building currently does not feature a Building Automation System (BAS). All HVAC systems are currently controlled by digital, non-programmable thermostats. It has been confirmed by the facility operator that thermostats are not adjusted adhering to any particular schedule.

Lights are all controlled by manual switches, with the exception of changeroom lights that are controlled by motion sensors. In adherence to applicable standards, ventilation in all changerooms is activated automatically when the spaces are occupied.

The arena's ice plant is controlled by a CIMCO seasonal controller. Installed in 2014, this piece of equipment allows for precision temperature control of the ice surface, thus reducing run hours of ice plant equipment.

Domestic Hot Water Systems

Domestic Hot Water (DHW) for the general facility, namely the entire building less the Arena, Zamboni Room, and Chiller Room zones, is provided by a natural gas-fired water heater, and circulated via four circulation pumps. Domestic hot water use include sinks and showers. The incumbent DHW heater was replaced in 2021 with a premium-efficiency model in 2021, as part of the long-term energy plan currently being developed for the Long Sault Arena.

Hot water is provided for the flood water systems via two natural gas-fired water heaters.

A summary of the water heating equipment at the Long Sault Arena can be found in Table 7 below.

Table 7 - Summary of water heating systems at the Long Sault Arena

	Location	Purpose	Year	Quantity	Manufacturer	Model	Size	Efficiency
DHW-0	New Addition	DHW	N/A	1	N/A	N/A	N/A	~70%
DHW-1	New Addition	DHW	2021	1	Triton	GHE80SU-160	160,000 BTU	98%
DHW-2	Zamboni Room	Floodwater Heating	2014	2	AO Smith	BTH 120 200	120,000 BTU	85%

Electrical Systems

Lighting

Interior Lighting

All interior lighting was replaced during a 2022 lighting retrofit. This retrofit replaced the incumbent system, primarily consisting of T8 strip lights throughout the facility and highbay lights for the arena, with various LED replacements. A summary of the incumbent and replacement lighting schedule can be found in Table 8 below.

Table 8 - Summary of incumbent and replaced interior lighting found at the Long Sault Arena

Incumbent				
Lamp	Model	Wattage [W]	Ballast	Ballast Wattage
1 Lamp Strip HO	Strip	48	Electronic	13 W
2 Lamp Strip	Strip	56	Electronic	13 W
2x4 Troffers	Troffer	112	Electronic	13 W
2 Lamp	Troffer	56	Electronic	13 W
8 ft Strips	Strip	112	Electronic	13 W
6 Lamp T5	Highbay	340	Electronic	13 W
Potlights	CFL	69	Electronic	13 W
Shower	CFL	69	Electronic	13 W

Replacement				
4 ft Strip LED	LED	37	N/A	N/A
2x2 Flat Panel	LED	30	N/A	N/A
2x4 Flat Panel	LED	36	N/A	N/A
1x4 Flat Panel	LED	30	N/A	N/A
100W Highbay	LED	100	N/A	N/A
150W Highbay	LED	150	N/A	N/A
Pot Lights	LED	9	N/A	N/A
Shower Lights	LED	9	N/A	N/A

The retrofit study, completed by Cooper Lighting Solutions projects a demand reduction from 22.87 kW to 13.02 kW for the lighting system, and a reduction in electricity consumption from 77,205 kWh to 43,949 kWh, assuming 9 operating hours daily, year-round.

All lighting control systems are manual except those for the changerooms which are controlled by motion sensors.

Exterior Lighting

Prior to 2019, exterior lighting for the facility consists of 12 fixtures, estimated to be 150 W high pressure sodium lamps as data is not available for these units. Between 2019 and 2021 all exterior lights were upgraded to 60 W LED models.

Plug Loads

Plug loads in the facility include office equipment such as desktops, monitors, laptops, printers, and servers, arena equipment such as grinders, floor polishers, welders, and plug-in compressors, as well as kitchen equipment such as refrigerators and coffee machines.

Historical Energy Use Analysis

General Information

Electricity, natural gas, and water suppliers for the Long Sault Arena are summarized in Table 9 below.

Table 9 - Utility providers and account information of Long Sault Arena

Facility Name:	Long Sault Arena
Location	60 Mille Roches Rd, Long Sault, ON K0C 1P0
Electrical Local Distribution Company:	Hydro One
Electrical Local Distribution Company Account Number:	Summary Bill Account: 200239651302 Sub-Account: 307068685
LAS:	Electricity is purchased through a third-party provided. Electricity is billed through the Electrical LDC to include electricity costs incurred through this third-party provider via a 'retailer line item' charge, as well as Global Adjustment charges paid to the Electrical LDC.
Natural Gas Distributor:	Enbridge
Natural Gas Account Number:	110-5311 101-1451
Water Provider:	Township of South Stormont
Water Account Number:	00000938

Utility Rates

The utility rates in Table 10 are used throughout this report to create a financial baseline consumption model and evaluate the energy efficiency measures identified in this ASHRAE Level II Energy Audit.

Table 10 - Summary of utility rates of the Long Sault Arena for the years 2017 through 2029

Electricity Consumption [$/kWh]	0.1258
Electricity Demand [$/kW] (2020)	23.83
Blended Electricity Cost (Pre-Tax) [$/kWh]	0.1957

Natural Gas Consumption [$/m^3]	0.3475
Water Consumption [$/m^3]	3.004

The electricity, natural gas, and water rates found in Table 10 above are averages determined using the utility bills over the 36-month course of the baseline period used during this analysis, for the years of 2017 through 2019. An exception to this is that electricity demand rates above are from 2020 given limitations of available data.

The Long Sault Arena operates under a 'General Service Demand' contract with the LDC, Hydro One. The figures in Table 10 above are average values taken from the bills for the 36-month baseline period.

Although the electricity costs for the Long Sault Arena are billed through the LAS commodity hedging program along with a number of other municipal facilities, Table 10 above as well as all further analysis are conducted according to the Hydro One tiered electricity pricing structure. Thus, no seasonal pricing algorithm was developed to examine historical electricity rates through the LAS. This simplification was made because of an early decision by the municipality to pursue Hydro One's Net-Metering program, which would require the transition to Hydro One's tiered pricing structure. Although not included in this report, electricity costs for the facility were calculated for the year 2019 using both the LAS and Hydro One tiered pricing structure, and the difference between models was determined minimal enough to be ignored.

Data Sources

The following data sources were used in this historical energy use analysis:

- 36 consecutive months of Hydro One electricity bills
- 36 months of Enbridge natural gas bills
- 36 months of Township of South Stormont water bills
- Daily weather data from NASA and correlated to long-term data from the same source

Facility Utility Use

General Information

The following sections detail the utility bill analyses performed on the facility, a benchmark comparison, generation of a baseline model, and a breakdown of energy use by end-use.

It should be noted for all forms of consumption within the Long Sault Arena that the facility was closed during the following periods because of the COVID-19 pandemic:

March 6th 2020 to October 1st 2020 – CLOSED
December 25th 2020 to February 16th 2021 – CLOSED
March 29 2021 to September 15th 2021 – CLOSED

It has been confirmed with the building operator that the hockey season ended in March for the first and third closure, however the ice remained maintained during the second closure.

This baseline analysis was initially to be conducted using the industry standard of the most recent 36 months utility data, namely the years 2019 through 2021. Through analysis of this period, it was determined without question that data for the years 2020 and 2021 cannot be used in the baseline analysis for two reasons: the impossible to quantify effects of the COVID-19 pandemic, and the effects of multiple energy efficiency retrofits that have been implemented since 2020, in adherence with the long-term energy management plan for the arena currently being developed. As such, the baseline analysis has been adjusted to the most recent 36-month period unaffected by either of these aforementioned reasons, namely the years 2017 through 2019.

Electricity Consumption

Electricity consumption and associated costs for the baseline period of 2017 through 2019 can be found in Table 11 below.

Table 11 - Summary of electricity consumption of the Long Sault Arena for the baseline period

Year	Electricity	
	Consumption (kWh)	Cost ($)
01/01/2017 – 12/31/2017	530,640	$103,831.54
01/01/2019 – 12/31/2018	518,172	$99,822.31
01/01/2019 – 12/31/2019	519,600	$103,284.02
Average 2017-2019	522,804	$102,312.62

Costs found in Table 11 above are pre-tax.

Figure 4 shows the monthly electricity consumption throughout the study period. As can be seen, electricity consumption varies throughout the year, with a clear increase in consumption between September and May. This increase represents the seasonal load associated with the hockey season, occurring between the first week of September and the first quarter of May.

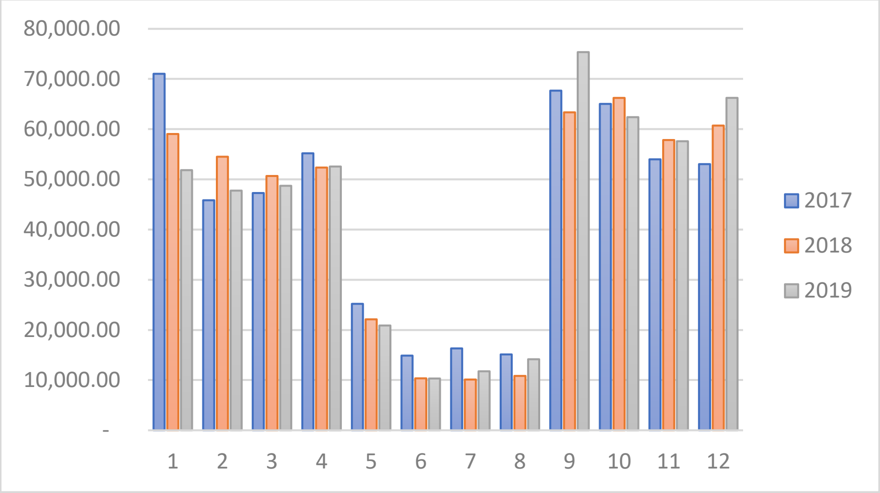


Figure 4 - Monthly electricity consumption (kWh) at the Long Sault Arena from 2017 through 2019

Summer electricity consumption reflects baseload use of lighting, cooling load, domestic hot water recirculating pumps, supply and exhaust fans that are part of the ventilation system, appliances, and other plug loads including office equipment.

To establish a baseline annual electricity consumption, linear regression analyses were completed comparing electricity consumption to both heating degree days (HDD) and cooling degree days (CDD). The r^2 value, also known as the coefficient of determination, is a measure of how well the model predicts the actual consumption data. An r^2 value of 1 indicates that the linear regression model correctly predicts every data point. Values can range to 0, indicating the opposite.

Via these regression analyses, r^2 values of 0.3524 and 0.42 were found for HDD and CDD, respectively, classifying both as a weak correlation. These weak correlations can be explained as electricity consumption is primarily correlated to the ice plant refrigeration system and the associated ice season, as opposed to space heating or cooling loads met by electricity. As such, annual and monthly electricity consumption for the baseline model was calculated as the applicable annual or monthly average of the three-year baseline period.

Electrical Demand

Figure 5 below shows the monthly peak demand for the baseline period. The monthly peak demand is noticeably much higher during the hockey season from September to May when the ice plant refrigeration system is active.

An average peak demand of roughly 40 kW during off-season hours and the average peak demand of roughly 160 kW during the ice-season implies an additional load of roughly 120 kW during the ice season.

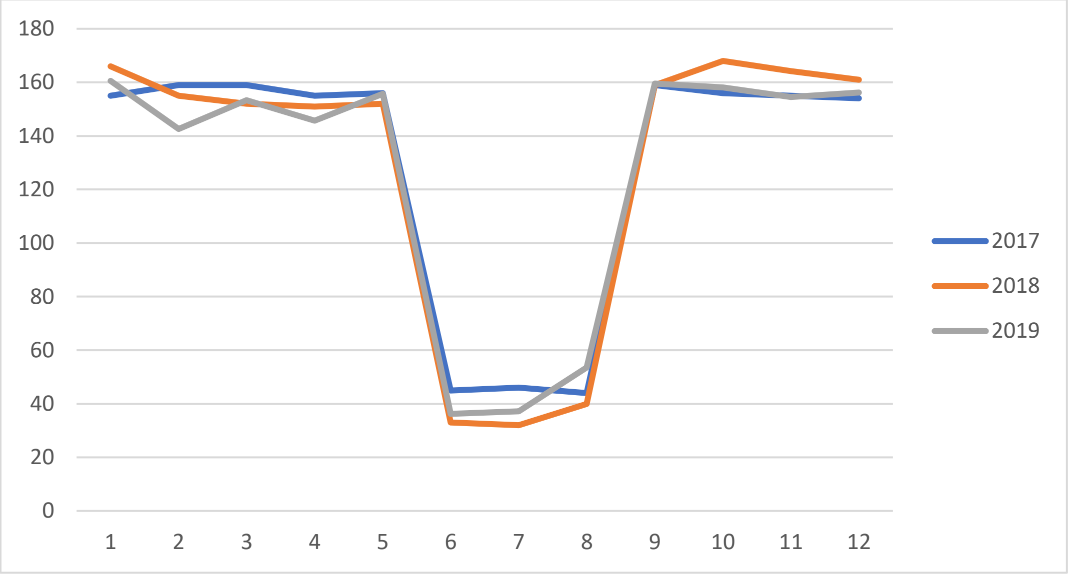


Figure 5 - Monthly peak demand (kW) at the Long Sault Arena from 2017 through 2019

Natural Gas Consumption

Table 12 below shows the annual natural gas consumption throughout the baseline period of 2017 through 2019.

Table 12 - Summary of natural gas consumption of the Long Sault Arena for the years 2017 through 2019

Average Annual Natural Gas Consumption [m^3]	41,338.00
Average Annual Natural Gas Costs [$]	$14,860.68

The Long Sault Arena uses natural gas for domestic hot water, space heating of the general building including the lobby, changerooms, washrooms, offices, and meeting room, radiant space heating for the arena spectator seating, space heating of arena maintenance rooms, heating of ventilation air, in-floor heating for the 2009 addition, ice-resurfacing flood water treatment, and the ice resurfacer. Figure 6 below shows the monthly natural gas consumption of the Long Sault Arena for the baseline period of 2017 through 2019.

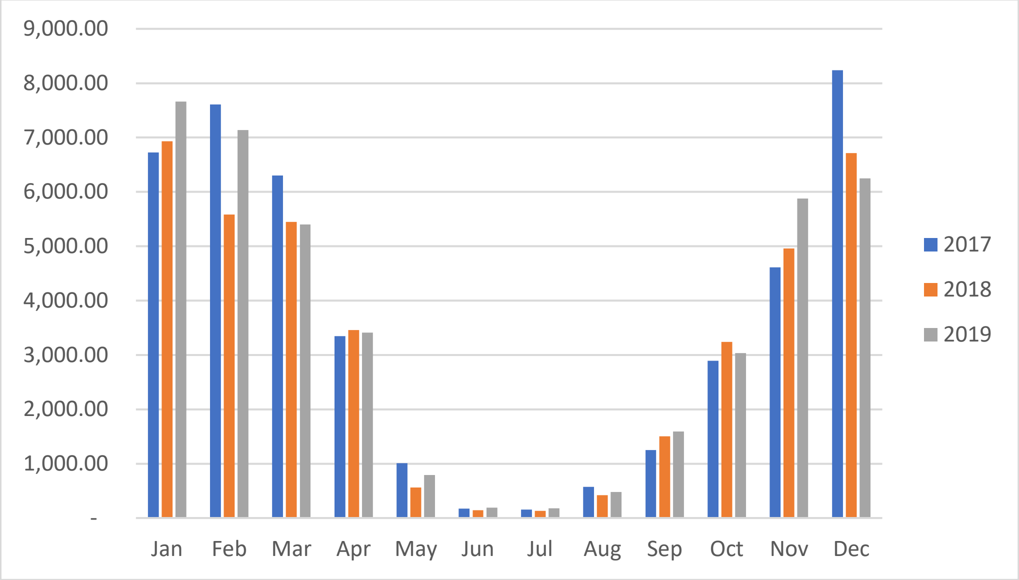


Figure 6 - Monthly natural gas consumption [m3] of the Long Sault Arena from 2017 through 2019

As can be seen, the natural gas consumption varies throughout the year, with a clear increase in consumption between September and May. This increase represents the seasonal load associated with the hockey season, occurring between the first week of September and the first week of May, as well as typical space heating requirements associated with the Ontario heating season.

To establish a baseline annual natural gas consumption, linear regression analysis was completed comparing natural gas consumption to HDD. Via this regression analysis an r^2 value of 0.9549 was found classifying a strong correlation. This strong correlation can be explained as natural consumption is closely correlated to maintaining the ice surface, increased domestic hot water use associated with the ice season, and space heating.

Despite the strong correlation, as natural gas consumption is primarily correlated to activities relating to the ice surface as opposed to HDD, weather normalized consumption would produce incorrect estimates for months at the beginning and end of the ice hockey season, namely September and May. Despite a reduced number of HDD in these months, natural gas consumption remains strong, well above weather normalized projection, due to the ice hockey season. As such, annual and monthly natural gas consumption for the baseline model was calculated as the applicable annual or monthly average of the three-year baseline period.

Water Consumption

Table 13 below summarizes the annual water consumption of the Long Sault Arena for the 36-month baseline period.

Table 13 - Summary of water consumption of the Long Sault Arena for the years 2017 through 2019

Annual Water Consumption [m^3]	5,571.64
Annual Water Costs [$]	$17,277.03

From municipal rate documentation, an annual increase in water rates of around 37% was found from 2019 to 2020, with a roughly 6% annual increase in the following years.

Quarterly water consumption can be seen summarized in Figure 7 below.

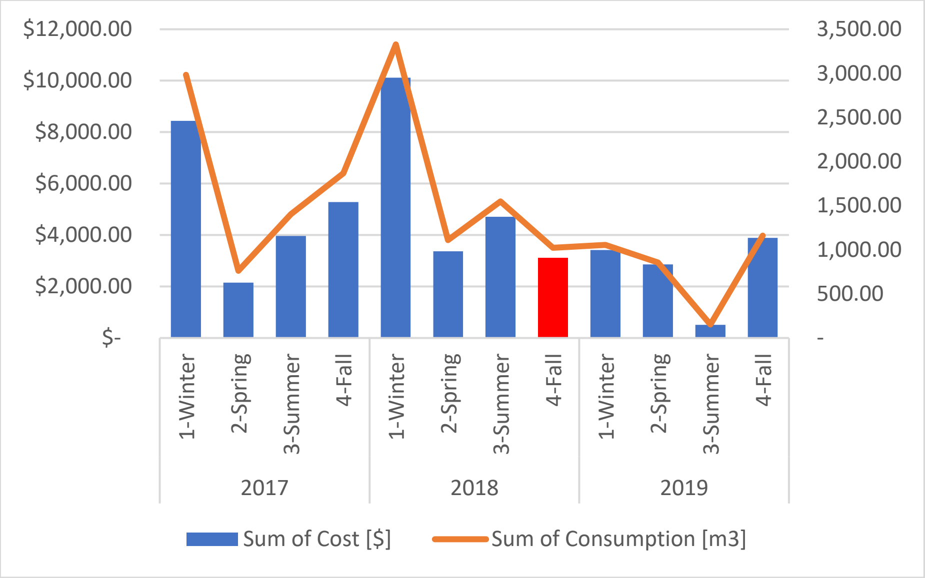


Figure 7 - Quarterly water consumption at the Long Sault Arena from 2017 through 2019

In Figure 7 above, Fall 2018 can be identified as the red column. This visual distinction was made for two reasons: per the building operator significant upgrades were completed to washroom water fixtures around this time, and the billing period was adjusted during this billing period. The following discusses each of these factors separately.

The building operator has confirmed that near the start of the Fall 2018 billing period, namely October 1st, 2018, through November 31st, 2018, various upgrades were completed to the washrooms and other water fixtures. These upgrades center around upgrades to low-flow sinks, toilets, and showers. These upgrades appear to have caused a significant reduction in water consumption at the Long Sault Arena. Prior to these upgrades, annual water consumption at the facility was typically above 20,000 m^3. After these upgrades, annual water consumption at the facility was 10,677 m^3 for the year 2019. Data cannot be used after this point as water consumption was significantly impacted by the COVID-19 pandemic.

Next, the billing cycles for the facility were adjusted during this period. This period is for only two months, whereas all billing cycles before and after this period are for three months. Prior to 2019, the billing cycles unfortunately do not clearly line-up with the ice season, blending consumption across seasons, making it more difficult to see a clear pattern in water consumption by season. Thankfully the adjusted billing cycle allows for a clearer pattern to be seen from Fall 2019 onwards. Water consumption for Fall 2019 through Summer 2023 can be seen in Figure 8 below.

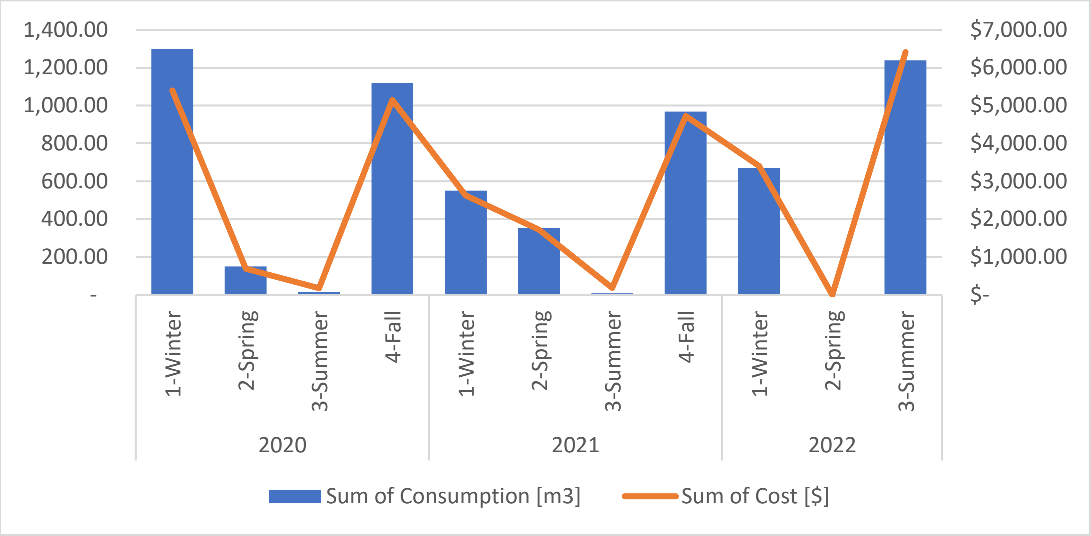


Figure 8 - Annual water consumption at the Long Sault Arena for the December 1, 2019, through August 31, 2022

The data in Figure 8 above, although significantly impacted by the results of the COVID-19 pandemic, allows for a clear pattern to be seen in the quarterly water consumption at the Long Sault Arena. As can be seen, there is a clear increase in water consumption at the facility between ‘Fall’, beginning September 1st, through ‘Spring’, ending May 31st. This pattern reflects increased consumption due to creating and maintaining the ice, and increased use of the facility. The surprising increase of water consumption during 2022 can be attributed to billing for both Spring and Summer 2022 being included on one bill, and a likely early flooding of the ice occurring during this period.

Energy Modelling

Baseline Energy Model Calibration

As mentioned previously, it was determined without question that data for the years 2020 and 2021 should not be used in the baseline analysis. The use of data from 2020 and 2021 may result in skewed or inaccurate conclusions, as the operations of the Long Sault were significantly impacted by the

COVID-19 pandemic and associated closures, as well as by ECMs implemented by the Township during this period.

Although industry standard requests the most recent three years of utility data be used to create the baseline, a decision was made during the auditing process to adjust the baseline period of 2019-2021 to a new period of 2017-2019. This decision was made to eliminate uncertainty caused by the impossible to quantify effects of the COVID-19 pandemic, as well as the fact that a number of ECMs that are included in this report were implemented as early as 2020. These implemented ECMs are included in this report as they directly tie into and are a part of the long-term energy management plan for the Long Sault Arena that has been in development since 2020.

Using DesignBuilder an energy model of the Long Sault Arena was created. This simulated energy model considers all components of the Long Sault Arena, including all relevant equipment and operating schedules, and all aspects of the facility location include climate data. This energy model was compared against baseline energy consumption to quantify accuracy of the baseline model, equipment schedules, and operating schedules.

A wide array of relevant data was collected and incorporated into this model including: all available construction, structural, mechanical, electrical, and lighting drawings, publicly available information such as climate data, equipment schedules, operating schedules, and information provided directly from facility operations staff. Any estimations were completed using insights from facility staff and industry best practices.

Given all the input data, the final DesignBuilder model used with this report was able to accurately predict consumption of the Long Sault Arena to within 5% of both natural gas and electricity consumption, in adherence with ASHRAE 14 calibration standards. It is typical for slight differences to exist between utility bills and calibrated energy models due to unpredictable or unquantifiable factors affecting the energy use profile of the facility. Calibrated energy models simulate the building in a typical or ideal manner, using the best information available. Table 14 below summarizes annual variance between the simulated results of the calibrated energy model and utility data.

Table 14 – Yearly Energy Model Calibration Summary

	Electricity	Variance	Natural Gas	Variance
2017	530,640.00	1%	42,886.42	0%
2018	518,172.00	-1%	39,114.22	-9%
2019	519,600.00	-1%	42,012.41	-2%
Baseline	522,804.00	0%	41,337.68	-4%
Calibrated	524,999.00	N/A	42,791.84	N/A

Table 15 and Figure 9 below summmarize monthly electricity consumption of the calibrated energy model and utility data.

Table 15 - Energy Model Electricity Calibration

	Electricity Consumption [kWh]				
	2017	2018	2019	Baseline	Calibrated Model
January	71,040.00	59,040.00	51,840.00	60,640.00	55,720.00
February	45,840.00	54,516.00	47,760.00	49,372.00	51,143.00
March	47,280.00	50,676.00	48,720.00	48,892.00	59,444.00
April	55,200.00	52,356.00	52,560.00	53,372.00	58,039.00
May	25,200.00	22,116.00	20,880.00	22,732.00	22,782.00
June	14,880.00	10,356.00	10,320.00	11,852.00	11,516.00
July	16,320.00	10,116.00	11,760.00	12,732.00	12,794.00
August	15,120.00	10,836.00	14,160.00	13,372.00	14,520.00
September	67,680.00	63,360.00	75,360.00	68,800.00	60,410.00
October	65,040.00	66,240.00	62,400.00	64,560.00	62,007.00
November	54,000.00	57,840.00	57,600.00	56,480.00	59,169.00
December	53,040.00	60,720.00	66,240.00	60,000.00	57,455.00
TOTAL	**530,640.00**	**518,172.00**	**519,600.00**	**522,804.00**	**524,999.00**

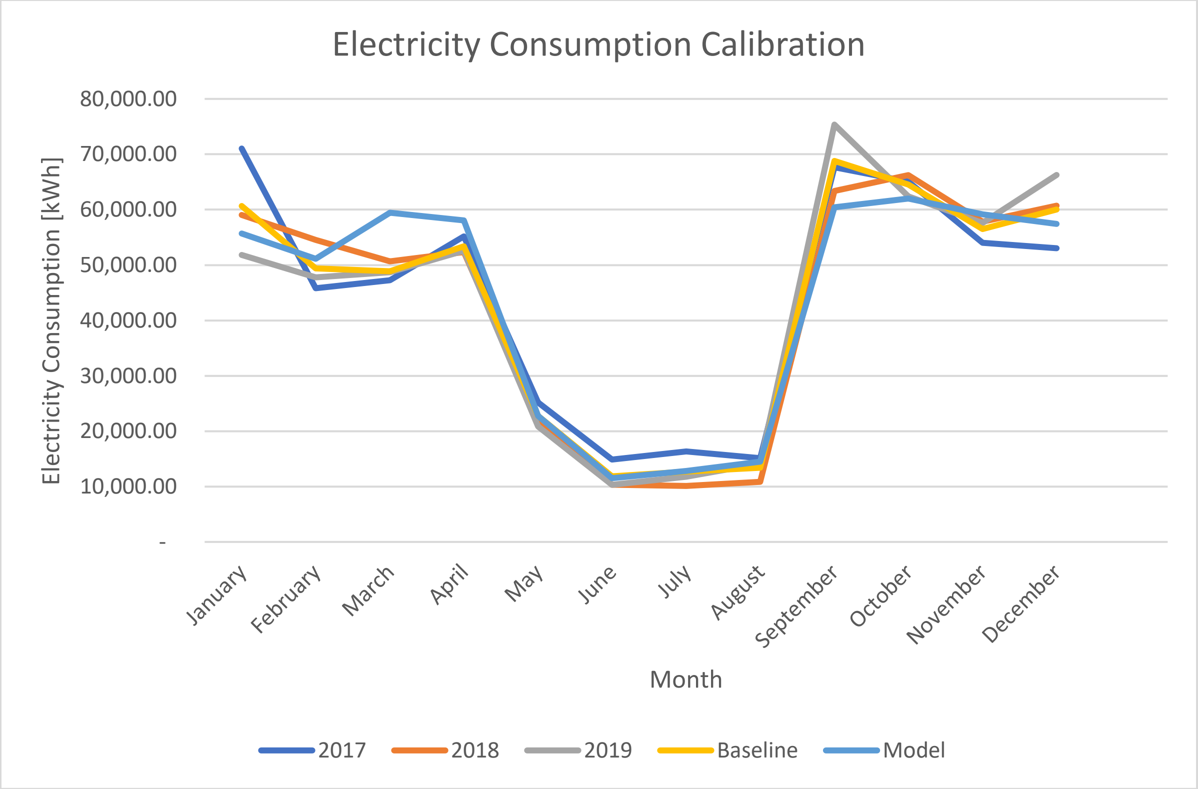


Figure 9 – Energy Model Electricity Consumption Calibration

Table 16 and Figure 10 below summmarize monthly natural gas consumption of the calibrated energy model and utility data.

Table 16 – Energy Model Natural Gas Calibration

	Natural Gas Consumption [m^3]				
	2017	2018	2019	Baseline	Calibrated Model
January	6,727.34	6,932.32	7,663.98	7,107.88	7,858.80
February	7,607.05	5,585.71	7,137.30	6,776.69	6,736.96
March	6,300.30	5,449.06	5,400.66	5,716.67	5,904.10
April	3,348.01	3,459.04	3,413.49	3,406.85	3,387.70
May	1,010.67	563.70	791.45	788.61	752.01
June	170.82	145.19	193.59	169.87	159.47
July	153.74	133.81	179.36	155.63	159.08
August	575.08	418.50	481.13	491.57	482.50
September	1,252.66	1,506.04	1,594.29	1,450.99	1,470.65
October	2,895.35	3,242.67	3,034.85	3,057.62	3,223.85
November	4,609.21	4,962.23	5,876.10	5,149.18	5,468.79
December	8,236.22	6,715.95	6,246.20	7,066.12	7,187.94
TOTAL	**42,886.42**	**39,114.22**	**42,012.41**	**41,337.68**	**42,791.84**

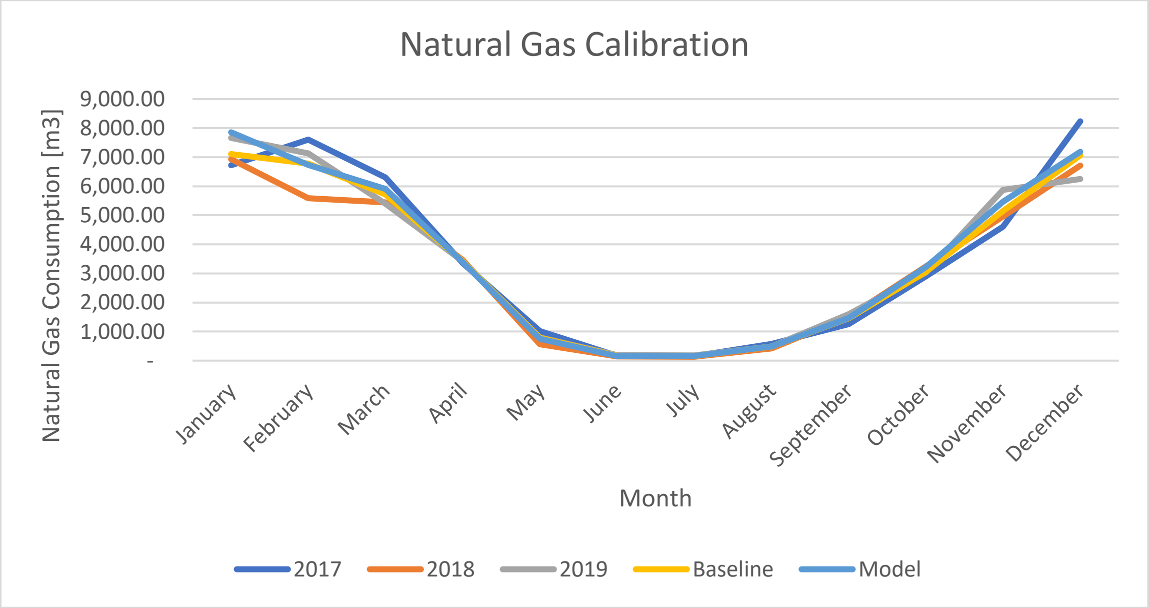


Figure 10 - Natural Gas Calibration

Desiccant Dehumidifiers

One note to be made on the DesignBuilder energy model is regarding the desiccant dehumidifiers in use at the facility. Unfortunately, at the time of writing this report no desiccant dehumidifier object is available for use within DesignBuilder. Although it would be possible to create a useable object via additional scripting, the decision was made to incorporate the dehumidification load as a process load.

The decision was made to incorporate dehumidification as a process load due to the malfunctioning performance of the units. It has been reported by facility staff that the desiccant dehumidifier installed in 2017 has been faulty since its installation. It has been reported that the unit will often operate at capacity while providing no dehumidification. This results in excessive consumption, only truly quantifiable by sub-metering.

Should a desiccant dehumidifier object be created and accurately reflected within the model, there would exist a discrepancy between modelled consumption and realized consumption due to the malfunction of the unit. Thankfully, with this 2017 installation the Township was provided an energy assessment of the expected operation of the desiccant dehumidifier. Given the malfunctioning unit and this available data, it was elected by the study team to model the dehumidification via a process load taking this energy assessment as a baseline. Furthermore, this decision could only be justified as the increased relative humidity within the unconditioned ice would have minimal impact on the energy performance of other equipment within the facility.

In the end, the desiccant dehumidification at the facility was modelled via a process load, with consumption reflecting that projected via an energy assessment from the ice plant maintenance provider. To account for the malfunctioning nature of the unit, an estimate was made to increase consumption beyond this energy assessment by 15% to reflect the malfunction.

Fuel Consumption Breakdown by Major End Uses

Figure 11 below shows the fuel consumption breakdown by major end uses for the Long Sault Arena, provided via the DesignBuilder energy model.

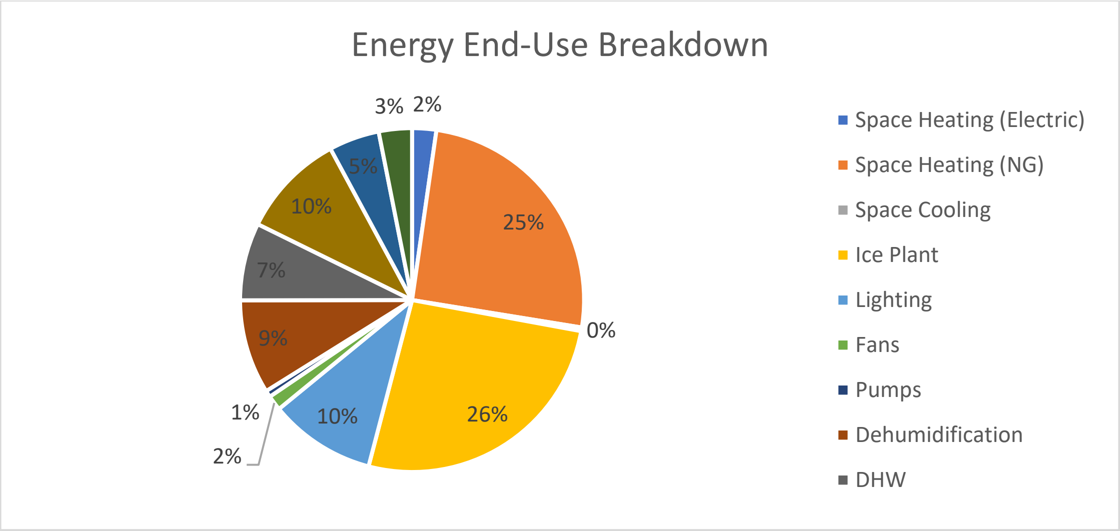


Figure 11 - DesignBuilder energy end-use breakdown of the Long Sault Arena for the simulated baseline year

Included in Figure 11 above is the 'Ice Plant' category. This end-use includes all equipment included in the three cycles used in the ice plant, namely the brine, ammonia, and condenser cycles. This end-use includes electricity consumed by the brine pump, compressors, cooling pump, cold water pump, and condenser fan.

Building Performance Metrics

Historical utility data for the baseline period of 2017 through 2019 was used to quantify two key building performance metrics. These metrics are as follows:

1) Energy Use Intensity (EUI) – Represents the total energy consumed within a specific period, typically a year, relative to the building's or facility's size or function [GJ/m^2]

2) Greenhouse Gas Intensity (GHGI) – Represents the total amount of greenhouse gas emissions within a specific period, typically a year, relative to the building's size or function [ekgCO_2/m^2]

Figure 12 below shows these metrics for each year of the baseline period, the baseline year used for model calibration, and the resulting output of the calibrated whole-building energy model.

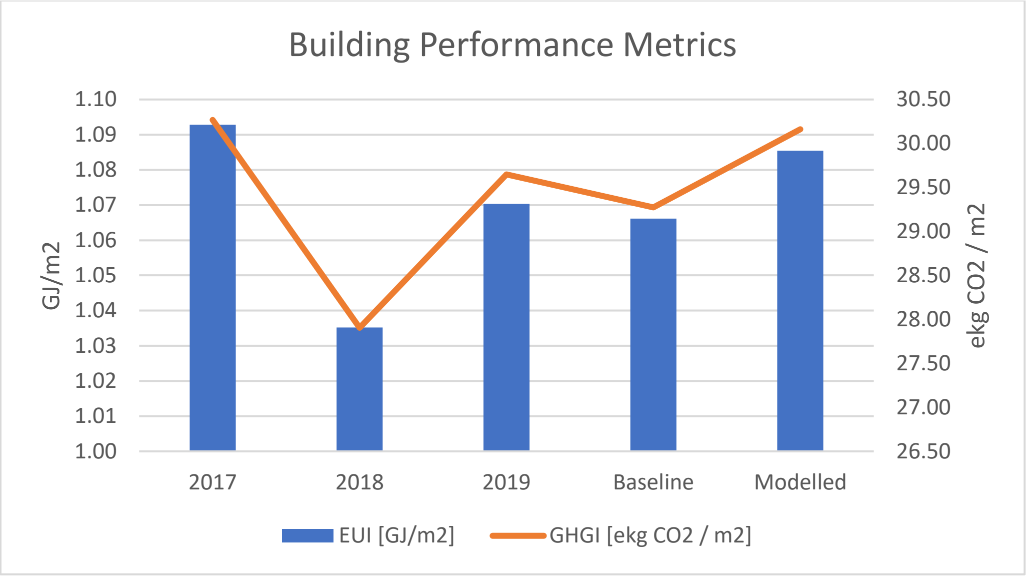


Figure 12 - Building Performance Metrics

Energy Use Intensity

EUIs of 1.07 GJ/m^2 and 1.06 GJ/m^2 were found for the baseline year and calibrated energy model, respectively. Using data from the Government of Canada, as of 2014 a typical one-rink arena operating out of Ontario has an site EUI of 1.27 GJ/m^2. Additional data from the Government of Canada states a national median site EUI of 1.5 GJ/m^2 for ice/curling rinks that were entered into Energy Star Portfolio Manager prior to December 2020.

As such, it can be plainly seen that the Long Sault Arena has a lower EUI than other similar facilities in Ontario and across the country. Likely reasons contributing to this reduced EUI are the ongoing efforts of the Township to address energy consumption, potentially a shorter ice season of the Long Sault Arena vs. other facilities in Ontario which may operate year-round, and a varying number of ice pads and per arena when comparing to the national median.

Energy Conservation Measures

As part of the energy audit conducted for the facility all parameters relevant to the energy consumption and emission profile of the facility were examined. From this audit, a series of energy conservation measures were identified to be examined in detail.

General Information

Lighting

In 2022 the Township elected to complete an LED lighting retrofit of the Long Sault Arena, replacing all internal lights with LED models. Although completed, this ECM is included in this report as it is part of the long term energy plan for the Long Sault Arena that has been under development since mid-2020.

Transitioning to LED lighting offers numerous benefits across various domains. Firstly, LED lights are highly energy-efficient, consuming significantly less electricity than traditional incandescent or fluorescent bulbs. This translates into lower energy bills and reduced environmental impacts. Additionally, LED lights have an impressively long lifespan, lasting up to 50,000 hours or more, reducing the frequency of replacements and maintenance costs. Furthermore, LED lighting emits very little heat, making them safer to use and reducing the risk of fire hazards. LED lights are also highly versatile, offering a range of color temperatures and dimming capabilities, allowing for customized lighting experiences in homes, offices, and public spaces. Overall, the transition to LED lighting contributes to energy conservation, cost savings, enhanced safety, and improved lighting quality, making it a smart and sustainable choice for any setting.

Heating and Cooling – Space and Water

Condensing Heating Equipment

Condensing heating equipment, such as condensing boilers and furnaces, is more energy-efficient compared to non-condensing alternatives due to its ability to extract additional heat from the combustion process. The key factor behind its efficiency is the utilization of the latent heat contained in the water vapor present in the flue gases. In non-condensing systems, these flue gases are typically released into the atmosphere, wasting the heat energy they carry. However, in condensing equipment, the flue gases are cooled to a temperature below the dew point, causing water vapor to condense. This condensation releases latent heat, which is then transferred back into the system, increasing the overall heating efficiency. By recovering this additional heat, condensing heating equipment can achieve efficiency ratings well above 90%, resulting in significant energy savings and reduced fuel consumption. This increased energy efficiency not only helps lower heating costs for users but also contributes to reduced greenhouse gas emissions and environmental impact.

Regarding the Long Sault Arena, most heating equipment within the facility are already high-efficiency condensing units. One exception to this is the facility's air handling unit (AHU). This unit is outdated and nearing end-of-life. In the 21 years since this unit was installed there have been developments with applicable technologies that allow for substantially increased efficiencies. The burner of the current AHU is rated for 400,000 BTU and is 78% efficient. As such, for some Pathways it is proposed to replace this AHU with a premium-efficiency condensing unit equipped with a variable frequency drive motor.

Heat Pumps

Unlike traditional heating equipment which works via the generation of heat, heat pumps work via the transfer of heat from one area to another using the principles of thermodynamics.

The existing HVAC systems for both the facility offices and John C. Cleary Media room consist of a condensing natural gas furnace, rooftop air conditioning unit, and ductwork. Transitioning these systems to heat-pumps with electric auxiliary heaters would provide the opportunity for energy savings and GHG emissions reduction.

Given the climate region in which the facility is located, should the Township look to transition to heat-pump technology, it is recommended to install cold-temperature heat pumps. Cold temperature heat pumps are designed to operate efficiently in colder climates where temperatures regularly drop below freezing. Unlike traditional heat pumps that may struggle to extract sufficient heat from frigid outdoor air, cold temperature heat pumps are engineered with advanced technologies to overcome these challenges. They incorporate features such as enhanced insulation, larger heat exchangers, and variable-speed compressors that allow them to extract heat from extremely low ambient temperatures. Some cold temperature heat pumps also utilize hybrid systems, combining a heat pump with a secondary heating source, such as electric resistance heating or a gas furnace, to provide supplemental heat during extremely cold conditions. These innovative heat pumps offer energy-efficient heating solutions in regions with harsh winter climates, ensuring optimal comfort while minimizing energy consumption.

Should the Township look to implement cold-temperature heat pumps, it is recommended that high efficiency units, with dual or variable speed capabilities and an electric auxiliary heating source are selected.

Rooftop Air Conditioning Units

Currently, air conditioning is provided for all applicable zones using two Heil Quacker roof top condensers connected to the DX coil of the applicable furnace for each unit. Each AC unit was manufactured circa 1993 and is charged with R-22 refrigerant. The systems require replacement to ensure compliance with the government mandate. Readily available technology on the market today would provide a significant efficiency upgrade for the existing units. Replacement in the short term is recommended.

Radiant Heaters

Radiant space heaters work by emitting infrared radiation to heat objects and people directly in their line of sight. Unlike traditional convection heaters that warm the surrounding air, radiant heaters primarily heat objects and surfaces in the room.

Radiant heaters are commonly used in hockey arenas due to their ability to provide efficient and effective heating in large, open spaces. Radiant heaters are able to: provide direct and radiant heat to people and objects close to their path, provide effective localized heating, reach set-temperatures quickly, and function in high-ceiling spaces such as many hockey arenas.

The Long Sault Arena currently utilizes standard efficiency natural gas radiant heaters for the spectator heating section. It is recommended that at end-of-life the Township upgrade to either premium efficiency natural gas or electric units readily available on the market today.

Ventilation

Variable Frequency Drives

Variable frequency drives (VFDs) are devices used in ventilation systems to control the speed and airflow of fans or motors. VFDs can control the speed of AC motors by adjusting the frequency of electrical power supplied to the motor. By incorporating VFDs into ventilation systems, facilities can save energy, improve indoor air quality, extend the useful life of equipment, and reduce noise.

Ice Plant

Desuperheaters

Desuperheaters are devices that extract excess heat from the superheated refrigerant vapor in a heat pump or air conditioning system. They operate by utilizing the high-temperature refrigerant vapor exiting the compressor to heat another fluid, typically water. The desuperheater is usually integrated into the system's refrigerant cycle. As the hot refrigerant vapor flows through the desuperheater, it transfers heat to the water circulating within the desuperheater's coil or heat exchanger. This process effectively cools down the refrigerant vapor, returning it to a saturated state. The heated water can then be used for various purposes, such as domestic hot water production or space heating. By utilizing the waste heat that would otherwise be expelled into the environment, desuperheaters enhance the overall energy efficiency of the system, providing an additional source of useful thermal energy.

Per consultation with both facility staff and the ice plant maintenance provider, prior to the 2015 installation of the seasonal controller the facility's ice plant incorporated desuperheaters to reclaim waste heat, otherwise to be rejected to the environment via the condenser. This waste heat was then used to pre-heat the floodwater, reducing the required natural gas consumption of the flood water heaters.

The desuperheaters were removed from the cycle due to the lack of available waste heat resulting from the seasonal controller. As such, desuperheaters were not examined further for the Long Sault Arena, however they should be considered as an energy conservation measure for many ice plants targeting energy efficiency.

Floodwater Treatment

It is recommended that the Township incorporate the REALice Precision Floodwater Treatment system into the ice resurfacing process. REALice is a high precision water treatment system for ice rinks that reduces the need for the costly, heavily emitting process of pre-heating water prior to ice resurfacing. REALice is a stationary component utilizing vortex technology to remove impurities and micro-bubbles from the water. The result is higher quality ice at a lower utility cost. By using colder water to flood the ice the arena will be able to: eliminating natural gas required to heat water, increase brine temperatures reducing the draw on the ice plant, reduce evaporation and thus reduce dehumidifier run-time.

Per facility operations, floodwater is currently heated to 160 F prior to resurfacing. Per the manufacturer and facility operators who have installed REALice, floodwater in the range of 60 F can be used, significantly reducing consumption. Considering the high volume of floodwater used in the facility, namely an average of 8 floods on weekdays and 14 on weekends, REALice provides the opportunity for tremendous savings without sacrificing performance.

REALice produces energy savings in 4 main ways: natural gas savings by using colder flood water, reduced energy to freeze this colder water as it is applied to the ice surface, reduced energy by raising the brine temperature of the system, and reduced dehumidifier duty cycles. The first three electricity considerations were quantified via an estimate from REALice, projected to save roughly 26 MWh annually. The fourth, namely the degree to which the dehumidifiers' duty cycles may be reduced is an estimate provided by both REALice and Elexicon, the Ontario distributor for REALice, of around 10%.

Interconnections for this ECM include reduced natural gas consumption via reduced use of the floodwater heaters, reduced load on the arena dehumidifiers via reduced evapotranspiration by using colder floodwater, and reduced cooling load on the ice plant by using colder floodwater.

Non-energy related benefits of this ECM include, per the manufacturer, that the ice resulting from a REALice system is stronger, and more durable that ice formed via the traditional process.

This ECM would be required to be installed in the off-season to allow time for sufficient training for facility staff, and to ensure the ice slab is initially flooded in adherence with the standards of the new system.

Compressor-Motor Package Upgrades

The ice plant at the Long Sault Arena is driven by two Mycom reciprocating compressors, each with a 50 HP electric motor. Both existing units are worn, and nearing end-of-life. Given the large quantity of energy consumed by these motors, it is proposed to replace these end-of-life units with new, premium efficiency models.

Regarding commissioning and implementation, replacement components to be used in the ice plant must be appropriately selected to be compatible with existing ice plant. As such, component selection for the ice plant was completed by CIMCO, the ice plant maintenance provider.

Brine Pump Upgrade

In 2021, in line with end-of-life the Township replaced the existing standard efficiency brine pump with a new, energy efficient model. This brine pump retrofit is included in this report as it was conducted as part of the Township's ongoing energy plan for the facility.

Regarding commissioning and implementation, replacement components to be used in the ice plant must be appropriately selected to be compatible with existing ice plant. As such, component selection for the ice plant was completed by the ice plant maintenance provider.

Condenser Replacement

As part of the Township's GICB application, the Township is looking to replace the existing condenser with a near like-for-like model. This new model, however, will include a variable frequency drive on the exhaust fan. As this piece of equipment was included in the Township's GICB application, it is recommended to move forward with this replacement.

At the next end-of-life replacement there are additional energy efficiency measures that the Township may consider regarding the condenser. Should budget allow, the Township may look into evaporative or adiabatic condensers for increased energy and water efficiencies.

Automatic Resurfacer Water Fill Attachment

It was noted by facility staff that substantial energy is wasted during the process of refilling the ice resurfacer. To maintain the ice surface, several times per day the ice resurfacer must be filled with 150 USG of hot water at roughly 160 F. As it takes several minutes to refill the ice resurfacer and building staff are simultaneously responsible for numerous other tasks, the refill is often left unsupervised. Per facility staff, this often leads to overfill of the ice resurfacer, wasting not only water, but hot water, and thus all of the natural gas consumed to heat this water.

As part of this report current technology was examined to find a suitable piece of equipment to automate this process, with the goal of ensuring that the ice resurfacer is filled with no waste, without allowing time for the water to cool down prior to use. Unfortunately, a suitable piece of readily available equipment could not be found. Through consultation with relevant suppliers a similar piece of equipment was once available, however is not currently. It is advised that the Township monitor new equipment should a suitable component come to market.

Dehumidifier Replacement

In 2018 the Township replaced an existing dehumidifier with a new Dry Solutions Smart-Dry-2000 unit. Per the facility operator, issues with this dehumidifier began not long after the installation. The facility operator has noted many issues with this dehumidifier, stating that the machine often provides no dehumidification, and that the automatic shut-off frequently malfunctions and cannot be relied upon. Given a number of issues with this model, the ice plant maintenance provider no longer offers this model.

With this dehumidifier, an energy estimate was provided by the supplier stating a duty cycle of 44% for the ice hockey season. To account for all issues experienced with this dehumidifier, the duty cycle was increased 10% in energy modelling. The same is true for the operational unit to account for the additional dehumidification load.

The Township should look to replace this malfunctioning unit to increase air quality within the arena, quality of the ice, and prevent potential issues that could occur if too much condensation is present in the arena. The Township should also look to relocate this dehumidifier to the North-East corner of the arena to ensure proper air circulation within the arena, however costs to do so have not been included in this update report.

Improved Air Tightness

Exterior Fenestration

The existing exterior fenestration at the facility was installed in 1993 and is thus outdated and nearing the end of its useful lifetime. It is recommended to replace end-of-life unis with modern, energy-efficient models. It is recommended that existing windows are replaced with triple pane models to increase energy efficiency. Energy efficient, triple-pane windows provide enhanced thermal insulation compared to single or double-pane alternatives. The additional pane of glass, along with the insulating gas layers between the panes, significantly reduces heat transfer, resulting in improved energy efficiency. This translates to reduced heating and cooling costs as the windows help maintain a more stable indoor temperature throughout the year.

Air Curtains

Air curtains are devices that create a high-velocity stream of air across an opening, such as a doorway or window. Air curtains act as a barrier between two different environments, preventing the exchange of air. By creating a continuous stream of air across an opening, they help to maintain indoor temperatures and reduce heat loss or gain. This can lead to significant energy savings by reducing the need for heating or cooling systems to compensate for the influx of outside air. Additionally, air curtains improve indoor air quality, enhance comfort, and control the entrance of insects and pests. The installation of an air curtain at the Long Sault arena would have no significant commissioning or implementation requirements.

As the arena already has vestibule doors, it is recommended that the Township implement a horizontal air-curtain above the interior of the outermost vestibule door of the main entrance.

Building Automation Systems and Controls

Programmable Thermostats

Currently, all HVAC systems are controlled through digital, non-programmable thermostats. It has been confirmed by the facility operator that thermostats are not adjusted adhering to any particular schedule.

Programmable thermostats with manual overrides are a relatively low-cost ECM that can allow for tremendous energy, cost, and emission savings by scheduling HVAC systems to operate on a set-schedule designed in adherence with facility operating schedules. Through a programmable thermostat, a facility operator can control HVAC systems such that indoor air conditions are within the comfortable range during predictable occupied times, and automatically adjusted to more energy conserving conditions during times when the zone is predicted to be unoccupied.

Honeywell T10s were selected as the ideal thermostat as they are adaptable, having additional input ports that allow for the incorporation of additional sensors and controls such as occupancy and motion sensors.

Building Automation System (BAS)

Building automation systems, also known as BAS or building management systems (BMS), are advanced technological systems that integrate various components and functions within a building to automate and optimize its operations. These systems utilize a combination of hardware, software, and networked technologies to monitor, control, and manage the building's heating, ventilation, air conditioning (HVAC), lighting, security, and other critical systems. Building automation systems enable centralized control and provide real-time monitoring and data analysis, allowing facility managers to optimize energy usage, enhance occupant comfort, and improve overall building performance. They often consist of sensors, controllers, actuators, and a central management software platform that allows for remote access and control. Building automation systems help streamline operations, increase energy efficiency, reduce maintenance costs, and provide valuable insights for ongoing optimization and decision-making, contributing to more sustainable and comfortable buildings.

For existing facility operations, a BAS is not recommended due to the high cost associated with these systems, the existence of the ice plant seasonal controller, and the relatively low requirements for BAS for the remaining facility.

Should however, the Township look to procced with a full or significant electrification of the facility, it is recommended that the BAS technology available at the time is considered to minimize increases to peak demand and streamline facility operations.

Roofing System

The roof of the arena portion of the facility is comprised of metal roofing panels, 6” insulation and a low emissivity ceiling. Per Township staff, this roof, installed in 1993, is nearing end-of-life and is creating posing a risk to the facility and its operations do to leaks, moisture retention, and ice formation.

Per the structural analysis completed for the Township by EVB, the facilities roof can bear the additional expected load of 2.5 psf the proposed solar array. However, as the existing roof is nearing the end of its rated life and is already experiencing issues it cannot be recommended to place solar panels, rated for 25 years, onto this roof.

As such, it is required to replace this roof with a like-for-like system such that the Township may proceed with the desired rooftop solar PV array. Additionally, minor structural repairs are suggested to the facility to accommodate the panels. Replacing the existing roof would improve the effectiveness of the low-emissivity ceiling, improve building quality and extend the useful life of the facility.

Given the Township's early interest in rooftop solar, no further examination was undergone into green or cool roofs. It is however recommended that green or cool roofs are considered for any new construction and/or retrofits that the Township pursues in future.

Plug Loads

Plug loads in the facility include office equipment such as desktops, monitors, laptops, printers, and servers, arena equipment such as grinders, floor polishers, welders, and plug-in compressors, as well as kitchen equipment such as refrigerators and coffee machines.

The Township has previously stated in it's 2021 'Energy Conservation and Demand Management Report' intensions to transition all existing appliances with Energy Start rated appliance at end-of-life. It is recommended that the Township continue to pursue this goal to minimize energy consumption, and associated costs and emissions.

Staff Engagement

Facility staff play a vital role in achieving energy efficient operations of the facility. Facility staff can aid in energy efficiencies by completing regular equipment maintenance, ensure occupancy awareness, ensure efficient use of equipment, and monitor ongoing practices for waste. By being aware of energy efficient practices, facility staff are equipped to identify energy conservation opportunities and rectify these opportunities accordingly.

Measure Level Analyses

A full summary of the results of the measure level analysis used to quantify the energy savings, GHG emissions reductions, and capital cost of all examined ECMs can be found in APPENDIX G This appendix provides for each ECM, where possible: general information, energy savings, GHG reduction potential, capital cost (year 0), operating savings (year 0), and simple payback. Additional considerations for each measure such as scope/high-level design of the measure, assumptions used to analyze the measure, interdependencies, implementation strategy, and potential commissioning, measurement and verification, and other relevant implementation measures can be found in the previous section.

Energy savings for all ECMs were quantified against baseline consumption, independent of other proposed ECMs. Given interdependencies between measures, total energy savings found for each Pathway in APPENDIX G may differ from the total energy savings found for said pathway calculated through energy modelling.

Peak Demand Considerations

The Long Sault Arena operates on a 'General Service Demand' electricity rate schedule. Through this schedule, electricity charges are calculated based on both total electricity (kWh) and monthly peak demand (kW) over the billing cycle. For the purposes of this report, all energy savings are calculated using the overall blended electricity rate including all pre-tax components of the electricity bill.

Regarding fuel switching from natural gas to electricity, significant increases in peak demand and related monthly charges should be expected. For the purposes of this report, it is assumed that increases to the demand portion of the monthly bill are offset by increases to the total kWh consumption. As such, the same blended rate is used to calculate all post-retrofit electricity charges.

Net-Metering Considerations

When considering the rooftop solar array with on-site battery storage, the proportion of solar generation used directly within the facility, stored in the battery for later use, or exported to the grid in exchange for credits can be a substantial impact on the grid-side load profile and billing charges. For the purposes of this report, cost savings associated with the renewable energy system are calculated assuming that 50% of the solar generation is used directly within the facility, offsetting electricity at the blended rate (including demand charges), and 50% is exported to the grid in exchange for financial credits at the rate for electricity (kWh only). Should the Township move forward with this project, further optimization of the battery operation will be required to ensure maximum peak demand reduction, emergency power, cost savings, and environmental benefits.

Renewable Energy Analysis

Where the previous section discussed a variety of topics to improve efficiency with the facility and reduce energy consumption, it is important to note that even net-zero buildings still consume energy. As such, it is important to quantify and target ways to transition energy consumption that cannot be eliminated to low-carbon or renewable energy sources.

Renewable energy generation refers to the production of electricity or other forms of energy using renewable energy sources. Renewable energy sources are those that can be replenished or renewed naturally, such as solar, wind, hydro, geothermal, and biomass. These sources of energy do not produce greenhouse gas emissions or other pollutants, and they are considered to be clean sources of energy. The use of renewable energy is a key strategy for reducing carbon emissions and combating climate change.

Low-carbon and renewable energy are related concepts, but they refer to different aspects of energy production and use. Low-carbon energy sources refer to any form of energy production or use that generates lower greenhouse gas emissions than traditional fossil fuel sources. This can include not only renewable energy sources but also non-renewable sources, such as natural gas, that produce lower emissions than coal or oil. Low-carbon energy technologies include a range of options such as nuclear power, carbon capture and storage, and energy efficiency measures.

Renewable and low-carbon energy generation has the potential to transform the energy sector and enable a transition to a more sustainable, low-carbon energy future. However, the deployment of renewable energy technologies still faces challenges related to cost, intermittency, and grid integration. As such, continued research and development, policy support, and investment in renewable energy generation technologies are critical for accelerating the transition to a more sustainable energy system.

For the Long Sault Arena, based on the location, consumption profile, available resource, and billing structure, three solar photovoltaic configurations were analyzed as will be discussed in the following section. Additional renewable energy generation technologies possible at the site such as geothermal, wind, and solar thermal generation were not examined further due to site specific considerations such as space requirements and resource potential.

Solar Photovoltaic (PV)

Solar photovoltaic (PV) panels generate electricity through a process known as the photovoltaic effect. The photovoltaic effect is the process by which certain materials, such as silicon, generate an electrical current when exposed to sunlight. Typical PV panels are rated for 25+ years, with very little maintenance required, and zero operational greenhouse gas emissions. Typical operations and maintenance materials for solar PV arrays include cleaning, inspections, and replacement of the system inverter after 10 years of operation. It is also important to monitor the performance of the system to identify any issues or required repairs.

It is recommended that the Township implement a rooftop solar photovoltaic system with on-site battery storage. Implementing a rooftop solar photovoltaic system will allow the Township to maximize the economic benefit from Hydro One's 'Net-Metering' program and reduce the amount of energy the facility draws from the grid.

Through the net-metering program the Township could use electricity generated/stored by the solar-plus-storage system to directly offset consumption when generation/storage capacity overlaps with consumption and offload excess generation directly into the Ontario electricity grid in exchange for credits that are applied to future Hydro One bills for the facility. Credits are generated at the rate paid for electricity, namely any line items billed on a kWh basis. Credits are automatically applied to future Hydro One bills for the facility at which the generation occurs, can only be accredited to line items billed on a kWh basis, and must be used within 12 months of the time of accreditation.

To further optimize the model, on-site battery storage was examined to determine the cost-savings opportunities of reducing peak demand and applicable charges. Additionally, the Township is attracted to the potential for on-site battery storage such that the facility may be adapted into a shelter during times of emergency.

Design Considerations

Our assessment was focused on modeling the arena's energy load profile using the long-term hourly interval and billing data obtained from Hydro One, as well as information gathered from consultation with numerous stakeholders. The purpose was to custom design a turnkey-ready rooftop solar array that could be installed within the available buildable area to meet the arena's energy needs at the lowest possible cost.

To optimize the system, we correlated the production output of the proposed solar array with the arena's hourly consumption of energy. Additionally, various battery and grid storage options were explored with the objective of finding the lowest possible Levelized Cost of Energy (LCOE), thus maximizing utility bill savings for the Township.

To determine the buildable area for the solar array it was necessary to first determine the state and structural integrity of the arena's existing roof and what improvements, if any, would be required to install a solar rooftop array. An engineering review and structural analysis of the pre-engineered building was conducted including the Zamboni area, lobby, and dressing room areas in the conventional building. This review concluded that the roof of the pre-engineered building can support the load of the proposed solar array upon the completion of some structural reinforcements. The engineering report also determined that the roof structure of the conventional building would require major structural upgrades to support the additional load of a solar array. As such, the roof area of the conventional building was excluded from the buildable area. In addition to structural reinforcements, the roof of the pre-engineered building including the Zamboni area, was also found to be in poor shape and therefore, should be replaced prior to installing the proposed rooftop array.

Battery storage

To determine the lowest cost and most efficient battery storage system to maximize the return from net-metering and bill savings from peak demand reduction, a variety of options were modeled, including lithium ion, lead acid and iron flow batteries. The purpose of these analyses were to determine which had the best performance and the lowest levelized cost of storage. Of the battery storage systems reviewed, lithium-Ion batteries had the best performance, but the high cost of the batteries combined with their reduced life cycle (8- 10 years life expectancy) made the project unfeasible.

Iron-flow batteries on the other hand, have a much longer projected life expectancy (30 years+), are more environmentally friendly than lithium-Ion, are less expensive, and just as capable of meeting the storage and load management requirements of the facility for the proposed GHG reduction pathways. The only drawback is their larger size, but fortunately, the arena has enough free space to accommodate the units at the back of the building.

Panels

For the rooftop models the CSI 440Wp panel was selected. This particular panel was selected due to its size and power output combination that allow it to easily be substituted by other manufacturers in the case of supply issues without having a significant impact on the overall yield or, cost assumption for the project.

For the ground-mounted solar canopy array model (211 kWp), a higher output panel was used, namely the CSI dual facial 660 Wp panel. This panel was selected due to its higher output given the limited area available, and to accommodate the array and higher costs associated with the racking system for the carport canopy design.

Inverters

The rooftop solar array was modeled using the SMA Sunny Tripower 25000TL-30 inverter. This inverter is readily available at a reasonable price and there are a variety of substitutes available without affecting the cost or efficiency of the model in case of supply issues.

The ground mounted solar canopy array was modeled using the SMA Sunny Tripower STP50-41-core1. This inverter is also readily available from a variety of manufacturers at a reasonable price and can therefore be readily substituted in case of supply issues. This particular model was selected due to its suitability for the solar array size of the proposed carport canopy.

Software

To design and analyze the feasibility of solar PV arrays at the facility, PVsyst was used. PVsyst is a powerful and widely used tool for designing and optimizing PV solar energy systems. It is widely recognized and respected in the solar energy industry and is often used by solar energy professionals to evaluate the performance and economic feasibility of solar energy projects.

Grid Interconnection

Should the Township incorporate solar photovoltaic at the Long Sault Arena, the array would be able to connect to the grid via the Long Saul North DS-FA 8.32kV line approximately 50m from the arena.

The grid interconnection costs can only be determined should the Township proceed with a capital project and submit a Form B - Connection Impact Assessment (CIA) to Hydro One.

Design Configurations

The three solar PV configurations proposed to meet the energy load of the facility are as follows:

- Maximum Rooftop Capacity [415 kWp]
- Rooftop Array – GICB Consumption [380 kWp]
- Full Site Electrification [626 kWp]

The full PVSyst reports for each configuration can be found in Appendix H, submitted outside of this report due to excessive length.

The first design configuration, ‘Maximize Rooftop Capacity’, was designed to assess the maximum energy generating capacity of a solar rooftop system at the arena. The buildable rooftop area was limited to the flat metal roofing of the arena. This decision was made given the conclusions of the structural review of the flat-roof areas, which were found to require substantial and costly retrofits to accommodate the extra weight of the panels. Additionally, these areas were found to be less productive due to shading from nearby trees.

The second configuration, ‘Rooftop Array – GICB Consumption’, was designed to match the annual consumption of the facility should all measures identified in the Township’s GICB application be implemented. This GICB application will be discussed further later in this report.

The third configuration analyzed was designed to match the annual consumption of the facility should the facility proceed with full electrification as will be discussed later in this report. To meet this demand, the full buildable rooftop area would be used (415 kWp) and further supplemented with the addition of a 211 kWp ground-mounted carport canopy array. These two arrays would allow the Township to fully meet the energy demand of the facility in a carbonless all-electric scenario. This model was analyzed via the combined output of the 415 kWp and the 211 kWp arrays.

Table 17 below shows a summary of the design specifications for each of the three modelled configurations.

Table 17 - Summary of solar design configurations

Configuration	System Size [kWp]	Total System Cost [$CAD]	System Cost per kW [$/kW]	Levelized Cost of Energy (LCOE) [$CAD/kWh]	Annual Electricity Generation [kWh/year]	Offset Utility Cost	Offset GHG Emissions [kg C0$_2$e]
1. Maximize Rooftop Capacity	415	$1,993,210.00	4,803.00	0.09	457,780.00	$79,839.86	13,132.00
2. Rooftop Array – GICB Consumption	380	$1,925,000.00	5,066.00	0.09	429,700.00	$73,149.66	12,031.60
3. Full Site Electrification	626	$2,525,710.00	4,035.00	415 kWp Rooftop: 0.09 211 kWp Ground Mount: 0.12	736,186.00	$118,341.90	20,613.21

The cost projections included in this report includes all costs associated with reinforcing the roof structure and replacing the roof in the pre-fabricated building area as recommended in the engineering review as well as, the cost of a 500 kWh battery storage system and all annual operating costs associated with the various technologies employed.

The levelized cost of energy (LCOE) is a metric used to evaluate and compare the cost of generating electricity from different sources or technologies over the lifetime of a power plant. It represents the average cost per unit of electricity produced (typically measured in dollars per megawatt-hour or cents per kilowatt-hour) necessary to recover the total lifetime costs, including initial investment, operation and maintenance expenses, fuel costs, and expected lifetime electricity production.

It should be noted that the LCOE's included in the table above are significantly impacted by the level of funding available and requirements in addition to the energy generation. LCOE's for configurations 1 and 2 above include costs associated with the required roof replacement and structural upgrades, as well as 80% funding through the GICB. These configurations also include the cost for the on-site battery storage system, however as will be discussed momentarily, without post-retrofit load data, cost savings found through the battery system cannot be holistically modelled in PVsyst, nor other available modelling software. It should also be noted that the LCOE for the ground-mounted array of configuration 3 includes only 20% funding which may be found through the CBR.

The Long Sault Arena purchases electricity under Hydro One's 'General Service Demand' rate structure. Under this rate structure, the facility is billed in terms of both total electricity consumption (kWh) and monthly peak demand (kW). Resulting from this rate structure, the overall monthly blended electricity cost (kWh and kW) varies from month-to-month, dependent on overall consumption, peak demand, and the electrical load profile for that month. PVsyst and other accredited software are unfortunately unable to model the reductions in monthly overall blended electricity rates caused by solar-induced reductions in monthly peak demand. With these limitations in available software, the pre-retrofit blended overall electricity rate was required used for all PVsyst modelling. These savings do not holistically reflect the savings caused by reductions in monthly peak demand, however they can be thought of as a near-accurate estimate.

Again, when considering the rooftop solar array with on-site battery storage, the proportion of solar generation used directly within the facility, stored in the battery for later use, or exported to the grid in exchange for credits can be a substantial impact on the grid-side load profile and billing charges. For the purposes of this report, cost savings associated with the renewable energy system are calculated assuming that 50% of the solar generation is used directly within the facility, offsetting electricity at the blended rate (including demand charges), and 50% is exported to the grid in exchange for financial credits at the rate for electricity (kWh only). Should the Township move forward with this project, further optimization of the battery operation will be required to ensure maximum peak demand reduction, emergency power, cost savings, and environmental benefits.

Ongoing measurement and verification of the performance of the PV array and post-retrofit consumption load profile will be required to fully quantify the effects of solar-induced peak demand reductions on the blended electricity rate and associated cost savings. This ongoing measurement and verification will also allow the Township to further optimize the integration of the PV generation and on-site battery storage to reduce monthly peak demand and associated charges.

General Facility Maintenance Projections

In addition to the GHG reduction pathways to follow, through the Building Condition Assessment completed late-2022 and consultation with applicable suppliers the following 20-year projection of general facility maintenance at the Long Sault Arena was generated. Replacements included in the below general facility maintenance projection include all non-energy consuming components, small plugs loads, as well as those energy consuming components for which potential energy savings are assumed to be negligible or unquantifiable.

An example of a replacement for which energy savings would be negligible or unquantifiable would be the ice plants electrical panel. Although this component may generate energy savings via soft-start technology, these savings were not quantified for the purpose of this report. For all energy consuming components included in this section such as the ice plant electrical panel and ice plant primary controller, it is recommended that the Township target the most energy efficient technology available at the time of replacement.

Per the Township's 2019 Energy Conservation & Demand Management Plan, where possible plug loads will be replaced with Energy Star certified models. Furthermore, for all scheduled replacements included in this section it is recommended that at the time of replacement the Township consider all technology available at that time and select the most energy efficient option where possible.

Figure 13 below shows a summary of projected general facility maintenance costs over the 20-year study period.

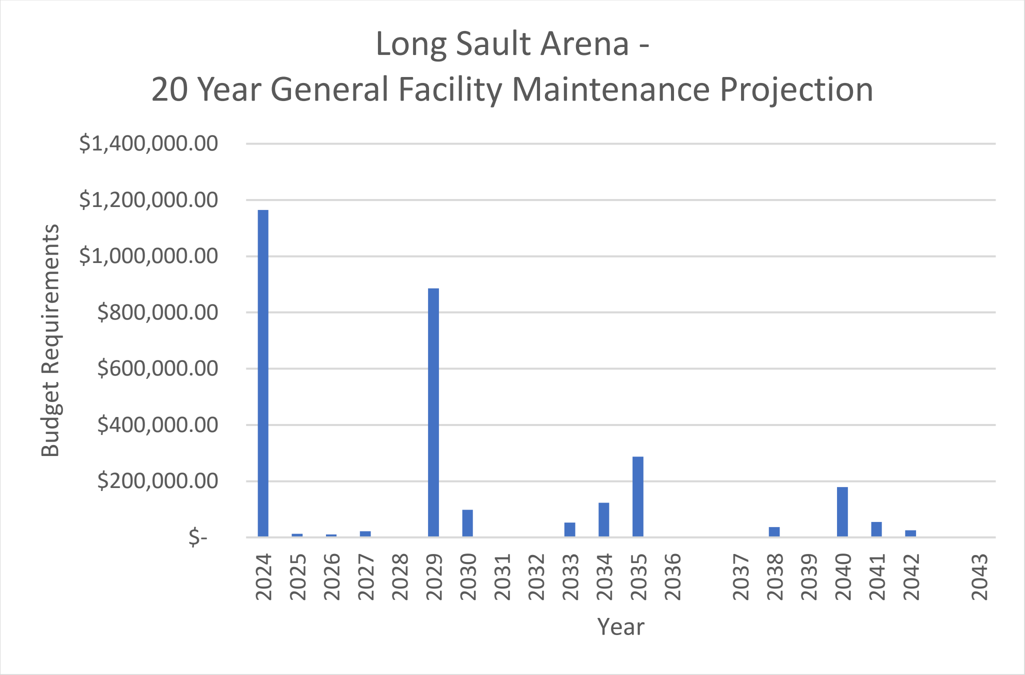


Figure 13 - General Facility Maintenance Projections

It is important to note that only a draft of the BCA was available at the time of writing this report. As such, minor changes were made to replacement requirements projected in the current version of the BCA to better reflect the study teams' understanding of the facility. Additionally, where possible changes were made to cost projections to adhere to forecasts provided by contracted suppliers such as the ice plant maintenance provider, or quotes received by the Township.

All costs included in this section are excluded from the GHG reduction pathways to follow. A full list of general facility maintenance requirements and associated costs can be found in APPENDIX E. An exception to these exclusions is the replacement of the facility's metal roof. To accommodate the Township's decision to pursue a rooftop photovoltaic solar array, this end-of-life roof will require replacement. As such, the cost for replacing the metal roof is included in all Pathways. As replacing the roof is an unavoidable expense regardless of if the Township moves forward with any of the identified Pathways, the cost to replace the metal roof is still included in the above general facility maintenance projections.

Notably, the following equipment is not included in the above general facility maintenance financial projections, as these costs are included in the Pathways to follow: furnaces (2), water heaters (3), air handling unit (1), boiler (1), rooftop air conditioning units (2), Zamboni room space heater (1), spectator radiant heaters (6), ice resurfacer (1), and windows.

GHG Reduction Pathways (GHG reduction pathway capital plan)

Strategies and Information Common to All Pathways

Measures common to all pathways address the short-term needs of the facility and have been included in the Townships GICB Application. These measures include the following:

- 2022 Brine Pump Replacement/Upgrade
- 2022 LED Lighting Retrofit
- 2021 Domestic Hot Water Heater Replacement
- Replacement of Malfunctioning Desiccant Dehumidifier
- Compressor Upgrades
- Condenser Replacement

It should be noted that the '2022 Brine Pump Replacement', '2022 LED Lighting Retrofit', and '2021 Domestic Hot Water Heater Replacement' have already been completed at the time of writing this report. These measures are included in this report as they are considered included with the Township's long-term energy management plan for the arena currently being developed. Funding has been requested for these measures as part of the Township's application into Infrastructure Canada's GICB program. However, these expenses would be ineligible for reimbursement should the Township look to move forward with an application for capital funding into the Federation of Canadian Municipalities 'Community Buildings Retrofit' program. As such, these measures are not included in any such funding requests.

To ensure fair comparison between Pathways, in addition to specific ECMs proposed within each Pathway, all end-of-life replacement costs not included in the General Facility Maintenance projections are included in all Pathways. If an ECM is recommended for a specific component within a Pathway, these costs are reflected. Should no ECM be recommended for said component within the Pathway, end-of-life like-for-like replacement costs are included. This set includes replacements for each of the following:

- Municipal Office HVAC equipment
- John C. Cleary Media Room HVAC equipment
- General Facility Air Handling Unit
- Zamboni Room Heating Equipment
- Spectator Seating Heating Equipment
- 2009 Addition In-Floor Boiler
- Domestic Hot Water Heater
- Process Hot Water Heaters
- Ice Resurfacer

Pathway 1 – Like-for-Similar

This pathway includes all measures mention in the 'Strategies Common to All Pathways', and only end-of-life like-for-like replacement costs for all equipment not included in the General Facility Maintenance projections. The intent of the Pathway is to provide a baseline to which the remaining Pathways can be referenced over the 20-year study period.

End-of-life like-for-like measures included in this pathway include:

- Non-Condensing AHU
- Rooftop AC Replacements
- Zamboni Room Condensing Natural Gas Unit Heater Upgrade
- Spectator Seating Radiant Heater Replacement
- Metal Roof Replacement

All other components not included in general facility maintenance are already premium efficiency, thus are not included in the list above. Costs for replacing existing units at end of life are however included in the financial analysis for this pathway. Components such as these include: two condensing furnaces, three condensing water heaters, one condensing boiler, ice resurfacer (check email from Kevin for quote).

Costs to replace the existing metal roof were included in this section to ensure fair comparison between Pathways. This decision was made to accurately reflect the short-term requirements of the facility. Given that all remaining Pathways include the cost of this roof replacement and that these costs are not otherwise accounted for in the General Facility Maintenance projections, to ensure the financial viability of Pathways and future budgets for the facility are fairly and accurately compared these costs were included.

Advantages

- Lowest implementation cost and complexity of installation
- Minimal impact on facility operations

Disadvantages

- Minimal energy conservation and/or GHG emission reduction
- Negative Net Present Value indicates that the costs associated with the project exceed the savings found. This is expected as for this baseline projection the majority of the costs are spent on measures that do not provide energy savings, and thus do not provide a financial benefit.
- Greatest amount of carbon offsets required for net-zero operation

Implementation, Scheduling, and Logistics

Phase 1 (Years 1 through 5):

Capital projects already completed:

- 2022 Brine Pump Replacement/Upgrade
- 2022 LED Lighting Retrofit
- 2021 Domestic Hot Water Heater Replacement

Capital projects in planning:

- Compressor Upgrades
- Condenser Replacement
- Condensing Natural Gas In-Floor Boiler
- Non-Condensing Air Handling Unit
- Dehumidifier Replacement
- Metal Roof Replacement

Additional required/recommended capital projects:

- Zamboni Room Condensing Natural Gas Unit Heater Upgrade
- Condensing Natural Gas Floodwater Heater Replacements
- Office Rooftop Air Conditioning Unit Replacement
- John C. Cleary Media Room Rooftop Air Conditioning Unit Replacement

Phase 2 (Years 6 through 10):

- Natural Gas Domestic Hot Water Heater Replacement
- Natural Gas Radiant Spectator Heaters
- Carbon Credits to reach 50% GHG Emissions Reduction

Phase 3 (Years 11 through 20):

- Natural Gas Ice Resurfacer
- Condensing Natural Gas Office Furnace
- Condensing Natural Gas John C. Cleary Media Room Furnace
- Carbon Credits to reach 100% GHG Emissions Reduction

Performance and Lifecycle Cost Analysis (LCCA) Results

Table 18 - Pathway 1 LCCA Results

LCCA (20 year period)	Unit	P1
Total Construction Cost:	$CAD	$1,345,339.13
Incentives and Grants:	$CAD	$19,833.00
NPV	$CAD	-$824,801.85
IRR	-	-4.0%

Table 19 - Pathway 1 Summary Results

	Pathway 1	Savings
Annual Energy Consumption [GJ]	3,196.56	8.0%
Annual Electricity Consumption [kWh]	454,386.00	13.4%
Annual Natural Gas Consumption [m^3]	42,182.76	1.4%
Energy Cost [$CAD yr. 1]	$ 112,962.75	11.9%
GHG Emissions [kg CO_2e]	93,755.98	3.2%

On-Site Electricity Generation [kWh]	-	N/A
On-Site Electricity Generation [$CAD yr. 1]	$ -	N/A
GHG Offsets Required [$CAD yr. 1]	$ 1,878.59	N/A

Energy Modelling Results

Energy modelling results below do not include electricity savings found through solar generation.

Table 20 - Pathway 1 Energy Modelling Results

	Electricity [kWh]		Natural Gas [m^3]	
	Calibrated Model	P1	Calibrated Model	P1
January	55,720.00	48,251.00	7,858.80	7,766.46
February	51,143.00	44,270.00	6,736.96	6,663.99
March	59,444.00	51,697.00	5,904.10	5,825.09
April	58,039.00	50,763.00	3,387.70	3,331.07
May	22,782.00	18,848.00	752.01	727.39
June	11,516.00	8,446.00	159.47	138.36
July	12,794.00	9,282.00	159.08	137.97
August	14,520.00	12,299.00	482.50	465.47
September	60,410.00	53,714.00	1,470.65	1,419.96
October	62,007.00	54,898.00	3,223.85	3,162.75
November	59,169.00	52,056.00	5,468.79	5,429.48
December	57,455.00	49,862.00	7,187.94	7,114.96
Total	**524,999.00**	**454,386.00**	**42,791.84**	**42,182.95**
Total Savings		70,613.00		608.89

Pathway 2 – GICB Application / Optimize Existing

This pathway centers around all measures included in the Township's 2023 GICB funding application. This pathway is meant to show the Township the impacts of all measures included in their GICB application, and the requirements to meet net-zero operations without radical change, but only an optimization of existing systems, beyond these measures.

This pathway also includes all additional replacements costs over the 20-year study period, not included in the general facility maintenance. These replacements are intended as an optimization of the existing configurations, without radical changes to the existing infrastructure.

Measures Included in the GICB Application:

- 380 kW Rooftop Solar PV Array with On-Site Battery Storage
    - Includes roof replacement and structural upgrades
- REALice Precision Floodwater Treatment
- Condensing AHU
- Programmable Thermostats
- Air Curtain

Additional measures not included in the GICB application, but required throughout the 20-year study period include:

- Zamboni Room Condensing Natural Gas Heater Upgrade
- Spectator Seating Premium Efficiency Natural Gas Radiant Heater
- Rooftop AC Replacements
- Electric Ice Resurfacer

All other components not included in general facility maintenance are already premium efficiency, thus are not included in the list above. Costs for replacing existing units at end of life are however included in the financial analysis for this pathway. Components such as these include: two condensing furnaces, three condensing water heaters, and one condensing boiler.

As stated previously in this report, although high level project scheduling has been proposed, at this stage a detailed project implementation schedule cannot be assumed for LCCA purposes. As such, for the purposes of all LCCAs included in this report, utility savings are assumed to be uniform throughout the 20-year project period, based on the results of the applicable measure analyses and modelling for each pathway.

An exception to this is for the replacement of the natural gas ice resurfacer with an electric model. Per discussions with Township staff, the Township sells ice resurfacer after 14 years to avoid increased upkeep. As such, utility savings for this Pathway are reflective of this.

Advantages

- Most financially attractive Pathway
- Significantly offsets fossil fuel consumption
- Majority of construction is at the start of the study period, allowing for minimal intrusion on operations throughout the remainder of the project life
- Ties in holistically with capital projects already planned, and pending funding applications
- Allows for the incorporation of on-site renewable generation with on-site battery storage

Disadvantages

- Relies significantly on carbon offsets to reach net-zero operation

Implementation, Scheduling, and Logistics

Phase 1 (Years 1 through 5):

Capital projects already completed:

- 2022 Brine Pump Replacement/Upgrade
- 2022 LED Lighting Retrofit
- 2021 Domestic Hot Water Heater Replacement

Capital projects in planning:

- Compressor Upgrades
- Condenser Replacement
- Condensing Natural Gas In-Floor Boiler
- Condensing Air Handling Unit
- Dehumidifier Replacement
- Metal Roof Replacement

Additional required/recommended capital projects:

- 380 kW Rooftop Solar PV Array with On-Site Battery Storage
    - Includes roof replacement and structural upgrades
- REALice Precision Floodwater Treatment
- Programmable Thermostats
- Air Curtain
- Zamboni Room Condensing Natural Gas Unit Heater
- Condensing Natural Gas Floodwater Heater Replacements
- Office Rooftop Air Conditioning Unit Replacement
- John C. Cleary Media Room Rooftop Air Conditioning Unit Replacement

Phase 2 (Years 6 through 10):

- Natural Gas Domestic Hot Water Heater Replacement
- Natural Gas Premium Efficiency Radiant Spectator Heaters
- Carbon Credits to reach 50% GHG Emissions Reduction

Phase 3 (Years 11 through 20):

- Electric Ice Resurfacer
- Condensing Natural Gas Office Furnace
- Condensing Natural Gas John C. Cleary Media Room Furnace
- Carbon Credits to reach 100% GHG Emissions Reduction

Performance and Lifecycle Cost Analysis (LCCA) Results

Table 21 - Pathway 2 LCCA Results

LCCA (20 year period)	Unit	P2
Total Construction Cost:	$CAD	$2,809,784.13
Incentives and Grants:	$CAD	$2,176,306.65
NPV	$CAD	**$1,513,290.25**
IRR	-	**17.8%**

Table 22 - Pathway 2 Summary Results

	Pathway 2	Savings
Annual Energy Consumption [GJ]	2,594.80	25.3%
Annual Electricity Consumption [kWh]	451,859.00	13.9%
Annual Natural Gas Consumption [m^3]	26,165.15	38.9%
Energy Cost [$CAD yr. 1]	$ 103,374.96	17.1%
Operating GHG Emissions [kg CO_2e]	56,899.51	41.3%
Net GHG Emissions [kg CO_2e]	50,883.71	47.5%
On-Site Electricity Generation [kWh]	429,700.00	N/A
On-Site Electricity Generation [$CAD yr. 1]	$ 73,149.66	N/A
GHG Offsets Required [$CAD yr. 1]	$ 1,113.05	N/A

Energy Modelling Results

Energy modelling results below do not include electricity savings found through solar generation.

Table 23 - Pathway 2 Energy Modelling Results

	Electricity [kWh]		Natural Gas [m^3]	
	Calibrated Model	P2	Calibrated Model	P2
January	55,720.00	48,563.00	7,858.80	5,355.54
February	51,143.00	44,562.00	6,736.96	4,546.61
March	59,444.00	51,848.00	5,904.10	3,711.60
April	58,039.00	50,593.00	3,387.70	1,774.02
May	22,782.00	18,484.00	752.01	423.24
June	11,516.00	7,935.00	159.47	135.24
July	12,794.00	8,733.00	159.08	135.54
August	14,520.00	11,438.00	482.50	109.56
September	60,410.00	53,104.00	1,470.65	329.16
October	62,007.00	54,660.00	3,223.85	1,519.30
November	59,169.00	51,939.00	5,468.79	3,376.61
December	57,455.00	50,000.00	7,187.94	4,748.69
Total	**524,999.00**	**451,859.00**	**42,791.84**	**26,165.15**
Total Savings		73,140.00		16,626.69

Pathway 3 – Full Electrification

This pathway provides the Township with a pathway to transition fully to electricity and eliminate fossil fuel consumption at the Long Sault Arena. This is done via efficiency improvements wherever possible, and fuel transition away from natural gas where required. The purpose of this Pathway it to provide the Township with a forecast on how they may fully electrify the facility, and what the energy, emission, and financial benefits would be.

This pathway centers around all measures included in the Township's 2023 GICB funding application. This pathway is meant to show the Township the impacts of all measures included in their GICB application, and the requirements to meet net-zero operations without radical change beyond these measures. Additional measures included in this Pathway include:

- 415 kW Rooftop Solar PV Array with On-Site Battery Storage
    - Includes roof replacement and structural upgrades
- 211 kW Ground Mounted Solar PV Array
- REALice Precision Floodwater Treatment
- Condensing AHU (Year 0)
- Electric AHU (Year 20)

- Zamboni Room Electric Heaters
- Spectator Seating Electric Radiant Heaters
- Electric Water Heaters
- Electric Boiler
- Cold Temperature Heat Pumps for Offices and John C. Cleary Media Room
- Air Curtain
- Programmable Thermostats
- Electric Ice Resurfacer

As stated previously in this report, although high level project scheduling has been proposed, at this stage a detailed project implementation schedule cannot be assumed for LCCA purposes. As such, for the purposes of all LCCAs included in this report, utility savings are assumed to be uniform throughout the 20 year project period, based on the results of the applicable measure analyses and modelling for each pathway. Three exceptions were made to this:

1. The replacement of the natural gas ice resurfacer with an electric model. Per discussions with Township staff, the Township sells ice resurfacer after 14 years to avoid increased upkeep. As such, utility savings for this Pathway are reflective of this.

2. The replacement of the proposed condensing natural gas air handling unit with an electric model. As part of the Township's GICB application, the Township is looking to replace the existing end-of-life air handling unit with a condensing natural gas model, equipped with a variable frequency drive motor. As this piece of equipment was included in the Township's GICB application, it is recommended to move forward with this replacement. As such, this condensing unit is used for calculations for years 1 through 19. To maximize GHG emissions reductions over the 20-year study period, it is recommended to replace the condensing AHU with an electric model. As such, utility savings for the Pathway are reflective of these scheduled changes.

3. The proposed solar configuration for this Pathway is comprised of two systems: a 415 kW rooftop array, and a 211 kW ground mounted array to account for the increased consumption associated with the full electrification. However, as not all electrification occurs in year 0 it is important to ensure that the solar array is not oversized at the start of the study period without purpose. As such, it is recommended that the rooftop solar array be adaptable to future changes, with only the 415 kW array being implemented in Year 0, and the remaining 238 kW array implemented in Year 10.

Advantages

- Maximum GHG Emission Reduction
- Full Facility Electrification
- Allows for net-zero carbon operation without purchasing carbon offsets

Disadvantages

- Requires ground mounted solar via a car canopy. The Township would like to avoid ground mounted arrays due to limited space and to allow flexibility for future development

- Significant overhaul of existing HVAC Systems and electrical infrastructure
- Potential replacement of condensing AHU prior to end-of-life
- Increased operating costs over the project life cycle due to increased electrification

Implementation, Scheduling, and Logistics

Phase 1 (Years 1 through 5):

Capital projects already completed:

- 2022 Brine Pump Replacement/Upgrade
- 2022 LED Lighting Retrofit
- 2021 Domestic Hot Water Heater Replacement

Capital projects in planning:

- Compressor Upgrades
- Condenser Replacement
- Condensing Natural Gas In-Floor Boiler
- Condensing Air Handling Unit
- Dehumidifier Replacement
- Metal Roof Replacement

Additional required/recommended capital projects:

- 380 kW Rooftop Solar PV Array with On-Site Battery Storage
    - Includes roof replacement and structural upgrades
- REALice Precision Floodwater Treatment
- Programmable Thermostats
- Air Curtain
- Zamboni Room Electric Heater
- Electric Floodwater Heaters
- Office Heat Pump
- John C. Cleary Media Room Heat Pump

Phase 2 (Years 6 through 10):

- Electric Domestic Hot Water Heater

- Electric Radiant Spectator Heaters
- Carbon Credits to reach 50% GHG Emissions Reduction
- (Year 10) 211 kW Ground Mounted Solar PV Array

Phase 3 (Years 11 through 20):

- Electric Ice Resurfacer
- Electric AHU
- Carbon Credits to reach 100% GHG Emissions Reduction

Performance and Lifecycle Cost Analysis (LCCA) Results

Table 24 - Pathway 3 LCCA Results

LCCA (20 year period)	Unit	P3
Total Construction Cost:	$CAD	$3,842,407.81
Incentives and Grants:	$CAD	$2,362,427.75
NPV	$CAD	**$1,072,432.85**
IRR	-	**11.8%**

Table 25 - Pathway 3 Summary Results

	Pathway 3	Savings
Annual Energy Consumption [GJ]	2,660.56	23.4%
Annual Electricity Consumption [kWh]	739,045.00	-40.8%
Annual Natural Gas Consumption [m^3]	-	100%
Energy Cost [$CAD yr. 1]	$144,631.11	-23.0%
Operating GHG Emissions [kg CO$_2$e]	10,386.66	89.3%
Net GHG Emissions [kg CO$_2$e]	80.05	99.9%

On-Site Electricity Generation [kWh]	736,186.00	N/A
On-Site Electricity Generation [$CAD yr. 1]	$125,324.07	N/A
GHG Offsets Required [$CAD yr. 1]	$1.60	N/A

Energy Modelling Results

Energy modelling results below do not include electricity savings found through solar generation.

Table 26 - Pathways 3 and 4 Energy Modelling Results

	Electricity [kWh]		Natural Gas [m^3]	
	Calibrated Model	P3	Calibrated Model	P3
January	55,720.00	112,418.00	7,858.80	0
February	51,143.00	98,450.00	6,736.96	0
March	59,444.00	95,936.00	5,904.10	0
April	58,039.00	68,946.00	3,387.70	0
May	22,782.00	22,723.00	752.01	0
June	11,516.00	9,361.00	159.47	0
July	12,794.00	10,190.00	159.08	0
August	14,520.00	12,626.00	482.50	0
September	60,410.00	56,551.00	1,470.65	0
October	62,007.00	70,926.00	3,223.85	0
November	59,169.00	91,124.00	5,468.79	0
December	57,455.00	106,215.00	7,187.94	0
Total	**524,999.00**	**755,466.00**	**42,791.84**	**0**
Total Savings		-230,467.00		42,791.84

Pathway 4 – Full Electrification Short Term Deep Retrofit

This Pathway includes all the same energy conservation and GHG reduction measures as Pathway 3 – Full Electrification, except that all measures are implemented in the first five years of the study period. The purpose of this Pathway is to provide the Township with an understanding of the requirements and implications of rapidly accelerating the electrification of the facility to within a 5 year window.

In reality, retrofits would be completed throughout the five-year period, however for the purposes of this report it is assumed that most retrofits are completed in Year 0, with uniform savings throughout the study period. To make use of existing equipment and avoid unnecessary supplemental replacement costs within the project lifetime, the existing domestic hot water heater, floodwater heaters, and ice resurfacer are replaced in Year 5. Residual values for incumbent equipment are assumed in Year 1 and 5, respectively.

To accommodate the 5-year timeline, one deviation between this Pathway and Pathway 3 is that this Pathway contains no condensing air handling unit; instead, the transition is made directly to an electric unit. As a condensing AHU is pending with the Township's GICB application, this change would need to be addressed with all applicable parties to ensure acceptance.

Advantages

- Maximum cumulative GHG emission reduction over the 20-year study period
- Achieves full site electrification within 5-years
- Allows for net-zero carbon operation without purchasing carbon offsets

Disadvantages

- Requires ground mounted solar via a car canopy. The Township would like to avoid ground mounted arrays due to limited space and to allow flexibility for future development
- Significant overhaul of existing HVAC Systems and electrical infrastructure
- Requires replacing some equipment prior to end-of-life
- May cause issues with the ongoing GICB application by altering plans for a condensing AHU for an electric model in Year 0
- Increased operating costs over the project life cycle due to increased electrification

Implementation, Scheduling, and Logistics

Year 1:

Capital projects already completed:

- 2022 Brine Pump Replacement/Upgrade
- 2022 LED Lighting Retrofit

- 2021 Domestic Hot Water Heater Replacement

Capital projects in planning:

- Compressor Upgrades
- Condenser Replacement
- Electric In-Floor Boiler
- Electric Air Handling Unit
- Dehumidifier Replacement
- Metal Roof Replacement

Additional required/recommended capital projects:

- 380 kW Rooftop Solar PV Array with On-Site Battery Storage
    - Includes roof replacement and structural upgrades
- 238 kW Ground Mounted Solar PV Array
- REALice Precision Floodwater Treatment
- Programmable Thermostats
- Air Curtain
- Zamboni Room Electric Heaters
- Spectator Seating Electric Radiant Heaters
- Electric Floodwater Heaters
- Office Heat Pump
- John C. Cleary Media Room Heat Pump

Year 5:

- Electric Ice Resurfacer
- Electric Floodwater Heaters
- Electric Domestic Water Heaters
- Carbon Credits to reach 100% GHG Emissions Reduction

Phase 3 (Years 6 through 20):

- Electric Floodwater Heaters Replacement
- Electric Domestic Water Heaters Replacement

Performance and Lifecycle Cost Analysis (LCCA) Results

Table 27 - Pathway 4 LCCA Results

LCCA (20 year period)	Unit	P4
Total Construction Cost:	$CAD	$3,804,907.81
Incentives and Grants:	$CAD	$2,355,927.75
NPV	$CAD	**$825,464.64**
IRR	-	**9.5%**

All remaining considerations for this Pathway 4 are identical to those provided previously for Pathway 3, as these summaries are provided at the end of the project life, assuming all retrofits have been initiated.

Energy Modelling Results

Energy modelling results for this Pathway are identical to those found in Pathway 3.

Measurement and Verification

Measurement and Verification (M&V) is an essential component of energy retrofits, ensuring that the energy savings and performance improvements achieved through the project are accurately measured and verified. The International Performance Measurement and Verification Protocol (IPMVP) outlines four options for Measurement and Verification (M&V) of energy savings and performance improvements. These options are: Option A - Partially Measured Retrofit Isolation, Option B – Retrofit Isolation, Option C: Whole Building, and Option D – Calibration Simulation.

The retrofit of the Long Sault Arena will involve numerous overlapping projects. Given this overlap, Option C, which relies upon whole facility utility data is not the recommended option for performing M&V on individual projects.

Options A and B are typically used for retrofits that are not typically seasonally or weather dependent, allowing for M&M of these measures to be completed in a few weeks. One measure for which M&V can be performed using Option A is the LED lighting retrofit.

As the vast majority of proposed measures cannot be measured individually as well as the overlap between projects, the overall M&V plan for the facility will be through Option C – Whole Facility. At minimum, upon completion of all projects a 12-month utility bill analysis should be performed to allow for savings to be calculated.

To provide further M&V of retrofits and optimize the on-site battery storage, it is recommended that the Township look to incorporate ongoing monitoring and analysis. Ongoing monitor and analysis is recommended to include sub-metering of large electricity consuming equipment, such that the on-site battery storage can be optimized to provide maximum cost savings, emissions reductions, and energy security. Should the Township look to incorporate ongoing measurement and analysis at the Long Sault Arena or additional municipal facilities, funding is available through the Federation of Canadian Municipalities for such projects.

Additional Considerations

Future Building Expansion

Although no confirmed plans are in place to expand the Long Sault Arena, community engagement found through the Township's 2019 'Parks and Recreation Master Plan' yielded feedback from the community that an expansion to the facility would be encouraged. As such, this report was completed to allow flexibility to future expansions of the facility.

Logistics of Implementation

At the time of writing this report an accurate timeline for the implementation of any of the four Pathways cannot be quantified due to limitations of available information. To ensure an accurate timeline, information not available at this time and outside of the scope of the report would be required, such as: equipment lead time, contractor availability, length of the tendering process, lead time for net-metering agreement, and seasonal schedules/requirements of the facility.

Regardless of the selected Pathway, considerable efforts will be made to develop a timeline and schedule that accommodates all stakeholders. It is crucial for the project to prioritize allowing sufficient time after completion for proper commissioning and training of the building staff. Given the ice hockey season of September through May, it may be required that many retrofits are completed during the short offseason to avoid impacting typical facility operations. This short offseason may limit the number of projects that can be completed on an annual basis. When finalizing the implementation schedule priority should be given to those measures required sooner, and/or with a larger impact on energy consumption and emission reductions, among other.

Climate Change Impact

With global average temperatures continuing to rise, the number of heating degree days can be expected to continue to decrease, while the number of cooling degree days can be expected to continue to increase.

As can be seen in the seasonal fluctuations of both utility data and data from the calibrated energy model, the electricity consumption of the facility can be seen to peak during the warmer months of the hockey season, and decrease during the colder months. Should global temperatures continue to rise the electrical consumption of the ice plant can be expected to increase accordingly.

Separately, summer electricity consumption can be forecast to increase due to an increased cooling load.

Utility Projections

Historically, utility rates have been seen to increase year-over-year for Ontario consumers. These rate increases can be caused by any of a number of factors including infrastructure investments, generation costs, transmission and distribution costs, regulatory and policy changes such as the federal carbon tax, and inflation and operating costs.

Electricity Rate and Projections

Electricity rates have historically risen year-over-year and will continue to do so. Annual electricity rate increases of 5.9% per year have been incorporated into life cycle cost analyses within this report.

The Ontario electricity grid can be considered a clean electricity grid with a range of diverse resources such as nuclear, hydro, natural gas, and renewables such as solar and wind. Per the Independent Electricity System Operator (IESO)[2], as of October 2021 the Ontario electricity gride is 94% emissions-free. Power data available through the IESO[3] shows that as of 2021 the majority of generation capacity within the province is, in order: nuclear, natural gas, hydro, wind, then solar and other renewables. Despite the available capacity, for 2021 the energy generation of the Ontario electricity gride was met by, in order: nuclear, hydro, natural gas, wind, then solar and other renewables. Given this clean generation mix, per the Government of Canada as of July 2022 the Ontario electricity grid boasts the third lowest electricity emissions factor in Canada at 28 g CO_2e/kWh.

When conducting a long-term energy and emission forecast, it is important to consider the projected emissions factor of the applicable electricity grid. Despite a strong performance of the past decade, the future of Ontario's electricity grid remains quite unclear at the time of writing this report. With aging low-carbon nuclear infrastructure, many project that a potential decrease in nuclear generation would require significant increases in natural gas consumption, significantly increasing the grid's emission factor[8].

Documentation available through The Atmospheric Fund[4] shows the projected Ontario grid emission factor rising to 91 g CO_2 e/kWh by 2025, and remaining at an average of 88 g CO_2 e/kWh through 2040. This projected spike in emissions factor is again caused by a projected increase in natural gas electricity generation within the province. It should be noted that in 2021 this documentation projected an Ontario grid emission factor of 70 g CO_2 e/kWh for the year 2023, more than double the realized accepted value of the year.

The future of the Ontario electrical grid emissions factor is unclear through publicly available information available at the time of writing this report. The emissions factor of the Ontario grid is dependent on various factors, including energy generation mix, policy decisions, technological advancements, and market dynamics. Given unclear projections available for the emissions factor, this report is completed using the current grid emission factor of 28 g CO_2 e/kWh, however this report is designed to be flexible for future adjustments.

Natural Gas Rates, Projections, and the Federal Carbon Tax

In Canada, carbon taxes are a policy tool implemented to reduce greenhouse gas emissions and address climate change. The specific details and implementation of carbon taxes can vary among provinces and territories, as they have the autonomy to design and implement their own carbon pricing systems. However, the following is a generate overview of how carbon taxes work in Canada.

- Pricing Carbon Emissions:
    - The government sets a price per tonne of carbon dioxide equivalent, which represents the emissions resulting from the burning of fossil fuels. This price is intended to reflect the social and environmental costs associated with carbon emissions.
- Taxation Point:
    - The carbon tax is typically applied at the point of production, distribution, or importation of fossil fuels, such as gasoline, diesel, natural gas, and coal. This means that the tax is levied on fuel producers, distributors, or importers.
- Payment and Cost Transfer:
    - Fuel producers, distributors, or importers are required to pay the carbon tax based on the amount of carbon emissions associated with their products. They bear the initial cost of the tax, but it can be transferred to consumers through higher fuel prices.
- Revenue Allocation:
    - The revenue generated from carbon taxes can be used in various ways, depending on the specific policies of each province or territory. Common approaches include:
        - a. Investments in Green Initiatives: The revenue can be invested in renewable energy projects, energy efficiency programs, or research and development of clean technologies.
        - b. Rebates and Tax Breaks: Some provinces choose to provide direct rebates or tax breaks to individuals, households, or businesses to help offset the increased fuel costs resulting from the carbon tax.

        - c. Climate Action Programs: The revenue may be allocated to fund climate change mitigation and adaptation measures, such as public transportation improvements or support for sustainable agriculture practices.
- Incentives for Emission Reductions:
    - By placing a price on carbon emissions, carbon taxes create economic incentives for individuals, businesses, and industries to reduce their carbon footprint. The higher cost of carbon-intensive fuels encourages the adoption of cleaner energy sources, energy efficiency measures, and investments in low-carbon technologies.

It's important to note that the specific rates, implementation mechanisms, and revenue allocation methods of carbon taxes can differ among provinces and territories in Canada.

The carbon tax in Canada has increased gradually over time. In 2019, the federal Government implemented a national minimum price on carbon pollution beginning at $20 per tonne of carbon equivalent in 2019, increasing at $10 per tonne per year, until reaching $50 per tonne in 2022. Since then, the federal government have announced that the carbon tax will continue to increase at a rate of $15 per tonne per year effective 2023 through 2030, resulting in a price of $170 per tonne of carbon equivalent[5].

For the forward projections of the Long Sault Arena completed with this report, future carbon tax increases were accounted for via a 5% increase in the cost of natural gas. This estimation was made using data[6] available from Enbridge Gas, the facility's natural gas utility provider. Per this data, natural gas prices can be seen projected to increase at a rate of 5% per year through 2030 when carbon tax increases are currently scheduled to reach their maximum.

It is important to note that this 5% increase only reflects price increases due to projected carbon taxes. To account for additional considerations such as inflation and other potential expenditures, an annual increase of 7% per year has been incorporated into life cycle cost analyses within this report.

Energy Security and Emergency Preparedness

It was established early in the pre-feasibility analyses of deep energy retrofits within the Township that establishing an emergency location within the Township with on-site energy generation and/or energy storage should be thought of as a priority. This decision was integral in the Township's decision to pursue a rooftop solar PV array with on-site battery storage. Although additional considerations may be required in future to further adapt the facility to serve the needs of the community during times of emergency, the incorporation of this renewable energy generation and storage system is a consideration step towards establishing this goal.

Fuel Switching

As mentioned throughout this report the Long Sault Arena consumes natural gas as part of the daily operations. Given the high emissions factor of natural gas when compared to the Ontario electricity grid, opportunities to fuel switching from natural gas to electricity should be the top priority for projects targeting net-zero operations. Per the Government of Canada at the time of writing this report the Ontario Grid Emissions Factor is 28 gCO_2e/kWh of electricity provided by the Ontario Grid, compared to an emissions factor of roughly 187 gCO_2e/kWh for energy produced by the combustion of natural gas.

Financially, fuel switching to electricity can be expected to increase operating costs given the current pricing and future price forecasts for electricity in Ontario.

Furthermore, when considering fuel shifting a significant amount of natural gas consumption to electricity, it is important to understand this will significantly increase the electrical load of the facility. This increase may have impacts this may have on existing electrical infrastructure within the facility, and potentially require modifications to accommodate the increased load. For pathways referencing a full facility fuel switch, costs have been included to account for required modifications to the existing electrical infrastructure. Specifically, to accommodate these changes the existing 400A-600V service must be upgraded to a 1200A-600V service. This would require a new pad mounted transformer and switchgear.

Summary, Recommendations, and Next Steps

Next Energy Development Group Inc. has completed the Long Sault Arena GHG Reduction Pathway Feasibility Study for the Township of South Stormont. This report quantified the technical and financial feasibility of performing a deep energy retrofit on the Long Sault Arena via the development of a 20-year plan for the facility with a net-goal of achieving net-zero operation.

Through this study the Township has: conducted an energy audit of the Long Sault Arena, developed a calibrated energy model of the facility, and quantified four ‘pathways’ which would allow the arena to experience a 50% reduction in greenhouse gas (GHG) emissions within 10 years, and an 80% GHG reduction within 20 years when compared to baseline consumption. The net-objective was to target pathways to net-zero operation at the facility. This report outlines the processes taken to achieve the above objectives, as well as the results.

This report quantified four deep energy retrofit pathways which would allow the Township to achieve net-zero operations at the Long Sault Arena. Each Pathway includes a variety of energy conservation and emission reduction measures targeted towards reaching the goal of net-zero operation. Additionally, three of the four pathways include a proposed rooftop photovoltaic system with on-site battery storage. Rooftop solar generation with on-site battery storage was selected as a focal point of these Pathways in order to: transition to renewable generation, capitalize on the available solar resource, aid in the potential for full site electrification, capitalize on Hydro One's Net Metering program, and advance the opportunity for the Township to use the facility as an emergency shelter.

In addition to quantifying the deep energy retrofit potential at the Long Sault Arena, this report is intended to provide the Township and all other interested parties with guidance and insight into how to achieve cost effective deep energy retrofits, reduce GHG emissions, and increase environmental stewardship. This report and its contents were generated using replicable processes based on industry best practices and standards, as well as generous contributions from various Township staff and industry professionals. Many of the processes used in this report can be replicated to analyze energy performance and retrofit potential at a wide variety of facilities. Lessons learned throughout this project are believed to have increased the internal capacity of the Township to undertake projects of a similar nature in future.

At the time of writing this report, substantial funding opportunities exist through various government programs to offset the financial requirements of implementing the selected GHG reduction pathway, and/or select energy efficiency upgrades identified in this report. In February 2023 the Township applied to Infrastructure Canada's Green and Inclusive Community Buildings program in hopes of receiving up to 80% of eligible project costs for all ECMs included in the application. Further funding is available through the Federation of Canadian Municipality's 'Green Municipal Fund' should the Township look to proceed with implementing the identified pathway. Additional retrofit rebates are available on a component specific nature through various utility providers.

In-line with the Township's established environmental and financial goals, it is recommended that the Township continue to pursue measures that will allow the Long Sault Arena to operate as efficiently as possible, minimizing operating costs, consumption, and greenhouse gas emissions.

Should funding become available, it is recommended that the Township pursue Pathway #2 – GICB / Optimize Existing. This Pathway is recommended as, if implemented, it would provide the Township with the plans to: achieve a substantial decrease in operating greenhouse gas emissions reductions (47.5%), achieve net-zero operation through the purchase of carbon offsets, improve efficiencies and environmental stewardship, and provide energy security for the local community. This Pathway would allow the Township to meet all of these goals all while addressing the short- and long-term needs of the facility in a cost-effective manner. This selected Pathway is the most cost-effective solution for the Township; by maximizing the financial benefits of this project, the Township would increase available funding as it continues to target ways to further reduce costs, consumption, and emissions across the entire municipal fleet.

It is further recommended that the Township look to pursue a green building certification such as Zero Carbon Building (ZCB) or Leadership in Energy and Environmental Design (LEED), in order to garner the recognition that comes with the certification, and promote environmental stewardship to the local and neighbouring communities.

Should the Township experience budget constraints related to this project, it is recommended that the Township closely examine the financial viability of individual energy conservation measures to maximize GHG emission reduction with available budget. Additionally, it is recommended that this report is referenced when replacing end-of-life equipment to identify and pursue energy efficient replacement options.

Table 28 below summarizes the key financial, energy, and GHG considerations for each analyzed Pathway.

Table 28 - Summary of GHG reduction pathways

Annual GHG emission reductions in the table below include all means of avoided emissions, less the purchase of carbon credits.

Pathway	Total Construction Costs	Incentives and Grants	Annual Energy Costs (Year 1)	Annual Cost Savings	Annual Energy Consumption [GJ]	Annual Energy Savings	Annual GHG Emissions	Annual GHG Emissions Reduction	NPV	IRR
P1 - Like-for-Similar	$1,345,339.13	$19,833.00	$112,962.75	11.9%	3,196.56	8.00%	93,755.98	3.2%	-$824,801.85	-4.0%
P2 - GICB / Optimize Existing	$2,809,784.13	$2,176,306.65	$103,374.96	17.1%	2,594.80	25.30%	50,883.71	47.5%	$1,513,290.25	17.8%
P3 -Full Electrification	$3,842,407.81	$2,362,427.75	$144,631.11	-23.0%	2,660.56	23.40%	10,386.66	99.9%	$1,072,432.85	11.8%
P4 - Full Electrification - Five Year Short Term Deep Retrofit	$3,804,907.81	$2,355,927.75	$144,631.11	-23.0%	2,660.56	23.40%	10,386.66	99.9%	$825,464.64	9.5%

Annual GHG emission reductions in Table 28 above include all means of avoided emissions, less the purchase of carbon credits. For all Pathways, the purchase of carbon credits is included to achieve net-zero operation.

References

[1] E. and C. C. Canada, “Government of Canada,” Canada.ca, https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/output-based-pricing-system/federal-greenhouse-gas-offset-system/emission-factors-reference-values.html (accessed Jun. 12, 2023).

[2] Independent Electricity System Operator, Decarbonization and Ontario’s Electricity System, Oct. 2021.

[3] “Ontario’s electricity grid,” Supply Mix and Generation, https://www.ieso.ca/en/Learn/Ontario-Electricity-Grid/Supply-Mix-and-Generation (accessed Jun. 12, 2023).

[4] The Atmospheric Fund, A Clearer View of Ontario’s Emissions, 2021.

[5] E. and C. C. Canada, “Government of Canada,” Canada.ca, https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/carbon-pollution-pricing-federal-benchmark-information.html (accessed Jun. 12, 2023).

[6] “Federal Carbon Charge,” Enbridge, https://www.enbridgegas.com/en/residential/my-account/rates/federal-carbon-charge (accessed Jun. 12, 2023).

Appendices

APPENDIX A – Assessment Methodology

Site Visits: The primary site visit consisted of a guided tour of the facility, led by the facility operator, as well as a detailed interview with the facility operator. All zones were examined, and all energy consuming equipment was documented. Supplemental site visits and communications with facility staff were completed to fill in any gaps discovered during the audit process.

Utility Analysis: Historical utility data was collected and reviewed to quantify a baseline consumption model of the facility. This baseline model allows the audit team to ensure understanding of the energy profile of the facility, and have a baseline to which energy conservation measures can be referenced.

Envelope System Assessment: The envelope of the facility was examined via non-destructive visual inspection, a review of all available facility drawings, and interviews with facility staff.

Mechanical and Electrical System Assessment: All mechanical and electrical assessments consist of collecting a detailed inventory of all mechanical and electrical consuming equipment, and operating profiles as determined via interviews with facility staff, and industry best practices. Where applicable or required drawings, case studies, and manufacturer specification sheets were reviewed.

Energy and Cost Assessment: All collected equipment and operational data was analyzed to create a baseline energy model using DesignBuilder. The generated energy model was calibrated against utility data to ensure accuracy of results. All electricity and natural gas consumption modelled was calibrated in adherence with ASHRAE 14 standards.

Energy savings calculations were calculated using RETScreen Expert unless otherwise specified in the report above.

Costs associated with implementing ECMs are estimated based on capital cost for materials and labour, and are determined from previous experience, published cost estimates, relevant reports, and quotes provided from applicable suppliers.

Recommendations: Recommendations were put forward based on environmental and cost benefits, and component expected end-of-lives.

APPENDIX B – Modelling Methodology

DesignBuilder was used to generate a calibrated whole building energy model. DesignBuilder is an industry valid energy modelling software, trusted globally. DesignBuilder is a building performance simulation software tool that is used to model, analyze, and optimize the energy performance of buildings. It is a user-friendly software platform that allows architects, engineers, and energy consultants to create detailed models of buildings and simulate their energy performance using a variety of parameters and inputs.

DesignBuilder Expert uses typical weather data along with user input data describing the facility to generate a baseline and proposed energy model of the facility. User input data includes a comprehensive overview of the building's energy profile including: building envelope materials, HVAC equipment, lighting, electrical equipment, plug loads, process loads, and occupancy profiles.

Equipment specifications and operating profiles, and whole building occupancy profiles were determined and are described in APPENDIX D.

Annual and monthly baseline electricity and natural consumption was taken as the average of the three annual and monthly averages found for the baseline period of 2017 through 2019, respectively. Weather normalized data could not be used as the consumption of the facility is primarily correlated to the ice hockey season as opposed to the regional climate. Although consumption is correlated to the regional climate, using weather normalized data would cause significant variance in the warmer months of the ice hockey season, namely September, April, and May.

To ensure the validity of the energy model, the baseline model was calibrated against available utility data and known independent variables such as weather, and occupancy schedule. The facility's baseline consumption was compared to the energy model's baseline consumption output both visually and analytically. All variances were kept to within 5% in adherence with ASHRAE 14 standards.

Summary of Energy Consumption				
	Electricity [kWh]	Variance from Calibrated Model	Natural Gas [m^3]	Variance from Calibrated Model
2017	530,640.00	1%	42,886.42	0%
2018	518,172.00	-1%	39,114.22	-9%
2019	519,600.00	-1%	42,012.41	-2%
Baseline	522,804.00	0%	41,337.68	-4%
Calibrated	524,999.00	N/A	42,791.84	N/A

APPENDIX C – Tabulated Utility Data

		Electricity			Natural Gas	
Year	**Month**	**Consumption [kWh]**	**Peak Demand [kW]**	**Cost [$]**	**Consumption [m^3]**	**Cost [$]**
2017	January	71,040.00	155	$ 11,360.20	6,727.34	$ 2,473.30
2017	February	45,840.00	159	$ 9,907.62	7,607.05	$ 2,793.21
2017	March	47,280.00	159	$ 9,257.62	6,300.30	$ 2,327.02
2017	April	55,200.00	155	$ 9,047.82	3,348.01	$ 1,267.11
2017	May	25,200.00	156	$ 6,587.43	1,010.67	$ 401.23
2017	June	14,880.00	45	$ 3,318.64	170.82	$ 86.70
2017	July	16,320.00	46	$ 3,353.42	153.74	$ 82.48
2017	August	15,120.00	44	$ 3,281.58	575.08	$ 249.13
2017	September	67,680.00	159	$ 14,701.11	1,252.66	$ 506.71
2017	October	65,040.00	156	$ 12,168.17	2,895.35	$ 1,122.37
2017	November	54,000.00	155	$ 11,202.32	4,609.21	$ 1,770.91
2017	December	53,040.00	154	$ 9,645.62	8,236.22	$ 3,136.97
2018	January	59,040.00	166	$ 11,164.89	6,932.32	$ 2,645.80
2018	February	54,516.00	155	$ 9,147.04	5,585.71	$ 2,167.28
2018	March	50,676.00	152	$ 8,869.48	5,449.06	$ 2,043.92
2018	April	52,356.00	151	$ 9,929.88	3,459.04	$ 1,193.10
2018	May	22,116.00	152	$ 5,706.53	563.70	$ 215.78
2018	June	10,356.00	33	$ 2,449.60	145.19	$ 71.66
2018	July	10,116.00	32	$ 2,024.98	133.81	$ 67.71
2018	August	10,836.00	40	$ 2,105.94	418.50	$ 166.13
2018	September	63,360.00	159	$ 10,836.92	1,506.04	$ 528.74
2018	October	66,240.00	168	$ 14,191.41	3,242.67	$ 1,092.37
2018	November	57,840.00	164.16	$ 12,342.77	4,962.23	$ 1,657.35
2018	December	60,720.00	161.04	$ 11,052.88	6,715.95	$ 2,274.04
2019	January	51,840.00	160.56	$ 8,489.83	7,663.98	$ 2,725.43
2019	February	47,760.00	142.56	$ 9,191.03	7,137.30	$ 2,540.01
2019	March	48,720.00	153.36	$ 8,746.53	5,400.66	$ 1,881.76
2019	April	52,560.00	145.68	$ 8,789.79	3,413.49	$ 1,112.02
2019	May	20,880.00	155.76	$ 6,390.70	791.45	$ 277.96
2019	June	10,320.00	36.24	$ 2,363.82	193.59	$ 84.82
2019	July	11,760.00	37.2	$ 2,851.92	179.36	$ 80.40
2019	August	14,160.00	53.52	$ 2,665.73	481.13	$ 190.42
2019	September	75,360.00	159.6	$ 15,029.91	1,594.29	$ 544.02
2019	October	62,400.00	158.16	$ 16,316.28	3,034.85	$ 965.35
2019	November	57,600.00	154.56	$ 11,342.80	5,876.10	$ 1,849.27
2019	December	66,240.00	156.24	$ 11,105.68	6,246.20	$ 1,989.58

APPENDIX D – Equipment Schedules

Heating							
Component	**Zone**	**Manufacturer**	**Model Number**	**Capacity**	**Energy Source**	**Efficiency**	**Quantity**
AHU-1 (Air Handling Unit)	1, 2, 3	Engineered Air	DJ-40	400,000 BTU	Gas	78%	1
Spectator Radiant Heaters	8	ecoSchwank	ecoSchwank 13	50,000 BTU	Gas	N/A	6
Gas Space Heater	9	N/A	N/A	~ 80,000 BTU	Gas	~ 80%	1
Electric Space Heater	10	N/A	N/A	5 kW	Electricity	100%	1
Furnace-1	4	Keeprite	N9MSE0601 410A	60,000 BTU	Gas	96.7%	1
Furnace-2 w/ Heat Recovery Ventilator	5, 11	Keeprite	G9MXE1202 422A1	120,000 BTU	Gas	97.5%	1
In-Floor Heating	6	Well-Mclain	Ultra	N/A	Gas	~93%	1

Cooling							
Component	**Zone**	**Manufacturer**	**Model Number**	**Capacity**	**Energy Source**	**COP**	**Quantity**
AC-1	4	ICP	CA5018QKB1	1.5 RT	Electricity	2	1
AC-2	5	ICP	CA5542QKA1	3.5 RT	Electricity	2	1

Ventilation							
Component	**Zone**	**Manufacturer**	**Model Number**	**CFM**	**Motor HP**	**Year**	**Quantity**
Furnace-1 Exhaust Fan	4	Keeprite	N9MSE0601410A	385	0.5	2014	1
Furnace-2 Exhaust Fan	5, 11	Keeprite	G9MXE1202422A1	385	1	2014	1
AHU-1 Exhaust Fan	1, 2, 3	N/A	N/A	N/A	N/A	1994	1
Arena Exhaust Fans	7	Penn Ventilator Co., Inc.	N/A	4,677	0.5	1994	2
Spectator Exhaust Fans	9	N/A	N/A	N/A	N/A	N/A	2
F4, F8	1, 2, 3, 4, 5	Penn Ventilator Co., Inc.	N/A	500	0.25	1994	2
F6, F7, F13	1, 2, 3, 4, 5	Penn Ventilator Co., Inc.	N/A	100	N/A	1994	3
F11	1, 2, 3, 4, 5	Penn Ventilator Co., Inc.	N/A	385	0.14	1994	1

Water Heating Equipment Schedule								
Unit	**Location**	**Purpose**	**Year**	**Quantity**	**Manufacturer**	**Model**	**Size**	**Efficiency**
DHW-0	New Addition	DHW	N/A	1	N/A	N/A	N/A	~70%
DHW-1	New Addition	DHW	2021	1	Triton	GHE80SU-160	160,000 BTU	98%
DHW-2	Zamboni Room	Floodwater Heating	2014	2	AO Smith	BTH 120 200	120,000 BTU	85%

Ice Plant Equipment Schedule

Description	Manufacturer	Model	Qty	Location	Installed	Condition
Compressor	MYCOM	N6WA	2	Chiller Room	1993	Poor
Motor #1	TECHTOP	GRA0504F-01	1	Chiller Room	2022	Poor
Motor #2	VENTPAK	HKH62	1	Chiller Room	N/A	Good
Chiller	Alfa Laval	MK15-BWFD	1	Chiller Room	2016	Good
Surge Drum	CIMCO	N/A	1	Chiller Room	2016	Good
Cold Pump	CIMCO	6X4X10	1	Chiller Room	2010	Good
Jacket Cooling Pump	ARMSTRONG	1.5X1.5X8 4380	1	Chiller Room	2015	Good
Condenser	Baltimore	Air Coil VC1-100	1	Rooftop	2009	Poor
Brine Pump	N/A	N/A	1	Chiller Room	2022	Good
Ice Resurfacer	Zamboni	446	1	Zamboni Room	2022	Good

Lighting Schedule

Incumbent

Lamp	Model	Wattage [W]	Ballast	Ballast Wattage
1 Lamp Strip HO	Strip	48	Electronic	13 W
2 Lamp Strip	Strip	56	Electronic	13 W
2x4 Troffers	Troffer	112	Electronic	13 W
2 Lamp	Troffer	56	Electronic	13 W
8 ft Strips	Strip	112	Electronic	13 W
6 Lamp T5	Highbay	340	Electronic	13 W

Potlights	CFL	69	Electronic	13 W
Shower	CFL	69	Electronic	13 W
Replacement				
4 ft Strip LED	LED	37	N/A	N/A
2x2 Flat Panel	LED	30	N/A	N/A
2x4 Flat Panel	LED	36	N/A	N/A
1x4 Flat Panel	LED	30	N/A	N/A
100W Highbay	LED	100	N/A	N/A
150W Highbay	LED	150	N/A	N/A
Pot Lights	LED	9	N/A	N/A
Shower Lights	LED	9	N/A	N/A
Other				
Exterior Lighting	LED	12	N/A	N/A
Exit Lights	LED	10	N/A	N/A

Plug Load Schedule						
Description	**Location**	**Manufacturer**	**Model**	**Quantity**	**Phase**	**Demand**
Dehumidifier-1	Arena	Dry Solutions	Smart-Dry-2000	1	3	17.67
Dehumidifier-2	Arena	ARID-ICE	MS-2600	1	3	13
Score Board	Arena	N/A	N/A	1	1	0.4
Floor Polisher	Arena	N/A	N/A	1	1	0.56
Arena Clock	Arena	N/A	N/A	1	1	0.4
Scoreboard	Arena	N/A	N/A	1	1	0.05
Garage Motor	Arena/Zamboni Room	N/A	N/A	3	1	0.375
Hot Chocolate Machine	Canteen	Bunn	N/A	1	1	1.8
Glass Fridge	Canteen	Habco	ESM28	1	1	1.15
Slushee Machine	Canteen	Slush Puppie	N/A	1	1	1.2
Coffee Machine	Canteen	BUNN	VPR-C	1	1	1.400
Hot Dog Machine	Canteen	Great Northern Pop Corn Company	83-DT5385	1	1	1.170

Popcorn Machine	Canteen	Cretors	GR6A1X-XX-X	1	1	1.150
Nacho Cheese Dispenser	Canteen	Ricos	5300	1	1	0.225
Keurig	Canteen	Keurig	N/A	1	1	0.5$_{\text{average}}$
Kettle	Canteen	Kettle	N/A	1	1	1.5
Microwave	Canteen	N/A	N/A	1	1	1
TV	Lobby	N/A	N/A	2	1	0.147
Refrigerated Vending Machine	Lobby	Crane Merchandising	BevMax	1	1	1.65
Energy Star Vending Machine	Lobby	Crane National Vendors	147	1	1	0.36 (4.2 kWh per day)
Automated Siding Doors	Lobby	N/A	N/A	2	1	0.19
ATM	Lobby	N/A	N/A	1	1	0.145
Cooled Drinking Fountain	Lobby	Elkay Manufacturing Co.	LVRCWS	1	1	0.115
Server	Offices	N/A	N/A	1	1	0.5
Desktop	Offices	N/A	N/A	4	1	0.2
Printer	Offices	Toshiba	eStudio	1	1	1.5
Monitor	Offices	N/A	N/A	7	1	0.02
Desk Phone	Offices	N/A	N/A	5	1	0.003
Security System	Offices	N/A	N/A	1	1	0.006
Refrigerator	John C. Cleary Music Room	Frigidaire	FFTR1821TW0	1	1	0.69
Projector	John C. Cleary Music Room	N/A	N/A	1	1	0.1
Compressor	Zamboni Room	Dewalt	N/A	1	1	1.2
Ceiling Fan	Zamboni Room	N/A	N/A	1	1	0.075
Mini Fridge	Zamboni Room	MasterChef	N/A	1	1	0.09
Grinder	Zamboni Room	TradeMaster	6” Bench Grinder	1	1	0.5
Welder	Zamboni Room	N/A	N/A	1	1	3.0
Clock Radio	Zamboni Room	N/A	N/A	1	1	0.01
Floor Polisher	Zamboni Room	N/A	N/A	1	1	0.560

APPENDIX E - General Facility Maintenance 20 Year Projection

General Facility Maintenance Projection										
	Budget Forecast									
Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Budget	$ 1,164,900.00	$ 12,500.00	$ 10,600.00	$ 30,500.00	$ 2,000.00	$ 886,700.00	$ 98,200.00	$ -	$ -	$ 52,800.00
Year	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Budget	$ 122,700.00	$ 286,700.00	$ 4,800.00	$ 37,648.00	$ 36,800.00	$ -	$ 179,200.00	$ 54,800.00	$ 25,000.00	$ -

APPENDIX F – Life Cycle Cost Analyses

Pathway 1

Life Cycle Cost Analysis (LCCA)

Initial Investment and Equipment

Year	0	1	2	3	4	5	6	7	8	9	10
Initial Investment											
Initial Investment [$]	-$ 1,140,287.13										
Funding											
GICB [$]		$ -									
CBR - Capital Projects (Grant Portion Only) [$]		$ 19,833.00									
Total Funding [$]		$ 19,833.00									
Ongoing Cash Flows											
Replacement Costs [$]		-$ 10,000.00	$ -	$ -	-$ 45,000.00	$ -	-$ 5,600.00	$ -	$ -	$ -	-$ 41,817.00
O&M Costs [$]		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Residual Value [$]		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Energy Savings, Generation, and Consumption											
Savings											
Electricity Savings [kWh]		64,412.00	64,412.00	64,412.00	64,412.00	64,412.00	64,412.00	64,412.00	64,412.00	64,412.00	64,412.00
NG Savings [m3]		609.08	609.08	609.08	609.08	609.08	609.08	609.08	609.08	609.08	609.08
Generation											
Renewable Energy Generation [kWh]	-	-	-	-	-	-	-	-	-	-	-
Direct Renewable Energy Consumption [kWh]	-	-	-	-	-	-	-	-	-	-	-
Net-Metering Credits Accrued [kWh]	-	-	-	-	-	-	-	-	-	-	-
Consumption											
Net Remaining Consumption - Electricity [kWh]		460,587.00	460,587.00	460,587.00	460,587.00	460,587.00	460,587.00	460,587.00	460,587.00	460,587.00	460,587.00
Net Remaining Consumption - Natural Gas [m3]		42,182.76	42,182.76	42,182.76	42,182.76	42,182.76	42,182.76	42,182.76	42,182.76	42,182.76	42,182.76
Carbon Budgets											
Emissions											
Net Remaining Emissions [kg CO2e]		93,929.51	93,929.51	93,929.51	93,929.51	93,929.51	93,929.51	93,929.51	93,929.51	93,929.51	93,929.51
Rate											
Cost of Carbon Offset (average) [$/kg CO2e]		$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02
Expense											
Carbon Offsets Required [$]		$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59
Cost Savings											
Electricity Cost Savings [$]		$ 13,349.15	$ 14,136.75	$ 14,970.82	$ 15,854.09	$ 16,789.49	$ 17,780.07	$ 18,829.09	$ 19,940.01	$ 21,116.47	$ 22,362.34
Natural Gas Cost Savings [$]		$ 226.47	$ 242.33	$ 259.29	$ 277.44	$ 296.86	$ 317.64	$ 339.87	$ 350.07	$ 360.57	$ 371.39
Direct Renewable Electricity Cost Savings [$]		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Net Metering Credits [$]		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Annual Utility Savings [$]		**$ 13,575.62**	**$ 14,379.07**	**$ 15,230.10**	**$ 16,131.53**	**$ 17,086.35**	**$ 18,097.71**	**$ 19,168.96**	**$ 20,290.08**	**$ 21,477.04**	**$ 22,733.73**
Yearly Cash Flow											
Present Value	-$ 1,140,287.13	$ 23,408.62	$ 14,379.07	$ 15,230.10	-$ 28,868.47	$ 17,086.35	$ 12,497.71	$ 19,168.96	$ 20,290.08	$ 21,477.04	-$ 19,083.27
Overall Project Financials											
Project NPV	-$824,801.85										
IRR	-4.0%										

Year	11	12	13	14	15	16	17	18	19	20
Ongoing Cash Flows										
Replacement Costs [$]	$ -	$ -	-$ 86,835.00	$ -	$ -	-$ 15,800.00	$ -	$ -	$ -	$ -
O&M Costs [$]	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Residual Value [$]	$ -	$ -	$ -	$ 19,296.67	$ -	$ -	$ -	$ -	$ -	$ 251,707.22
Energy Savings, Generation, and Consumption										
Savings										
Electricity Savings [kWh]	64,412.00	64,412.00	64,412.00	64,412.00	64,412.00	64,412.00	64,412.00	64,412.00	64,412.00	64,412.00
NG Savings [m3]	609.08	609.08	609.08	609.08	609.08	609.08	609.08	609.08	609.08	609.08
Generation										
Renewable Energy Generation [kWh]	-	-	-	-	-	-	-	-	-	-
Direct Renewable Energy Consumption [kWh]	-	-	-	-	-	-	-	-	-	-
Net-Metering Credits Accrued [kWh]	-	-	-	-	-	-	-	-	-	-
Consumption										
Net Remaining Consumption - Electricity [kWh]	460,587.00	460,587.00	460,587.00	460,587.00	460,587.00	460,587.00	460,587.00	460,587.00	460,587.00	460,587.00
Net Remaining Consumption - Natural Gas [m3]	42,182.76	42,182.76	42,182.76	42,182.76	42,182.76	42,182.76	42,182.76	42,182.76	42,182.76	42,182.76
Carbon Budgets										
Emissions										
Net Remaining Emissions [kg CO2e]	93,929.51	93,929.51	93,929.51	93,929.51	93,929.51	93,929.51	93,929.51	93,929.51	93,929.51	93,929.51
Rate										
Cost of Carbon Offset (average) [$/kg CO2e]	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02
Expense										
Carbon Offsets Required [$]	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59	$ 1,878.59
Cost Savings										
Electricity Cost Savings [$]	$ 23,681.72	$ 25,078.94	$ 26,558.59	$ 28,125.55	$ 29,784.96	$ 31,542.27	$ 33,403.27	$ 35,374.06	$ 37,461.13	$ 39,671.33
Natural Gas Cost Savings [$]	$ 382.53	$ 394.01	$ 405.83	$ 418.00	$ 430.54	$ 443.46	$ 456.76	$ 470.47	$ 484.58	$ 499.12
Direct Renewable Electricity Cost Savings [$]	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Net Metering Credits [$]	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Annual Utility Savings [$]	**$ 24,064.25**	**$ 25,472.94**	**$ 26,964.42**	**$ 28,543.55**	**$ 30,215.50**	**$ 31,985.73**	**$ 33,860.03**	**$ 35,844.52**	**$ 37,945.71**	**$ 40,170.45**
Yearly Cash Flow										
Present Value	$ 24,064.25	$ 25,472.94	-$ 59,870.58	$ 47,840.22	$ 30,215.50	$ 16,185.73	$ 33,860.03	$ 35,844.52	$ 37,945.71	$ 291,877.67

Pathway 2

Life Cycle Cost Analysis (LCCA)

Initial Investment and Equipment

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Initial Investments																					
Initial Investment [$]	-$ 2,462,487.13																				
Funding																					
GICB [$]		$ 2,012,194.25																			
CBR - Capital Projects (Grant Portion Only) [$]		$ 164,112.40																			
Total Funding [$]		$ 2,176,306.65																			
Ongoing Cash Flows																					
Replacement Costs [$]		-$ 69,000.00	$ -	$ -	-$ 45,000.00	$ -	-$ 5,600.00	$ -	$ -	$ -	-$ 51,897.00	$ -	$ -	$ -	-$ 160,000.00	$ -	-$ 15,800.00	$ -	$ -	$ -	$ -
O&M Costs [$]		-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 45,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00	-$ 6,300.00
Residual Value [$]		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 19,296.67	$ -	$ -	$ -	$ -	$ -	$ 651,942.92
Energy Savings, Generation, and Consumption																					
Savings																					
Electricity Savings [kWh]		105,993.00	105,993.00	105,993.00	105,993.00	105,993.00	105,993.00	105,993.00	105,993.00	105,993.00	105,993.00	105,993.00	105,993.00	105,993.00	105,993.00	73,140.00	73,140.00	73,140.00	73,140.00	73,140.00	73,140.00
NG Savings [m3]		13,665.41	13,665.41	13,665.41	13,665.41	13,665.41	13,665.41	13,665.41	13,665.41	13,665.41	13,665.41	13,665.41	13,665.41	13,665.41	13,665.41	16,626.69	16,626.69	16,626.69	16,626.69	16,626.69	16,626.69
Generation																					
Renewable Energy Generation [kWh]		429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00	429,700.00
Direct Renewable Energy Consumption [kWh]		214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00
Net-Metering Credits Accrued [kWh]		214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00	214,850.00
Consumption																					
Net Remaining Consumption - Electricity [kWh]		204,156.00	204,156.00	204,156.00	204,156.00	204,156.00	204,156.00	204,156.00	204,156.00	204,156.00	204,156.00	204,156.00	204,156.00	204,156.00	204,156.00	237,009.00	237,009.00	237,009.00	237,009.00	237,009.00	237,009.00
Net Remaining Consumption - Natural Gas [m3]		29,126.43	29,126.43	29,126.43	29,126.43	29,126.43	29,126.43	29,126.43	29,126.43	29,126.43	29,126.43	29,126.43	29,126.43	29,126.43	29,126.43	26,165.15	26,165.15	26,165.15	26,165.15	26,165.15	26,165.15
Carbon Budgets																					
Emissions																					
Net Remaining Emissions [kg CO2e]		55,652.44	55,652.44	55,652.44	55,652.44	55,652.44	55,652.44	55,652.44	55,652.44	55,652.44	55,652.44	55,652.44	55,652.44	55,652.44	55,652.44	50,883.71	50,883.71	50,883.71	50,883.71	50,883.71	50,883.71
Rate																					
Cost of Carbon Offset (average) [$/kg CO2e]		$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02
Expense																					
Carbon Offsets Required [$]		$ 1,113.05	$ 1,113.05	$ 1,113.05	$ 1,113.05	$ 1,113.05	$ 1,113.05	$ 1,113.05	$ 1,113.05	$ 1,113.05	$ 1,113.05	$ 1,113.05	$ 1,113.05	$ 1,113.05	$ 1,113.05	$ 1,017.67	$ 1,017.67	$ 1,017.67	$ 1,017.67	$ 1,017.67	$ 1,017.67
Cost Savings																					
Electricity Cost Savings [$]		$ 21,966.66	$ 23,262.69	$ 24,635.19	$ 26,088.66	$ 27,627.90	$ 29,257.94	$ 30,984.16	$ 32,812.23	$ 34,748.15	$ 36,798.29	$ 38,969.39	$ 41,268.58	$ 43,703.43	$ 46,281.93	$ 33,820.90	$ 35,816.33	$ 37,929.50	$ 40,167.34	$ 42,537.21	$ 45,046.91
Natural Gas Cost Savings [$]		$ 5,081.14	$ 5,436.82	$ 5,817.40	$ 6,224.62	$ 6,660.34	$ 7,126.56	$ 7,625.42	$ 8,159.20	$ 8,730.34	$ 9,341.47	$ 9,995.37	$ 10,695.05	$ 11,443.70	$ 12,244.76	$ 15,941.06	$ 17,056.94	$ 18,250.92	$ 19,528.49	$ 20,895.48	$ 22,358.17
Direct Renewable Electricity Cost Savings [$]		$ 44,526.87	$ 47,153.95	$ 49,936.04	$ 52,882.26	$ 56,002.32	$ 59,306.45	$ 62,805.53	$ 66,511.06	$ 70,435.21	$ 74,590.89	$ 78,991.75	$ 83,652.27	$ 88,587.75	$ 93,814.43	$ 99,349.48	$ 105,211.10	$ 111,418.55	$ 117,992.25	$ 124,953.79	$ 132,326.06
Net Metering Credits [$]		$ 28,622.79	$ 30,311.53	$ 32,099.91	$ 33,993.81	$ 35,999.44	$ 38,123.41	$ 40,372.69	$ 42,754.68	$ 45,277.21	$ 47,948.56	$ 50,777.53	$ 53,773.40	$ 56,946.03	$ 60,305.85	$ 63,863.89	$ 67,631.86	$ 71,622.14	$ 75,847.85	$ 80,322.87	$ 85,061.92
Annual Utility Savings [$]		**$ 100,197.45**	**$ 106,165.00**	**$ 112,488.54**	**$ 119,189.35**	**$ 126,289.99**	**$ 133,814.37**	**$ 141,787.81**	**$ 150,237.17**	**$ 159,190.91**	**$ 168,679.21**	**$ 178,734.04**	**$ 189,389.30**	**$ 200,680.91**	**$ 212,646.96**	**$ 212,975.34**	**$ 225,716.23**	**$ 239,221.12**	**$ 253,535.92**	**$ 268,709.36**	**$ 284,793.06**
Yearly Cash Flow																					
Present Value	**-$ 2,462,487.13**	**$ 2,201,204.10**	**$ 99,865.00**	**$ 106,188.54**	**$ 67,889.35**	**$ 119,989.99**	**$ 121,914.37**	**$ 135,487.81**	**$ 143,937.17**	**$ 152,890.91**	**$ 110,482.21**	**$ 172,434.04**	**$ 183,089.30**	**$ 194,380.91**	**$ 65,643.63**	**$ 167,675.34**	**$ 203,616.23**	**$ 232,921.12**	**$ 247,235.92**	**$ 262,409.36**	**$ 930,435.98**

Overall Project Financials

Project NPV	**$1,513,290.35**
IRR	**17.8%**

Pathway 3

Life Cycle Cost Analysis (LCCA)

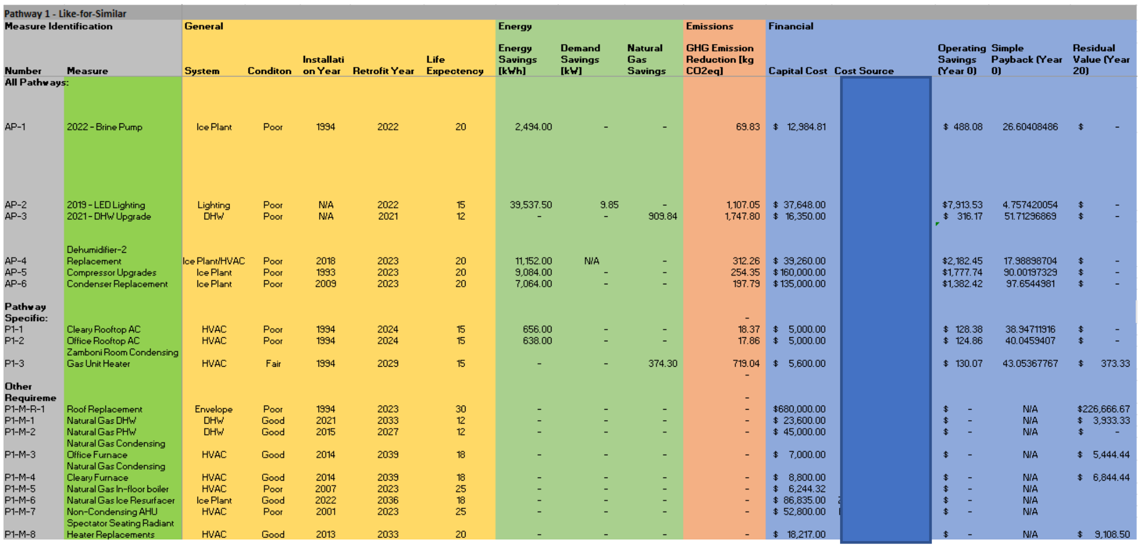
Initial Investment and Equipment

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Initial Investments																					
Initial Investment [$]	-$ 2,745,992.81																				
Funding																					
GICB [$]		$ 2,012,194.25																			
CBR - Capital Projects (Grant Portion Only) [$]		$ 350,233.50																			
Total Funding [$]		$ 2,362,427.75																			
Ongoing Cash Flows																					
Replacement Costs [$]		-$ 162,000.00	$ -	$ -	-$ 60,000.00	$ -	-$ 5,350.00	$ -	$ -	$ -	-$ 579,065.00	$ -	$ -	$ -	-$ 160,000.00	$ -	$ -	$ -	$ -	$ -	-$ 130,000.00
O&M Costs [$]		-$ 6,450.00	-$ 6,450.00	-$ 6,450.00	-$ 6,450.00	-$ 6,450.00	-$ 6,450.00	-$ 6,450.00	-$ 6,450.00	-$ 6,450.00	-$ 6,450.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 46,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00
Residual Value [$]		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 86,835.00	$ -	$ -	$ -	$ -	$ -	$ 1,210,772.02
Energy Savings, Generation, and Consumption																					
Savings																					
Electricity Savings [kWh]		- 99,271.00	- 99,271.00	- 99,271.00	- 99,271.00	- 99,271.00	- 99,271.00	- 99,271.00	- 99,271.00	- 99,271.00	- 99,271.00	- 99,271.00	- 99,271.00	- 99,271.00	- 99,271.00	- 112,757.00	- 112,757.00	- 112,757.00	- 112,757.00	- 112,757.00	- 214,046.00
NG Savings [m3]		29,192.01	29,192.01	29,192.01	29,192.01	29,192.01	29,192.01	29,192.01	29,192.01	29,192.01	29,192.01	29,192.01	29,192.01	29,192.01	29,192.01	32,134.19	32,134.19	32,134.19	32,134.19	32,134.19	42,791.84
Generation																					
Renewable Energy Generation [kWh]	-	457,780.00	457,780.00	457,780.00	457,780.00	457,780.00	457,780.00	457,780.00	457,780.00	457,780.00	457,780.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00
Direct Renewable Energy Consumption [kWh]	-	228,890.00	228,890.00	228,890.00	228,890.00	228,890.00	228,890.00	228,890.00	228,890.00	228,890.00	228,890.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00
Net-Metering Credits Accrued [kWh]	-	228,890.00	228,890.00	228,890.00	228,890.00	228,890.00	228,890.00	228,890.00	228,890.00	228,890.00	228,890.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00
Consumption																					
Net Remaining Consumption - Electricity [kWh]		395,380.00	395,380.00	395,380.00	395,380.00	395,380.00	395,380.00	395,380.00	395,380.00	395,380.00	395,380.00	256,177.00	256,177.00	256,177.00	256,177.00	269,663.00	269,663.00	269,663.00	269,663.00	269,663.00	370,952.00
Net Remaining Consumption - Natural Gas [m3]		13,599.83	13,599.83	13,599.83	13,599.83	13,599.83	13,599.83	13,599.83	13,599.83	13,599.83	13,599.83	13,599.83	13,599.83	13,599.83	13,599.83	10,657.65	10,657.65	10,657.65	10,657.65	10,657.65	-
Carbon Budgets																					
Emissions																					
Net Remaining Emissions [kg CO2e]		30,786.99	30,786.99	30,786.99	30,786.99	30,786.99	30,786.99	30,786.99	30,786.99	30,786.99	30,786.99	22,991.62	22,991.62	22,991.62	22,991.62	17,717.31	17,717.31	17,717.31	17,717.31	17,717.31	80.05
Rate																					
Cost of Carbon Offset (average) [$/kg CO2e]		$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02
Expense																					
Carbon Offsets Required [$]		$ 615.74	$ 615.74	$ 615.74	$ 615.74	$ 615.74	$ 615.74	$ 615.74	$ 615.74	$ 615.74	$ 615.74	$ 459.83	$ 459.83	$ 459.83	$ 459.83	$ 354.35	$ 354.35	$ 354.35	$ 354.35	$ 354.35	$ 1.60
Cost Savings																					
Electricity Cost Savings [$]		-$ 20,573.55	-$ 21,787.39	-$ 23,072.84	-$ 24,434.14	-$ 25,875.75	-$ 27,402.42	-$ 29,019.17	-$ 30,731.30	-$ 32,544.44	-$ 34,464.57	-$ 36,497.98	-$ 38,651.36	-$ 40,931.79	-$ 43,346.76	-$ 52,140.33	-$ 55,216.60	-$ 58,474.38	-$ 61,924.37	-$ 65,577.91	-$ 131,830.88
Natural Gas Cost Savings [$]		$ 10,854.32	$ 11,614.12	$ 12,427.11	$ 13,297.01	$ 14,227.80	$ 15,223.75	$ 16,289.41	$ 17,429.67	$ 18,649.74	$ 19,955.23	$ 21,352.09	$ 22,846.74	$ 24,446.01	$ 26,157.23	$ 30,809.08	$ 32,965.72	$ 35,273.32	$ 37,742.45	$ 40,384.42	$ 57,542.84
Direct Renewable Electricity Cost Savings [$]		$ 47,436.61	$ 50,235.37	$ 53,199.25	$ 56,338.01	$ 59,661.95	$ 63,182.01	$ 66,909.74	$ 70,857.42	$ 75,038.01	$ 79,465.25	$ 135,333.07	$ 143,317.72	$ 151,773.47	$ 160,728.11	$ 170,211.06	$ 180,253.52	$ 190,888.47	$ 202,150.89	$ 214,077.80	$ 226,708.39
Net Metering Credits [$]		$ 30,493.23	$ 32,292.33	$ 34,197.58	$ 36,215.23	$ 38,351.93	$ 40,614.70	$ 43,010.96	$ 45,548.61	$ 48,235.98	$ 51,081.90	$ 86,994.89	$ 92,127.59	$ 97,563.12	$ 103,319.34	$ 109,415.19	$ 115,870.68	$ 122,707.05	$ 129,946.77	$ 137,613.63	$ 145,732.83
Annual Utility Savings [$]		**$ 68,210.61**	**$ 72,354.43**	**$ 76,751.10**	**$ 81,416.11**	**$ 86,365.93**	**$ 91,618.02**	**$ 97,190.95**	**$ 103,104.40**	**$ 109,379.28**	**$ 116,037.81**	**$ 207,182.08**	**$ 219,640.70**	**$ 232,850.81**	**$ 246,857.92**	**$ 258,295.01**	**$ 273,873.31**	**$ 290,394.46**	**$ 307,915.74**	**$ 326,497.94**	**$ 298,153.18**
Yearly Cash Flow																					
Present Value	**-$ 2,745,992.81**	**$ 2,262,188.36**	**$ 65,904.43**	**$ 70,301.10**	**$ 14,966.11**	**$ 79,915.93**	**$ 79,818.02**	**$ 90,740.95**	**$ 96,654.40**	**$ 102,929.28**	**-$ 469,477.19**	**$ 199,882.08**	**$ 212,340.70**	**$ 225,550.81**	**$ 166,392.92**	**$ 211,995.01**	**$ 266,573.31**	**$ 283,094.46**	**$ 300,615.74**	**$ 319,197.94**	**$ 1,371,625.21**
Overall Project Financials																					
Project NPV	**$1,072,432.85**																				
IRR	**11.8%**																				

Pathway 4

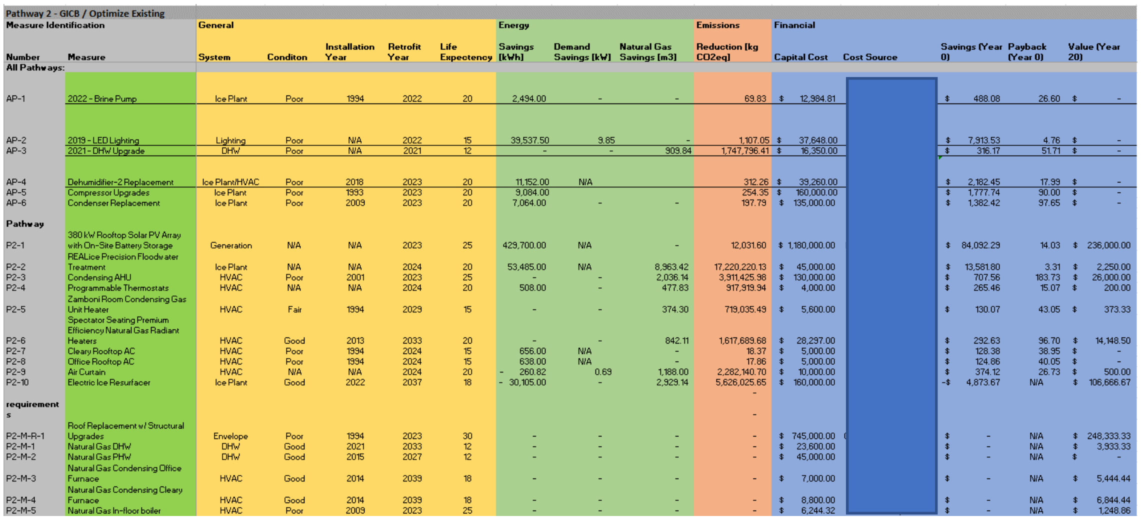
Life Cycle Cost Analysis (LCCA) **Initial Investment and Equipment**																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Initial Investments																					
Initial Investment [$]	-$ 3,346,907.81																				
Funding																					
GICB [$]		$ 2,012,194.25																			
CBR - Capital Projects (Grant Portion Only) [$]		$ 343,733.50																			
Total Funding [$]		$ 2,355,927.75																			
Ongoing Cash Flows																					
Replacement Costs [$]		$ -	$ -	$ -	$ -	-$ 365,500.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	-$ 92,500.00	$ -	$ -	$ -
O&M Costs [$]		-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 61,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00	-$ 7,300.00
Residual Value [$]		$ 10,192.50	$ -	$ -	$ -	$ 58,515.83	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 35,555.56	$ -	$ -	$ -	$ -	$ -	$ 798,417.86
Energy Savings, Generation, and Consumption																					
Savings																					
Electricity Savings [kWh]		- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00	- 214,046.00
NG Savings [m3]		42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84	42,791.84
Generation																					
Renewable Energy Generation [kWh]	-	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00	736,186.00
Direct Renewable Energy Consumption [kWh]	-	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00
Net-Metering Credits Accrued [kWh]	-	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00	368,093.00
Consumption																					
Net Remaining Consumption - Electricity [kWh]		370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00	370,952.00
Net Remaining Consumption - Natural Gas [m3]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon Budgets																					
Emissions																					
Net Remaining Emissions [kg CO2e]		80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05
Rate																					
Cost of Carbon Offset (average) [$/kg CO2e]		$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02
Expense																					
Carbon Offsets Required [$]		$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60	$ 1.60
Cost Savings																					
Electricity Cost Savings [$]		-$ 44,360.24	-$ 46,977.50	-$ 49,749.17	-$ 52,684.37	-$ 55,792.75	-$ 59,084.52	-$ 62,570.51	-$ 66,262.17	-$ 70,171.63	-$ 74,311.76	-$ 78,696.15	-$ 83,339.23	-$ 88,256.24	-$ 93,463.36	-$ 98,977.70	-$ 104,817.38	-$ 111,001.61	-$ 117,550.70	-$ 124,486.19	-$ 131,830.88
Natural Gas Cost Savings [$]		$ 15,911.08	$ 17,024.85	$ 18,216.59	$ 19,491.75	$ 20,856.17	$ 22,316.11	$ 23,878.23	$ 25,549.71	$ 27,338.19	$ 29,251.86	$ 31,299.49	$ 33,490.46	$ 35,834.79	$ 38,343.23	$ 41,027.25	$ 43,899.16	$ 46,972.10	$ 50,260.15	$ 53,778.36	$ 57,542.84
Direct Renewable Electricity Cost Savings [$]		$ 76,285.91	$ 80,786.78	$ 85,553.20	$ 90,600.84	$ 95,946.29	$ 101,607.12	$ 107,601.94	$ 113,950.46	$ 120,673.53	$ 127,793.27	$ 135,333.07	$ 143,317.72	$ 151,773.47	$ 160,728.11	$ 170,211.06	$ 180,253.52	$ 190,888.47	$ 202,150.89	$ 214,077.80	$ 226,708.39
Net Metering Credits [$]		$ 49,038.16	$ 51,931.41	$ 54,995.36	$ 58,240.09	$ 61,676.26	$ 65,315.15	$ 69,168.75	$ 73,249.71	$ 77,571.44	$ 82,148.15	$ 86,994.89	$ 92,127.59	$ 97,563.12	$ 103,319.34	$ 109,415.19	$ 115,870.68	$ 122,707.05	$ 129,946.77	$ 137,613.63	$ 145,732.83
Annual Utility Savings [$]		**$ 96,874.91**	**$ 102,765.55**	**$ 109,015.99**	**$ 115,648.31**	**$ 122,685.97**	**$ 130,153.86**	**$ 138,078.42**	**$ 146,487.71**	**$ 155,411.53**	**$ 164,881.53**	**$ 174,931.31**	**$ 185,596.55**	**$ 196,915.14**	**$ 208,927.32**	**$ 221,675.81**	**$ 235,205.98**	**$ 249,566.02**	**$ 264,807.11**	**$ 280,983.59**	**$ 298,153.18**
Yearly Cash Flow																					
Present Value	**-$ 3,346,907.81**	**$ 2,455,695.15**	**$ 95,465.55**	**$ 101,715.99**	**$ 108,348.31**	**-$ 191,598.19**	**$ 122,853.86**	**$ 130,778.42**	**$ 139,187.71**	**$ 148,111.53**	**$ 157,581.53**	**$ 167,631.31**	**$ 178,296.55**	**$ 189,615.14**	**$ 237,182.87**	**$ 160,375.81**	**$ 227,905.98**	**$ 149,766.02**	**$ 257,507.11**	**$ 273,683.59**	**$ 1,089,271.04**
Overall Project Financials																					
Project NPV	**$825,464.64**																				
IRR	**9.5%**																				

Appendix G – Measure Level Analyses / Package Analyses



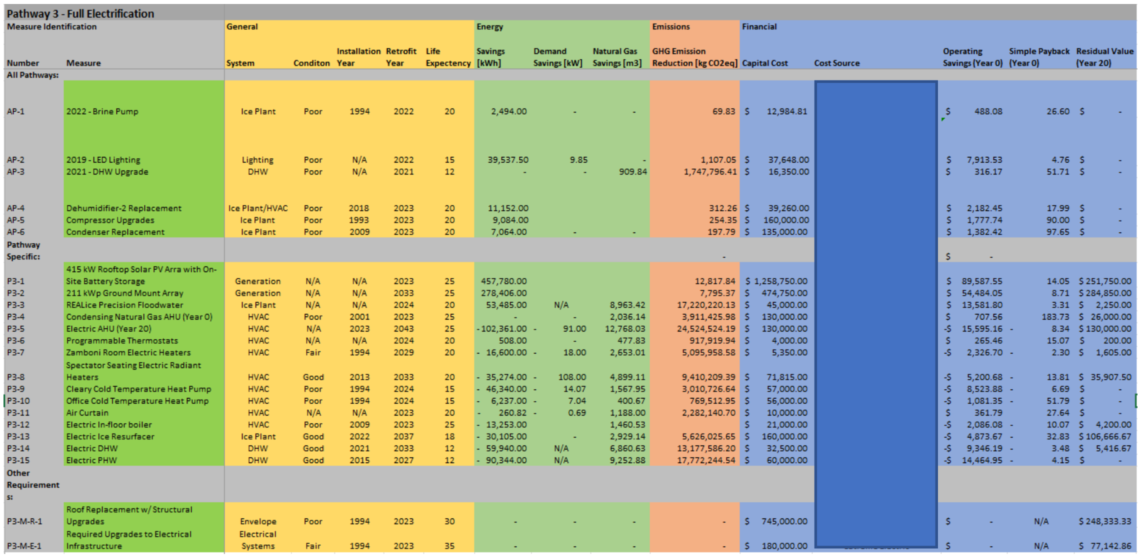
Pathway 1 - Like-for-Similar

Measure Identification		General					Energy			Emissions	Financial				
Number	Measure	System	Conditon	Installation Year	Retrofit Year	Life Expectency	Energy Savings [kWh]	Demand Savings [kW]	Natural Gas Savings	GHG Emission Reduction [kg CO2eq]	Capital Cost	Cost Source	Operating Savings (Year 0)	Simple Payback (Year 0)	Residual Value (Year 20)
All Pathways:															
AP-1	2022 - Brine Pump	Ice Plant	Poor	1994	2022	20	2,494.00	-	-	69.83	$ 12,984.81	[redacted]	$ 488.08	26.60408486	$ -
AP-2	2019 - LED Lighting	Lighting	Poor	N/A	2022	15	39,537.50	9.85	-	1,107.05	$ 37,648.00	[redacted]	$7,913.53	4.757420054	$ -
AP-3	2021 - DHW Upgrade	DHW	Poor	N/A	2021	12	-	-	909.84	1,747.80	$ 16,350.00	[redacted]	$ 316.17	51.71296869	$ -
AP-4	Dehumidifier-2 Replacement	Ice Plant/HVAC	Poor	2018	2023	20	11,152.00	N/A	-	312.26	$ 39,260.00	[redacted]	$2,182.45	17.98898704	$ -
AP-5	Compressor Upgrades	Ice Plant	Poor	1993	2023	20	9,084.00	-	-	254.35	$ 160,000.00	[redacted]	$1,777.74	90.00197329	$ -
AP-6	Condenser Replacement	Ice Plant	Poor	2009	2023	20	7,064.00	-	-	197.79	$ 135,000.00	[redacted]	$1,382.42	97.6544981	$ -
Pathway Specific:										-					
P1-1	Cleary Rooftop AC	HVAC	Poor	1994	2024	15	656.00	-	-	18.37	$ 5,000.00	[redacted]	$ 128.38	38.94711916	$ -
P1-2	Office Rooftop AC	HVAC	Poor	1994	2024	15	638.00	-	-	17.86	$ 5,000.00	[redacted]	$ 124.86	40.0459407	$ -
P1-3	Zamboni Room Condensing Gas Unit Heater	HVAC	Fair	1994	2029	15	-	-	374.30	719.04	$ 5,600.00	[redacted]	$ 130.07	43.05367767	$ 373.33
										-					
Other Requireme										-					
P1-M-R-1	Roof Replacement	Envelope	Poor	1994	2023	30	-	-	-	-	$680,000.00	[redacted]	$ -	N/A	$226,666.67
P1-M-1	Natural Gas DHW	DHW	Good	2021	2033	12	-	-	-	-	$ 23,600.00	[redacted]	$ -	N/A	$ 3,933.33
P1-M-2	Natural Gas PHW	DHW	Good	2015	2027	12	-	-	-	-	$ 45,000.00	[redacted]	$ -	N/A	$ -
P1-M-3	Natural Gas Condensing Office Furnace	HVAC	Good	2014	2039	18	-	-	-	-	$ 7,000.00	[redacted]	$ -	N/A	$ 5,444.44
P1-M-4	Natural Gas Condensing Cleary Furnace	HVAC	Good	2014	2039	18	-	-	-	-	$ 8,800.00	[redacted]	$ -	N/A	$ 6,844.44
P1-M-5	Natural Gas In-floor boiler	HVAC	Poor	2007	2023	25	-	-	-	-	$ 6,244.32	[redacted]	$ -	N/A	
P1-M-6	Natural Gas Ice Resurfacer	Ice Plant	Good	2022	2036	18	-	-	-	-	$ 86,835.00	[redacted]	$ -	N/A	
P1-M-7	Non-Condensing AHU	HVAC	Poor	2001	2023	25	-	-	-	-	$ 52,800.00	[redacted]	$ -	N/A	
P1-M-8	Spectator Seating Radiant Heater Replacements	HVAC	Good	2013	2033	20	-	-	-	-	$ 18,217.00	[redacted]	$ -	N/A	$ 9,108.50



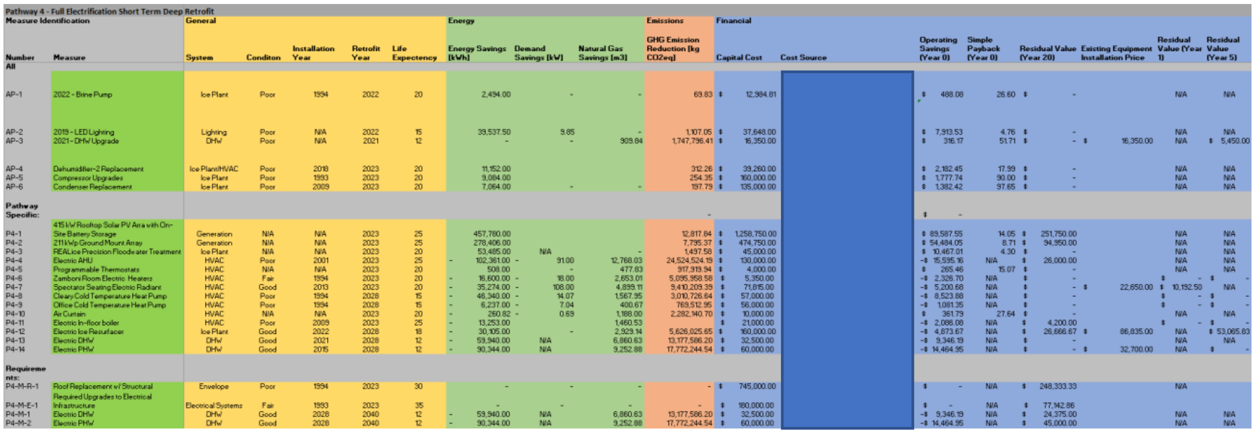
Pathway 2 - GICB / Optimize Existing

Measure Identification		General					Energy			Emissions	Financial				
Number	Measure	System	Conditon	Installation Year	Retrofit Year	Life Expectency	Savings [kWh]	Demand Savings [kW]	Natural Gas Savings [m3]	Reduction [kg CO2eq]	Capital Cost	Cost Source	Savings (Year 0)	Payback (Year 0)	Value (Year 20)
All Pathways:															
AP-1	2022 - Brine Pump	Ice Plant	Poor	1994	2022	20	2,494.00	-	-	69.83	$ 12,984.81	[redacted]	$ 488.08	26.60	$ -
AP-2	2019 - LED Lighting	Lighting	Poor	N/A	2022	15	39,537.50	9.85	-	1,107.05	$ 37,648.00	[redacted]	$ 7,913.53	4.76	$ -
AP-3	2021 - DHW Upgrade	DHW	Poor	N/A	2021	12	-	-	909.84	1,747,796.41	$ 16,350.00	[redacted]	$ 316.17	51.71	$ -
AP-4	Dehumidifier-2 Replacement	Ice Plant/HVAC	Poor	2018	2023	20	11,152.00	N/A		312.26	$ 39,260.00	[redacted]	$ 2,182.45	17.99	$ -
AP-5	Compressor Upgrades	Ice Plant	Poor	1993	2023	20	9,084.00			254.35	$ 160,000.00	[redacted]	$ 1,777.74	90.00	$ -
AP-6	Condenser Replacement	Ice Plant	Poor	2009	2023	20	7,064.00	-	-	197.79	$ 135,000.00	[redacted]	$ 1,382.42	97.65	$ -
Pathway															
P2-1	380 kW Rooftop Solar PV Array with On-Site Battery Storage	Generation	N/A	N/A	2023	25	429,700.00	N/A	-	12,031.60	$ 1,180,000.00	[redacted]	$ 84,092.29	14.03	$ 236,000.00
P2-2	REALice Precision Floodwater Treatment	Ice Plant	N/A	N/A	2024	20	53,485.00	N/A	8,963.42	17,220,220.13	$ 45,000.00	[redacted]	$ 13,581.80	3.31	$ 2,250.00
P2-3	Condensing AHU	HVAC	Poor	2001	2023	25	-	-	2,036.14	3,911,425.98	$ 130,000.00	[redacted]	$ 707.56	183.73	$ 26,000.00
P2-4	Programmable Thermostats	HVAC	N/A	N/A	2024	20	508.00	-	477.83	917,919.94	$ 4,000.00	[redacted]	$ 265.46	15.07	$ 200.00
P2-5	Zamboni Room Condensing Gas Unit Heater	HVAC	Fair	1994	2029	15	-	-	374.30	719,035.49	$ 5,600.00	[redacted]	$ 130.07	43.05	$ 373.33
P2-6	Spectator Seating Premium Efficiency Natural Gas Radiant Heaters	HVAC	Good	2013	2033	20	-	-	842.11	1,617,689.68	$ 28,297.00	[redacted]	$ 292.63	96.70	$ 14,148.50
P2-7	Cleary Rooftop AC	HVAC	Poor	1994	2024	15	656.00	N/A	-	18.37	$ 5,000.00	[redacted]	$ 128.38	38.95	$ -
P2-8	Office Rooftop AC	HVAC	Poor	1994	2024	15	638.00	N/A	-	17.86	$ 5,000.00	[redacted]	$ 124.86	40.05	$ -
P2-9	Air Curtain	HVAC	N/A	N/A	2024	20	- 260.82	0.69	1,188.00	2,282,140.70	$ 10,000.00	[redacted]	$ 374.12	26.73	$ 500.00
P2-10	Electric Ice Resurfacer	Ice Plant	Good	2022	2037	18	- 30,105.00	-	2,929.14	5,626,025.65	$ 160,000.00	[redacted]	-$ 4,873.67	N/A	$ 106,666.67
										-					
requirements										-					
P2-M-R-1	Roof Replacement w/ Structural Upgrades	Envelope	Poor	1994	2023	30	-	-	-	-	$ 745,000.00	[redacted]	$ -	N/A	$ 248,333.33
P2-M-1	Natural Gas DHW	DHW	Good	2021	2033	12	-	-	-	-	$ 23,600.00	[redacted]	$ -	N/A	$ 3,933.33
P2-M-2	Natural Gas PHW	DHW	Good	2015	2027	12	-	-	-	-	$ 45,000.00	[redacted]	$ -	N/A	$ -
P2-M-3	Natural Gas Condensing Office Furnace	HVAC	Good	2014	2039	18	-	-	-	-	$ 7,000.00	[redacted]	$ -	N/A	$ 5,444.44
P2-M-4	Natural Gas Condensing Cleary Furnace	HVAC	Good	2014	2039	18	-	-	-	-	$ 8,800.00	[redacted]	$ -	N/A	$ 6,844.44
P2-M-5	Natural Gas In-floor boiler	HVAC	Poor	2009	2023	25	-	-	-	-	$ 6,244.32	[redacted]	$ -	N/A	$ 1,248.86



Pathway 3 - Full Electrification

Measure Identification		General					Energy			Emissions	Financial				
Number	Measure	System	Conditon	Installation Year	Retrofit Year	Life Expectency	Savings [kWh]	Demand Savings [kW]	Natural Gas Savings [m3]	GHG Emission Reduction [kg CO2eq]	Capital Cost	Cost Source	Operating Savings (Year 0)	Simple Payback (Year 0)	Residual Value (Year 20)
All Pathways:															
AP-1	2022 - Brine Pump	Ice Plant	Poor	1994	2022	20	2,494.00	-	-	69.83	$ 12,984.81	[redacted]	$ 488.08	26.60	$ -
AP-2	2019 - LED Lighting	Lighting	Poor	N/A	2022	15	39,537.50	9.85	-	1,107.05	$ 37,648.00	[redacted]	$ 7,913.53	4.76	$ -
AP-3	2021 - DHW Upgrade	DHW	Poor	N/A	2021	12	-	-	909.84	1,747,796.41	$ 16,350.00	[redacted]	$ 316.17	51.71	$ -
AP-4	Dehumidifier-2 Replacement	Ice Plant/HVAC	Poor	2018	2023	20	11,152.00			312.26	$ 39,260.00	[redacted]	$ 2,182.45	17.99	$ -
AP-5	Compressor Upgrades	Ice Plant	Poor	1993	2023	20	9,084.00			254.35	$ 160,000.00	[redacted]	$ 1,777.74	90.00	$ -
AP-6	Condenser Replacement	Ice Plant	Poor	2009	2023	20	7,064.00	-	-	197.79	$ 135,000.00	[redacted]	$ 1,382.42	97.65	$ -
Pathway Specific:										-		[redacted]	$ -		
P3-1	415 kW Rooftop Solar PV Arra with On-Site Battery Storage	Generation	N/A	N/A	2023	25	457,780.00			12,817.84	$ 1,258,750.00	[redacted]	$ 89,587.55	14.05	$ 251,750.00
P3-2	211 kWp Ground Mount Array	Generation	N/A	N/A	2033	25	278,406.00			7,795.37	$ 474,750.00	[redacted]	$ 54,484.05	8.71	$ 284,850.00
P3-3	REALice Precision Floodwater	Ice Plant	N/A	N/A	2024	20	53,485.00	N/A	8,963.42	17,220,220.13	$ 45,000.00	[redacted]	$ 13,581.80	3.31	$ 2,250.00
P3-4	Condensing Natural Gas AHU (Year 0)	HVAC	Poor	2001	2023	25	-	-	2,036.14	3,911,425.98	$ 130,000.00	[redacted]	$ 707.56	183.73	$ 26,000.00
P3-5	Electric AHU (Year 20)	HVAC	N/A	2023	2043	25	- 102,361.00	- 91.00	12,768.03	24,524,524.19	$ 130,000.00	[redacted]	-$ 15,595.16	- 8.34	$ 130,000.00
P3-6	Programmable Thermostats	HVAC	N/A	N/A	2024	20	508.00	-	477.83	917,919.94	$ 4,000.00	[redacted]	$ 265.46	15.07	$ 200.00
P3-7	Zamboni Room Electric Heaters	HVAC	Fair	1994	2029	20	- 16,600.00	- 18.00	2,653.01	5,095,958.58	$ 5,350.00	[redacted]	-$ 2,326.70	- 2.30	$ 1,605.00
P3-8	Spectator Seating Electric Radiant Heaters	HVAC	Good	2013	2033	20	- 35,274.00	- 108.00	4,899.11	9,410,209.39	$ 71,815.00	[redacted]	-$ 5,200.68	- 13.81	$ 35,907.50
P3-9	Cleary Cold Temperature Heat Pump	HVAC	Poor	1994	2024	15	- 46,340.00	- 14.07	1,567.95	3,010,726.64	$ 57,000.00	[redacted]	-$ 8,523.88	- 6.69	$ -
P3-10	Office Cold Temperature Heat Pump	HVAC	Poor	1994	2024	15	- 6,237.00	- 7.04	400.67	769,512.95	$ 56,000.00	[redacted]	-$ 1,081.35	- 51.79	$ -
P3-11	Air Curtain	HVAC	N/A	N/A	2023	20	- 260.82	- 0.69	1,188.00	2,282,140.70	$ 10,000.00	[redacted]	$ 361.79	27.64	$ -
P3-12	Electric In-floor boiler	HVAC	Poor	2009	2023	25	- 13,253.00		1,460.53		$ 21,000.00	[redacted]	-$ 2,086.08	- 10.07	$ 4,200.00
P3-13	Electric Ice Resurfacer	Ice Plant	Good	2022	2037	18	- 30,105.00	-	2,929.14	5,626,025.65	$ 160,000.00	[redacted]	-$ 4,873.67	- 32.83	$ 106,666.67
P3-14	Electric DHW	DHW	Good	2021	2033	12	- 59,940.00	N/A	6,860.63	13,177,586.20	$ 32,500.00	[redacted]	-$ 9,346.19	- 3.48	$ 5,416.67
P3-15	Electric PHW	DHW	Good	2015	2027	12	- 90,344.00	N/A	9,252.88	17,772,244.54	$ 60,000.00	[redacted]	-$ 14,464.95	- 4.15	$ -
Other Requirements:												[redacted]			
P3-M-R-1	Roof Replacement w/ Structural Upgrades	Envelope	Poor	1994	2023	30	-	-	-	-	$ 745,000.00	[redacted]	$ -	N/A	$ 248,333.33
P3-M-E-1	Required Upgrades to Electrical Infrastructure	Electrical Systems	Fair	1994	2023	35	-	-	-	-	$ 180,000.00	[redacted]	$ -	N/A	$ 77,142.86



Pathway 4 - Full Electrification Short Term Deep Retrofit

Measure Identification		General					Energy			Emissions	Financial							
Number	Measure	System	Conditon	Installation Year	Retrofit Year	Life Expectency	Energy Savings [kWh]	Demand Savings [kW]	Natural Gas Savings [m3]	GHG Emission Reduction [kg CO2eq]	Capital Cost	Cost Source	Operating Savings (Year 0)	Simple Payback (Year 0)	Residual Value (Year 20)	Existing Equipment Installation Price	Residual Value (Year 1)	Residual Value (Year 5)
All																		
AP-1	2022 - Brine Pump	Ice Plant	Poor	1994	2022	20	2,494.00	-	-	69.83	$ 12,984.81	[redacted]	$ 488.08	26.60	$ -		N/A	N/A
AP-2	2019 - LED Lighting	Lighting	Poor	N/A	2022	15	39,537.50	9.85	-	1,107.05	$ 37,648.00	[redacted]	$ 7,913.53	4.76	$ -		N/A	N/A
AP-3	2021 - DHW Upgrade	DHW	Poor	N/A	2021	12	-	-	909.84	1,747,796.41	$ 16,350.00	[redacted]	$ 316.17	51.71	$ -	$ 16,350.00	N/A	$ 5,450.00
AP-4	Dehumidifier-2 Replacement	Ice Plant/HVAC	Poor	2018	2023	20	11,152.00			312.26	$ 39,260.00	[redacted]	$ 2,182.45	17.99	$ -		N/A	N/A
AP-5	Compressor Upgrades	Ice Plant	Poor	1993	2023	20	9,084.00			254.35	$ 160,000.00	[redacted]	$ 1,777.74	90.00	$ -		N/A	N/A
AP-6	Condenser Replacement	Ice Plant	Poor	2009	2023	20	7,064.00	-	-	197.79	$ 135,000.00	[redacted]	$ 1,382.42	97.65	$ -		N/A	N/A
Pathway Specific:										-		[redacted]	$ -					
P4-1	415 kW Rooftop Solar PV Arra with On-Site Battery Storage	Generation	N/A	N/A	2023	25	457,780.00			12,817.84	$ 1,258,750.00	[redacted]	$ 89,587.55	14.05	$ 251,750.00		N/A	N/A
P4-2	211 kWp Ground Mount Array	Generation	N/A	N/A	2023	25	278,406.00			7,795.37	$ 474,750.00	[redacted]	$ 54,484.05	8.71	$ 94,950.00		N/A	N/A
P4-3	REALice Precision Floodwater Treatment	Ice Plant	N/A	N/A	2023	20	53,485.00	N/A	-	1,497.58	$ 45,000.00	[redacted]	$ 10,467.01	4.30	$ -		N/A	N/A
P4-4	Electric AHU	HVAC	Poor	2001	2023	25	- 102,361.00	- 91.00	12,768.03	24,524,524.19	$ 130,000.00	[redacted]	-$ 15,595.16	N/A	$ 26,000.00		N/A	N/A
P4-5	Programmable Thermostats	HVAC	N/A	N/A	2023	20	508.00	-	477.83	917,919.94	$ 4,000.00	[redacted]	$ 265.46	15.07	$ -		N/A	N/A
P4-6	Zamboni Room Electric Heaters	HVAC	Fair	1994	2023	20	- 16,600.00	- 18.00	2,653.01	5,095,958.58	$ 5,350.00	[redacted]	-$ 2,326.70	N/A	$ -		$ -	$ -
P4-7	Spectator Seating Electric Radiant	HVAC	Good	2013	2023	20	- 35,274.00	- 108.00	4,899.11	9,410,209.39	$ 71,815.00	[redacted]	-$ 5,200.68	N/A	$ -	$ 22,650.00	$ 10,192.50	N/A
P4-8	Cleary Cold Temperature Heat Pump	HVAC	Poor	1994	2028	15	- 46,340.00	- 14.07	1,567.95	3,010,726.64	$ 57,000.00	[redacted]	-$ 8,523.88	N/A	$ -		$ -	$ -
P4-9	Office Cold Temperature Heat Pump	HVAC	Poor	1994	2028	15	- 6,237.00	- 7.04	400.67	769,512.95	$ 56,000.00	[redacted]	-$ 1,081.35	N/A	$ -		$ -	$ -
P4-10	Air Curtain	HVAC	N/A	N/A	2023	20	- 260.82	- 0.69	1,188.00	2,282,140.70	$ 10,000.00	[redacted]	$ 361.79	27.64	$ -		N/A	N/A
P4-11	Electric In-floor boiler	HVAC	Poor	2009	2023	25	- 13,253.00		1,460.53		$ 21,000.00	[redacted]	-$ 2,086.08	N/A	$ 4,200.00		$ -	$ -
P4-12	Electric Ice Resurfacer	Ice Plant	Good	2022	2028	18	- 30,105.00	-	2,929.14	5,626,025.65	$ 160,000.00	[redacted]	-$ 4,873.67	N/A	$ 26,666.67	$ 86,835.00	N/A	$ 53,065.83
P4-13	Electric DHW	DHW	Good	2021	2028	12	- 59,940.00	N/A	6,860.63	13,177,586.20	$ 32,500.00	[redacted]	-$ 9,346.19	N/A	$ -		N/A	N/A
P4-14	Electric PHW	DHW	Good	2015	2028	12	- 90,344.00	N/A	9,252.88	17,772,244.54	$ 60,000.00	[redacted]	-$ 14,464.95	N/A	$ -	$ 32,700.00	N/A	$ -
Requirements:												[redacted]						
P4-M-R-1	Roof Replacement w/ Structural	Envelope	Poor	1994	2023	30	-	-	-	-	$ 745,000.00	[redacted]	$ -	N/A	$ 248,333.33		N/A	
P4-M-E-1	Required Upgrades to Electrical Infrastructure	Electrical Systems	Fair	1993	2023	35	-	-	-	-	$ 180,000.00	[redacted]	$ -	N/A	$ 77,142.86			
P4-M-1	Electric DHW	DHW	Good	2028	2040	12	- 59,940.00	N/A	6,860.63	13,177,586.20	$ 32,500.00	[redacted]	-$ 9,346.19	N/A	$ 24,375.00		N/A	N/A
P4-M-2	Electric PHW	DHW	Good	2028	2040	12	- 90,344.00	N/A	9,252.88	17,772,244.54	$ 60,000.00	[redacted]	-$ 14,464.95	N/A	$ 45,000.00		N/A	N/A