TOWNSHIP OF ESQUIMALT

BUILDING RETROFIT STUDY

ARCHIE BROWNING SPORTS CENTRE, 1151 ESQUIMALT RD

FEBRUARY 2026

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TOWNSHIP OF ESQUIMALT

PROJECT NO.: CA0051294.1761
DATE: FEBRUARY 2026

WSP
3600 UPTOWN BOULEVARD
SUITE 301
VICTORIA, BC
V8Z 0B9

T: 579-252-0248

WSP.COM

SIGNATURES

PREPARED BY

Sonia Tsang, M.E.L., LEED AP (BD+C, O+M), WELL AP
Energy Efficiency & Sustainability Specialist

Carolyn Balant, P. Eng., LEED AP
Project Manager, Energy Efficiency and Sustainability

REVIEWED BY

N. Ekrami

Navid Ekrami, Ph.D., M.Sc., P.Eng.
Project Manager, Energy and Sustainability Specialist

TABLE OF CONTENTS

APPENDICES

1 EXECUTIVE SUMMARY

ENERGY AND GHG ANALYSIS

The Archie Browning Sports Centre is a two-storey recreational facility that includes a hockey rink, a curling rink, dressing rooms, offices, a gym, a lounge, etc. It was originally constructed 1960 but had major renovations 1985 and 2007. It has a floor area of 6,050 m^2.

The site used approximately 2,300,000 ekWh of energy at a cost of nearly $195,000 and an energy intensity of 35.4 ekWh/ft^2.

The current GHG emissions are approximately **136** tCO2e, which is 60% less than the 2010 baseline of **337.7** tCO2e and 25% less than the 2023 baseline of **182** tCO2e.

ENERGY CONSERVATION AND GHG REDUCTION MEASURES

We identified a number of measures, including measures and bundles put forward by Polar Engineering. These have been grouped and summarized below.

MEASURE		POTENTIAL SAVINGS			COST/PAYBACK	
#	ENERGY CONSERVATION MEASURE	Energy (ekWh[1]/Yr)	Utility Cost ($/Yr)	Emissions Reduction (tCO_2e/Yr)	Opinion Of Cost	Simple Payback (years)
Energy Conservation Measures						
7.1	REALice De-oxygenerator	75,000	$2,700	12	$38,400	5
7.2	BAS Recommissioning	46,000	$2,500	2	$10,000	4
	Totals (Rounded)	**121,000**	**$5,200**	**14**	**$48,400**	**9.3**
Polar Engineering Bundle 1						
7.3	Underfloor Heat Recovery	100,000	$6,500	1	$1,500,000	231
7.4	Snowmelt Pit Heat Recovery	100,000	$3,600	18	$342,500	95
	Totals (Rounded)	**200,000**	**$10,100**	**19**	**$1,842,500**	**182.4**
Polar Engineering Bundle 2						
7.5	Site-specific Heatpump	200,000	$2,700	55	$382,000	141
7.6	Arena dehumidifier preheat coil	84,500	$5,500	1	$76,000	14
7.7	Boiler Replacement	6,700	$200	1	$193,500	968
7.8	Low-Flow Showerheads	20,000	$500	4	$20,000	40
	Totals (Rounded)	**311,200**	**$8,900**	**61**	**$671,500**	**75**
GHG Reduction Measures						
8.1	Heat Pump Boilers	186,000	$2,400	50	$1,100,000	458
8.2	PV Panels	235,800	$15,400	3	$560,000	36
	Totals (Rounded)	**421,800**	**$17,800**	**53**	**$1,660,000**	**93.3**

[1] ekWh – equivalent kilowatt hour.

The total potential savings will not equal the simple addition of the individual values. The integrated totals represent an estimate of the combined savings.

Cost savings are based on historic utility rates. Future utility rates are on the rise in many jurisdictions. Higher utility rates result in higher, more attractive cost savings from energy conservation.

To realize the benefits outlined in this report, the measures identified must be implemented. We have recommended next steps for the measures. Depending on the size, complexity, and volume of projects, you may need to prepare engineering designs and/or specifications, develop bid documents for competitive quotes, manage construction review and/or contract administration, commission systems, verify installation as intended, train operators on system changes, measure performance improvement, and analyze/prepare/administer incentive applications and associated reporting. WSP can provide the expertise and services that will lead to successful implementation of energy conservation measures.

2 INTRODUCTION

2.1 AUTHORIZATION

This report was prepared at the request of Steve Knoke, Director, Parks and Recreation Services at the Township of Esquimalt, in accordance with our proposal dated February 28, 2025.

2.2 BACKGROUND

Esquimalt Council has made climate action a strategic priority, declared a climate emergency, and set ambitious targets to reduce corporate greenhouse gas emissions (GHGs) by 45% from 2010 levels by 2030, and to becoming a 100% renewable energy community by 2050. Recently, Council resolved to complete a **GHG Reduction Building Feasibility Study** that would meet Federation of Canadian Municipalities (FCM) goals to identify a sequence of GHG reduction measures to reduce GHG emissions for community buildings by at least 50% within 10 years and by at least 80% (i.e. near net-zero GHG emissions) within 20 years from 2023 (the base year), while managing capital costs and reducing operating costs.

The completion of the Retrofit Feasibility Study would ultimately enable the municipality to integrate reductions in GHG emissions and energy use into longer-term asset management plans for managing the municipal buildings and attain future FCM funding to complete innovative capital projects.

The Township of Esquimalt contracted WSP to conduct Building Retrofit Studies on a portfolio of 5 buildings, with the primary focus on the two largest energy consumers and GHGs emitters.

- Esquimalt Recreation Centre (527 Fraser Street): Built in 1973. Gross floor area = 4828. Heated with gas. A community recreation facility with an aquatics centre, weight room, gymnasium, and multi-purpose spaces.
- **Archie Browning Sports Centre** (1151 Esquimalt Road): Built in 1960. Gross floor area = 6050 m^2. Heated with gas. This facility includes an ice arena, a six-sheet curling rink, lounge areas, and Esquimalt Parks and Recreation administrative offices.
- Municipal Hall (1229 Esquimalt Road): Built in 2002. Gross floor area = 935 m^2.Heated with gas and electric heat pump. The Hall, a three-storey building includes a council chamber, administrative offices, and satellite police offices.
- Public Works building (601 Canteen Road) Built in 1996. Gross floor area = 1150 square metres. Heated with gas. Home to Esquimalt's public works staff and the municipal fleet, including administration offices, mechanics shop, and stores.
- Parks Nursery building (1100 Craigflower Road) Built in 1979. Gross floor area = 223 m^2. Heated with gas. Home to Esquimalt's parks staff, including administrative offices, meeting /lunchroom and storage.

This report focuses on the **Archie Browning Sports Centre,** 1151 Esquimalt Road.

2.3 OPINION OF COSTS

The opinions of probable costs presented in this report should be considered preliminary budgets. They are intended to be sufficient for making educated investment decisions and obtaining preliminary project approval. Significant projects will typically require further investigation and design to accurately determine construction budgets and timing. Unless noted otherwise, we have assumed that all the measures identified in our report will be implemented as a single project. Actual costs may be higher if projects are implemented individually. Costs do not include HST.

For each option where an incentive may be available, we have included an estimate of the potential eligible incentive value, less the anticipated cost of incentive administration. You would need to apply for incentives before proceeding with any work. Incentive programs periodically change. The values presented are based on the program in effect at the time of our investigation. The incentives considered are described below.

2.4 PROJECT SAVINGS

Savings were developed using tabulated data, energy handbooks, the ASHRAE Handbook, weather data, WSP's previous project experience, supplier data sheets, and background information gathered during the site visits, as well as mechanical, electrical, and architectural plans provided by the clients. Equipment operation was based on schedules and control sequences provided by the client during the site visit.

2.5 UTILITY RATE

The utility rates used throughout this project to assess the savings from implementing energy conservation and decarbonization measures were the current rates published by the supplier. The rates used are summarized in the table below.

Table 2-1 Summary Utility Savings Rates

Electricity	BC Hydro: Large General Service Rate 1610 Consumption rate = \$0.0653/kWh, Demand rate = \$13.30/kW
Natural Gas	FORTIS BC: Large Commercial Rate Total rate (Supply, Delivery, Storage& transport) = \$8.29/GJ
Water	City of Victoria Rate = \$5.30 /100 ft^3, or \$1.87 /m^3

2.6 INCENTIVES

The Federation of Canadian Municipalities (FCM) Community Buildings Retrofit (CBR) initiative helps to optimize the energy performance and reduce greenhouse gas (GHG) emissions of community buildings owned by municipalities and not-for-profit organizations. The CBR initiative is administered through FCM's Green Municipal Fund (GMF).

FCM's Community Buildings Retrofit initiative is a \$167 million initiative that was made possible through a federal government contribution of \$950 million in its 2019 budget. Applicants can stack CBR funding with funding from other programs, including programs available through provincial and territorial governments.

Grants for GHG reduction pathway feasibility studies help to integrate energy and GHG reductions into longer-term plans for managing community buildings. These studies will enable municipalities to identify a sequence of GHG reduction measures—the "GHG reduction pathway"—that will help to reduce GHG emissions for community buildings by at least 50% within 10 years and by at least 80% (i.e. near net-zero GHG emissions) within 20 years while managing capital costs and reducing operating costs. For a full list of eligibility requirements for the CBR initiative and GHG reduction pathway feasibility studies, see the application guide.

2.7 EMISSION ENERGY & CONVERSIONS FACTORS

The emission energy factors and conversion factors used in this report comes from NRCan and are summarized below:

Table 2-2 Emission Energy Factors and Conversions Factors

ENERGY	EMISSION FACTOR (TCO2/EKWH)	EMISSION FACTOR (TCO2E/GWH)	CONVERSION FACTOR
Electricity	0.000014	14.0	
Natural Gas	0.000185995	185.995	0.05167 tCO2/GJ

Updated projections for the future emissions factors for electricity were published in December 2025. The projected factors for British Columbia are listed below.

Table 2-3 Projected Emission Energy Factors for Electricity

YEAR	REGION	EMISSION FACTOR (TCO2E/GWH)*
2025	British Columbia	5.8
2026	British Columbia	7.2
2027	British Columbia	7.7
2028	British Columbia	8.2
2029	British Columbia	8.5
2030	British Columbia	5.7
2031	British Columbia	5.8
2032	British Columbia	5.4
2033	British Columbia	6.5
2034	British Columbia	7.4
2035	British Columbia	2.2

** Excluding Biomass and RNG CO2 emissions*

See ECCC Data Catalogue

3 BUILDING DESCRIPTION

GENERAL DESCRIPTION

Archie Browning Sport Centre is a sports Centre located at Esquimalt in British Columbia. Built in 1960, the building has an area of approximately 65,122 sq.ft. (6,050 m²), spread over 2 floors. The building mainly houses ice rink, curling rink, offices, lounge areas and Esquimalt Parks and Recreation administrative offices. The summary description of the building is presented in the following table.

Table 3-1 General description of the Archie Browning Sport Centre

COMPONENTS

Name and Address	Archie Browning Sports Centre – 1151 Esquimalt Road, Esquimalt, BC, V9A 3N6
Gross Floor Area	6,050 m2
Year Constructed	1960
Number of Levels	2 storeys
Cladding	Exterior walls include uninsulated wood-framed end walls with vinyl siding and wood plank sheathing. The remaining walls are constructed of concrete masonry units (CMUs) with painted or clear-coated face-sealed finishes.
Parking	Outdoor parking space
Current Occupancy (%)	Full Occupancy
Building Usage	Hockey and curling rink

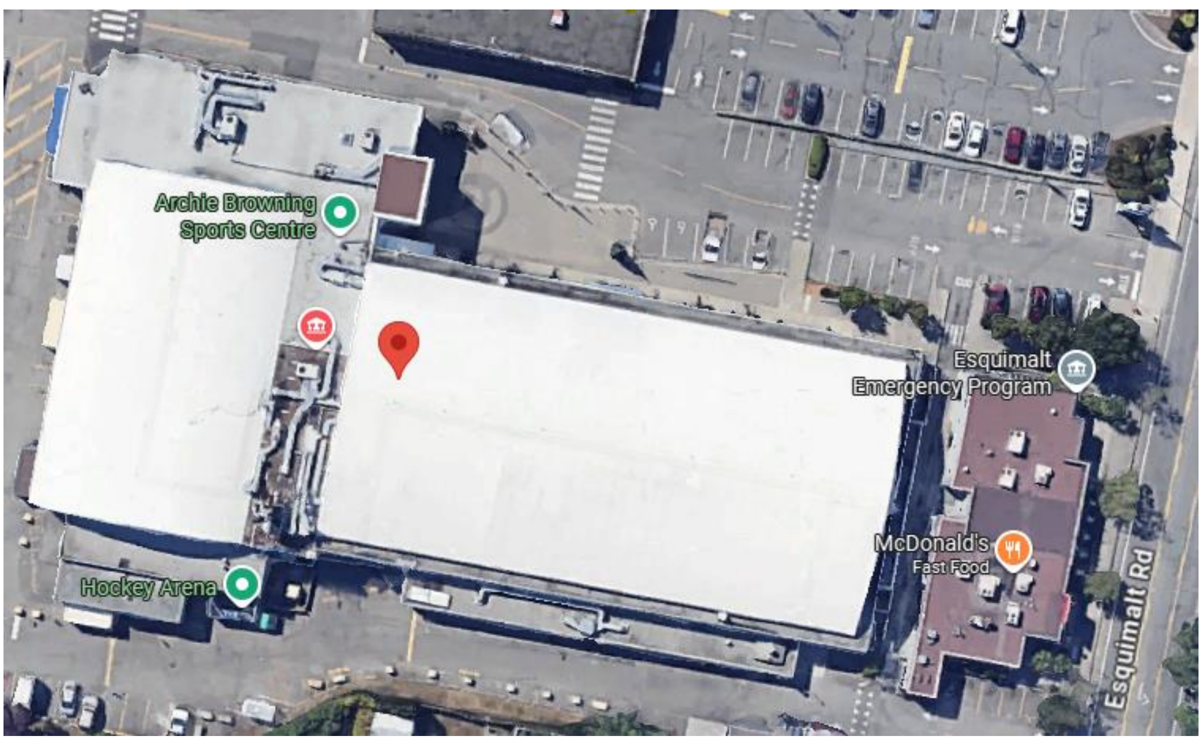


Figure 3-1. Aerial view of Archie Browning Sports Centre

GENERAL SCHEDULES

The schedules considered for the Archie Browning Sport Centre were retrieved from the documentation received and the site visit.

Table 3-2 Summary of the Schedule for the Archie Browning Sport Centre

	ON	OFF	DAYS/WK	WK/YR
Occupancy - Week days	5:30	22:30	7	52
Ventilation	5:30	23:00	7	52
Lighting	5:30	22:30	7	52

Ice is put in the hockey arena around mid-August and taken out in the 1st or 2nd week of April. For curling rink, ice is put in around mid-September and taken out in mid-March.

3.1 BUILDING ENVELOPE

Exterior walls include uninsulated wood-framed end walls with vinyl siding and wood plank sheathing. The remaining walls are constructed of concrete masonry units (CMUs) with painted or clear-coated face-sealed finishes.

Windows are limited to office areas and include older single-glazed metal-framed units and newer PVC or aluminum-framed units with insulated glazing units (IGUs). The main entrance features a two-storey aluminum curtain wall with clear and fritted glazing, one operable unit, and a canopy with integrated lighting.

Exterior doors include a main aluminum sliding door, roll-up service doors, aluminum storefront office doors, and metal service doors, some with card readers.

Flat roofs are surfaced with modified bitumen and drained via gutters, scuppers, and downspouts. Most are unballasted, except the section between arenas, which has a liquid-applied membrane with gravel ballast.

Two large curved barrel roofs over the arenas are clad in white TPO, slope to metal gutters and downspouts, and include ridge-mounted fall arrest systems and grated walkways for maintenance.

The Curling Arena has a suspended foil-faced fabric ceiling for acoustic dampening, radiant heat reflection, and concealing roof framing. A similar ceiling in the Hockey Arena was removed due to puck damage.

3.2 ELECTRICAL INFRASTRUCTURE

Electricity is supplied underground via a pad-mounted transformer on the east side of the building to the lower-level electrical room off the boiler room. There is a high-voltage switchgear manufactured by Federal Pioneer located in the lower-level electrical rated at 600A, 347/600V, three-phase, four-wire and contains two cells:
- Cell 1: Main disconnect switch, rated at 600A
- Cell 2: three 400A disconnects and one 200A disconnect

The lower-level electrical room also contains a dry-type transformer rated at 300 kVA, stepping voltage down from 600 V to 120/208 V, to serve the main switchgear.

The main switchgear is manufactured by Federal Pioneer and is located in the upper-level electrical room. The switchgear is rated for 1200A, 120/208V, three-phase, four-wire and contains three cells:
- Cell 1: Main disconnect switch, rated at 1000A
- Cell 2: one 15A, five 100A, three 200A, and one 300A disconnect switches for various subpanels
- Cell 3: two 60A, six 100A, two 200A, and one 400A disconnect switches for various subpanels

The upper-level electrical room also contains the following:
- disconnect switches rated at 600A, 400A, 200A, 125A, and 100A
- Electrical distribution panel 'H' rated at 225A and panel 'M' rated at 100A
- Two heating panels, each rated at 225A
- lighting control panel 'H'

Power is distributed to approximately 14 subpanels located throughout the hallways, common areas, and service rooms before being supplied to the end fixtures. The circuit-breaker-type panels are rated from 100A to 300A, 120/208V.

3.3 VENTILATION SYSTEMS

Ventilation in Archie Browning Sport Centre is provided mainly by 7 air handling units serving the lounge, lobby, Crow's Nest, dressing rooms, offices and the board room. AHU-4 is also equipped with heat recovery ventilator to recover heat from the dressing rooms, but it is no longer functioning. The hockey arena and curling rink are equipped with dehumidifiers DH-1 and DH-2. There are also 20 exhaust fans.

Table 3-3 Ventilation Systems

SYSTEM ID	AREA SERVED	SCHEDULE	NOMINAL FLOW (CFM)	Fan Power	DESCRIPTION
AHU-1	Lounge	0700-2300	6900	4.5HP	- Model Trane WSC120EWRGA05E4 - Heating and cooling are provided by heat pump - VFD on fan's motors, Installed in 2011
AHU-2	Lower Lobby	0500-2300			- Model MagicAire Model - HW Heating, No Cooling, VFD on fan's motors - Installed in 2011
AHU-3	Crow's Nest	0730-2200	6900	4.5HP	- Model Trane WSC120EWRGA08 - Heating and cooling are provided by heat pump - VFD on fan's motors, Installed in 2011
AHU-4	Dressing rooms	Mon-Fri 1500-2400 Sat-Sun 0700-2400			- Model Trane Model - HW heating, No Cooling, VFD on fan's motors - Installed in 2011
AHU-5	Administration				- Model MicroMetl B6HZ030A25A - Heating and cooling are provided by heat pump - VFD on fan's motors, Installed in 2013
AHU-6	Board Room		1200	0.25HP	- Model York XP036E05P2AZZ10003C - Heating and cooling are provided by heat pump - VFD on fan's motors, Installed in 2015
	1st Floor offices		593	153W	- Model Samsung AC024BXADCH - Heating & cooling are provided by electric heat pump - VFD on fan's motors, Installed in 2023
HRV 1	Dressing Rooms				- Model Renewaire Model - Connected to AHU-4, Not in use, Installed in 2011

SYSTEM ID	AREA SERVED	SCHEDULE	NOMINAL FLOW (CFM)	Fan Power	DESCRIPTION
DH-1	Hockey Rink	Always on during when ice is in	5000		- Model NOVELAIRE DH-8000 - Installed in 2024
DH-2	Curling Rink	Always on during when ice is in	1125		- Model Munters Model, natural gas desiccant wheel - Installed in 2011

Figure 3-2 AHU-3

Figure 3-3 DH-1

Table 3-4 Exhaust Systems

SYSTEM ID	AREA SERVED	DESCRIPTION
Exhaust Fan 1	Wall Under West Bleachers	Model Delki Blowers 618, Installed in 2015
Exhaust Fan 2	Mechanical Room in Lobby	Model Delki Blowers 618, Installed in 2015
Exhaust Fan 3	Roof Above Lounge	Model Greenheck, Installed in 2011
Exhaust Fan 4	Roof Above 2nd Floor Foyer	Model Greenheck, Installed in 2011
Exhaust Fan 5	Roof Above 2nd Floor Foyer	Model Greenheck, Installed in 2011
Exhaust Fan 6	Roof beside Condenser	
Exhaust Fan 7	Roof beside Condenser	
Exhaust Fan 8	Lounge Bar	
Exhaust Fan 9	Crow's Nest Bar	
Exhaust Fan 10	Concession	
Exhaust Fan 11	Gable End Curling Roof (East)	
Exhaust Fan 12	Gable End Hockey Roof (South)	
Exhaust Fan 13	Arena Spectator (East)	Model Greenheck, Installed in 2011
Exhaust Fan 14	Arena Spectator (West)	Model Greenheck, Installed in 2011
Exhaust Fan 15	Zamboni Room Roof	
Exhaust Fan 16	Above Female Changeroom	Model Greenheck, Installed in 2011

SYSTEM ID	AREA SERVED	DESCRIPTION
Exhaust Fan 17	Above Changeroom 1	Model Greenheck, Installed in 2011
Exhaust Fan 18	Above Changeroom 3	Model Greenheck, Installed in 2011
Exhaust Fan 19	Above Changeroom 3	Model Greenheck, Installed in 2011
Exhaust Fan 20	Storage Room	Model Greenheck, Installed in 2011

3.4 SPACE HEATING, DHW AND ICE RESURFACING WATER

The Archie Browning Sport Centre is mainly heated by the central boiler plant. The plant consists of two natural gas fired hot water boilers. One boiler provides hot water for space heating which includes coils in AHU-2 and AHU-4, hydronic baseboard heaters and force flow heaters. The force flow heaters are found in the foyer and curling viewing area; the hydronic baseboard heaters are found in the lounge, hockey viewing area, curling viewing area, washrooms, changing rooms, stairs and reception offices. The other boiler provides hot water for domestic hot water, ice resurfacing (Zamboni) water and additional hot water for the ice melting pit.

Air handling units for the lounge, lobby, Crow's Nest, offices and the board room provide heating using heat pumps. Electric baseboards also provide heating in hockey rink, water supply room and board room.

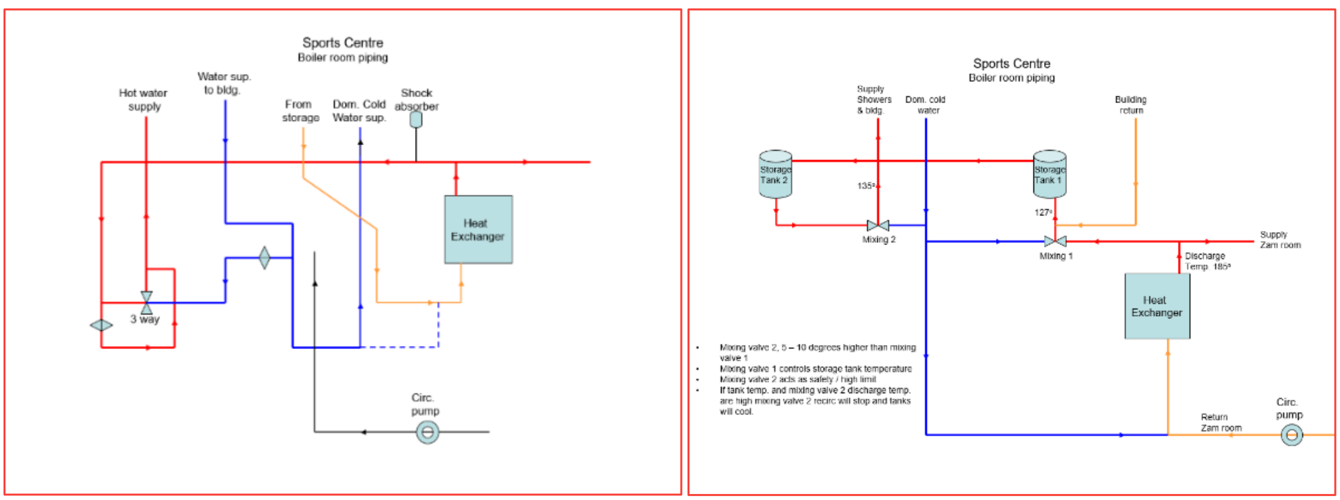


Figure 3-4 Flow diagram of the central heating system of the Archie Browning Sport Centre

Table 3-5 Heating Systems

SYSTEM ID	AREA SERVED	FUEL TYPE	MAX INPUT MBTU/HR	YEAR INSTALLED	DESCRIPTION
Boiler 1	Primary Heating loop	Natural gas	1273	1985	- Buderus Model - Forced Draft boiler
Boiler 2	Primary Heating loop	Natural gas	1273	1985	- Buderus Model - Forced Draft boiler

3.5 REFRIGERATION SYSTEM

Ice for the hockey rink and curling rink is provided by 4 ammonia compressors, connected to two chillers: 1 for the hockey rink and 1 for the curling rink. Heat is rejected to a rooftop evaporative condenser and a rooftop fluid cooler. Condenser heat is also recovered through 3 Therma-Stor tanks. The tanks are currently connected to the ice melting pit. Originally, snow and ice from the Zamboni or ice resurfacing was dumped outside. A snow melt pit was added later. Since there was very little room for the pit, it is small and fills up easily. Also, the coil in the pit is not capable of keeping up with the snow. The operators often have to spray hot water into the pit to melt the snow.

Figure 3-5 Ice Plant Archie Browning Sport Centre

Figure 3-6 Evaporative Cooler

Figure 3-7 Glycol Condenser

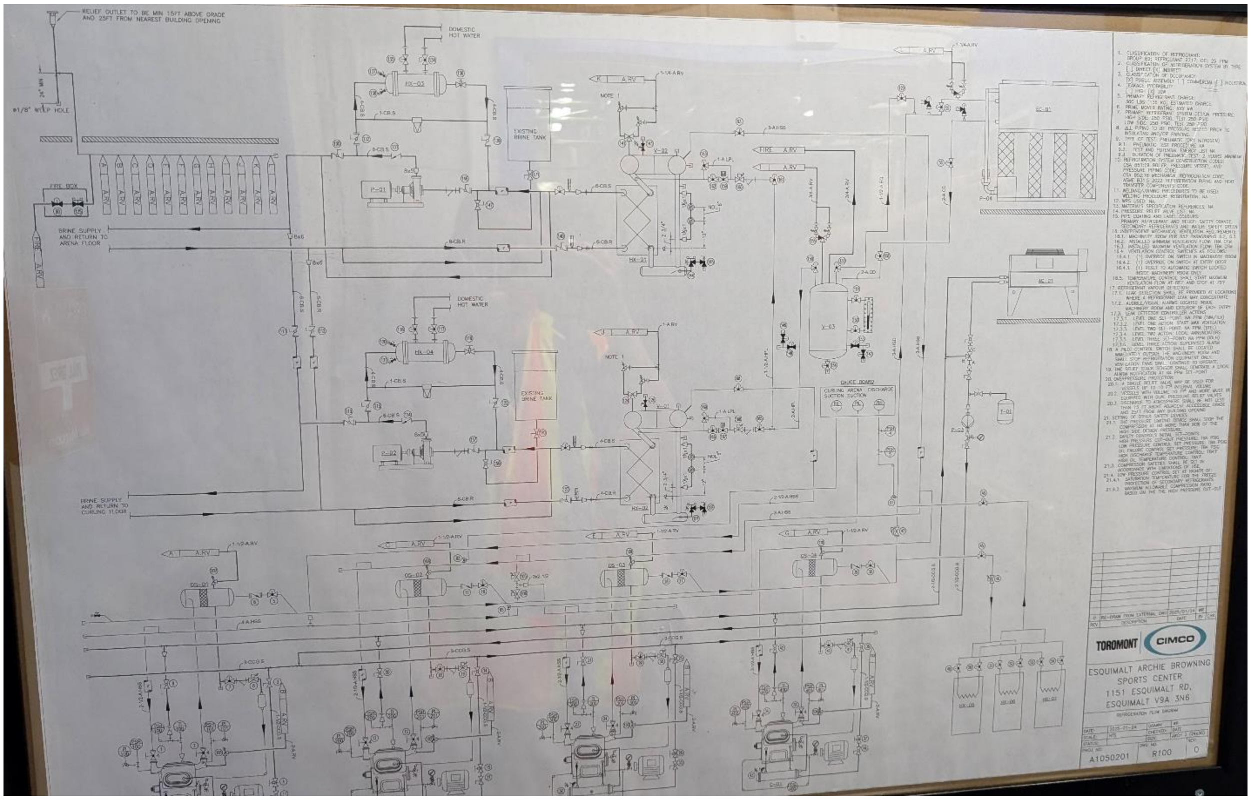


Figure 3-8 Refrigeration Plant Schematic

Table 3-6 Cooling Systems

SYSTEM ID	AREA SERVED	SCHEDULE	CAPACITY (MBH)	YEAR INSTALLED	TYPE	DESCRIPTION
C-01	Hockey and Curling Rink	Ice Rink	420	1985	Compressor	Model Mycom N6WA
C-02	Hockey and Curling Rink	Ice Rink	420	1985	Compressor	Model Mycom N6A
C-03	Hockey and Curling Rink	Ice Rink	420	2000	Compressor	Model Mycom N6WA
C-04	Hockey and Curling Rink	Ice Rink	780	2011	Compressor	Model Mycom N4M
EC-01	Hockey and Curling Rink	Ice Rink	2285	2024	Evaporative Cooler	Model BAC VC1-205
AC-01	Hockey and Curling Rink	Ice Rink	89	2024	Fluid Cooler	Model REFPLUS FLD-113F-9-E013

The refrigeration plant is equipped with 4 pumps: 1 brine pump for each of the hockey and curling rinks, 1 for the glycol loop and 1 for the evaporative cooler loop.

Table 3-7 Pumps

PUMP ID	AREA SERVED	SCHEDULE	POWER (HP)	NOMINAL FLOW (L/S)	DESCRIPTION
P-01	Arena Brine Pump	Brine	25	63.1	VFD operated as a 2 speed pump
P-02	Curling Brine Pump	Brine	15	37.9	VFD operated as a 2 speed pump
P-03	Glycol Pump	Ice Rink	2	4.7	
P-04	Condenser Pump	Ice Rink	1.5	13.9	

3.6 BUILDING AUTOMATION SYSTEM

Archie Browning Sport Centre has a Delta Controls EnteliWEB building automation system (BAS). It monitors and controls the operation of the HVAC systems. The BAS is operated remotely by the service contractor, Island Temperature Controls, and can be accessed remotely by the maintenance staff.

There is a second EnteliTOUCH BAS monitoring and operating the ammonia ice plant components and alarm system. This includes the hockey and curling rink ice temperatures, compressors, condensers, brine pumps and the dehumidifiers. This BAS system is operated remotely by the service contractor, Cimco, and can be accessed remotely by the maintenance staff.

The BAS systems allow operators to schedule the equipment and set nighttime setback. But staff report that BAS scheduling not easy to use and they have not been able to setup what they would like to see. Further training is recommended.

3.7 LIGHTING

Interior lighting are primarily LED lamps, except the Crow's Nest and a few storage and service rooms are still T8 fluorescent lamps. Most of the interior lighting is controlled by motion sensors, with storage and service rooms controlled by manual switches.

Exterior lighting is mainly LED wall mounted fixtures, all the fixtures are LED lamps with timer control.

3.8 PLUG LOADS

The plug loads include office equipment in the reception and 1st floor office, and 3 vending machines in the atrium.

4 EXISTING ENERGY PERFORMANCE

4.1 EXISTING ENERGY PERFORMANCE AND GHG EMISSIONS

4.1.1 ANNUAL UTILITY USAGE AND COSTS

The Archie Browning Sport Centre is supplied with energy and water from these sources:

- Electricity from BC Hydro
- Natural gas from Fortis BC
- Water from the City of Victoria

The utility usage and costs are summarized below. A baseline period of May 2024 through April 2025 was selected as this is after the replacement of the natural gas fired dehumidifier and best reflects the current conditions.

Table 4-1 Baseline Data (May 2024 – April 2025)

Utility	Consumption		Equivalent Consumption		Rate		Cost	Energy Use Intensity (ekWh/ft²)
Electricity Consumption	1,704,194	kWh	1,704,194	kWh	0.0653	$/kWh	$99,324	26.17
Electricity Demand	3,641	kW			13.30	$/kW/mo	$48,425	
Natural Gas	2,166	GJ	601,574	ekWh	8.29	$/GJ	$28,338	9.24
Water*	9,426	m³			1.87	$/m3	$17,642	
Total Equiv. Energy Consumption			**2,305,768**	**ekWh**	**Total Cost**		**$193,730**	**35.41**

* Water baseline is May 2023 - April 2024 to avoid excess water consumption issues at the condenser in the fall 2024

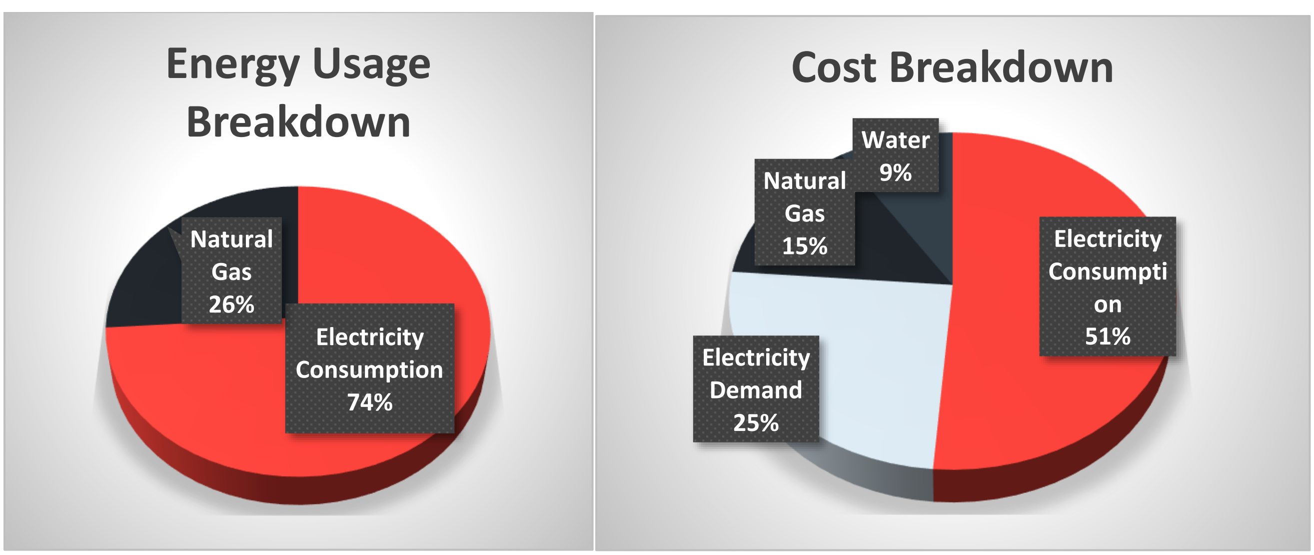


Figure 4-1 Energy and Utility Cost Breakdown

The monthly energy usage shows a very unusual profile where the usage is high beginning in August and ending in April. This matches the hockey and curling rink ice schedule which is expected. The summer energy usage is low. This indicates that the majority of the energy consumption occurs when the ice plant is active.

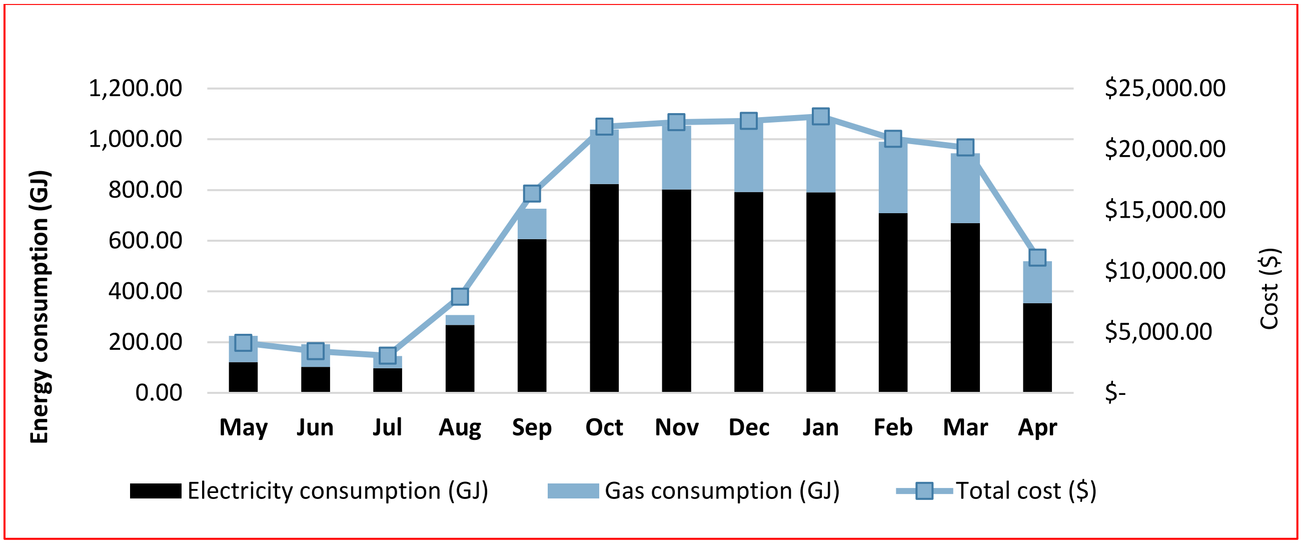


Figure 4-2 Monthly Energy Consumption and Cost

4.1.2 ANNUAL GHGS

The annual GHG emissions for the Archie Browning Sports Centre during the baseline period of May 2024 through April 2025 is summarized below. The majority of the emissions come from natural gas consumption.

Table 4-2 4-3 GHG Emissions Data (May 2024 – April 2025)

Utility	Consumption		% of Total Energy	GHG Emissions (tCO_2e)	% of total GHG emissions	GHG Emissions Intensity (kg CO_2e/ft^2)
Electricity	1,704,194	kWh	74%	24	18%	0.37
Natural Gas	2,166	GJ	26%	112	82%	1.72
Total				136		2.08

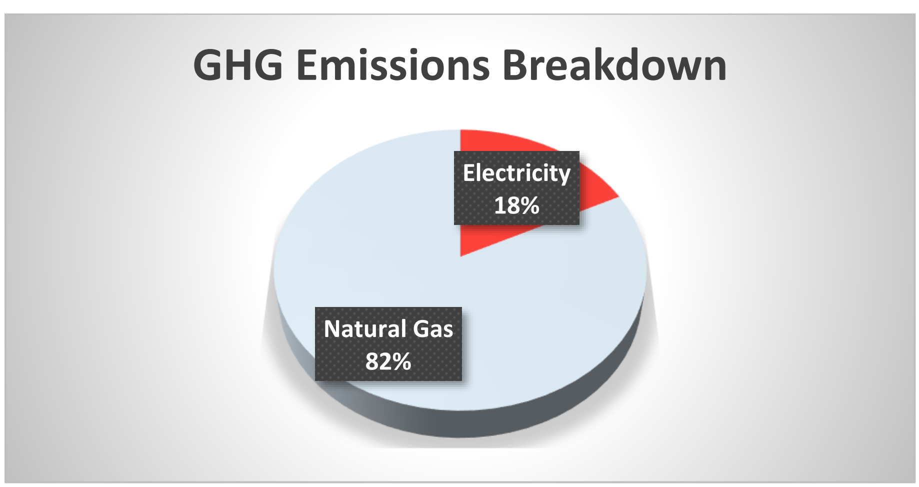


Figure 4-3 GHG Emissions Breakdown

4.1.3 ELECTRICITY

Electricity consumption at the Archie Browning Sports Centre was assessed starting from December 2022. The data is shown below with a starting month of August to match the ice plant operation. The electricity consumption dramatically increased starting in August 2024. This is due to the replacement of the natural gas fired dehumidifier with a new electric unit. Given this change, the baseline was selected as May 2024 to April 2025.

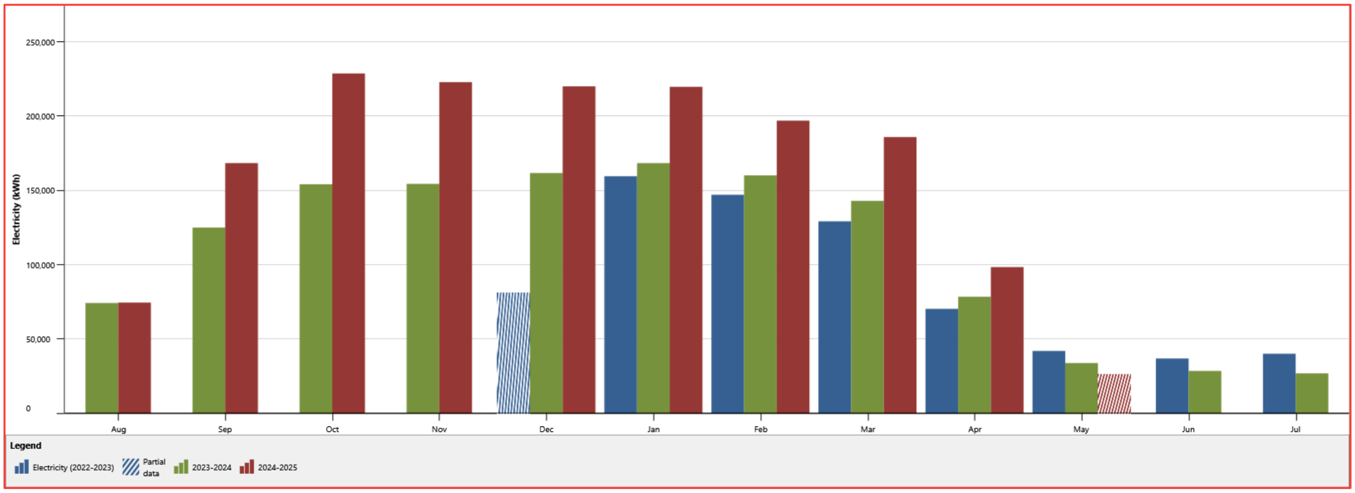


Figure 4-4 Monthly Electricity Consumption December 2022 to April 2025

The Archie Browning Sports Centre consumed 1,700,000 kWh of electricity from May 2024 to April 2025 with a peak power demand of 444 kW in March and a total cost of $147,750.

The following figure shows the monthly electricity consumption and power demand. Electricity and demand follow the seasonal operation of the ice plant. Consumption and demand are lowest in the summer when the ice plant is shut down.

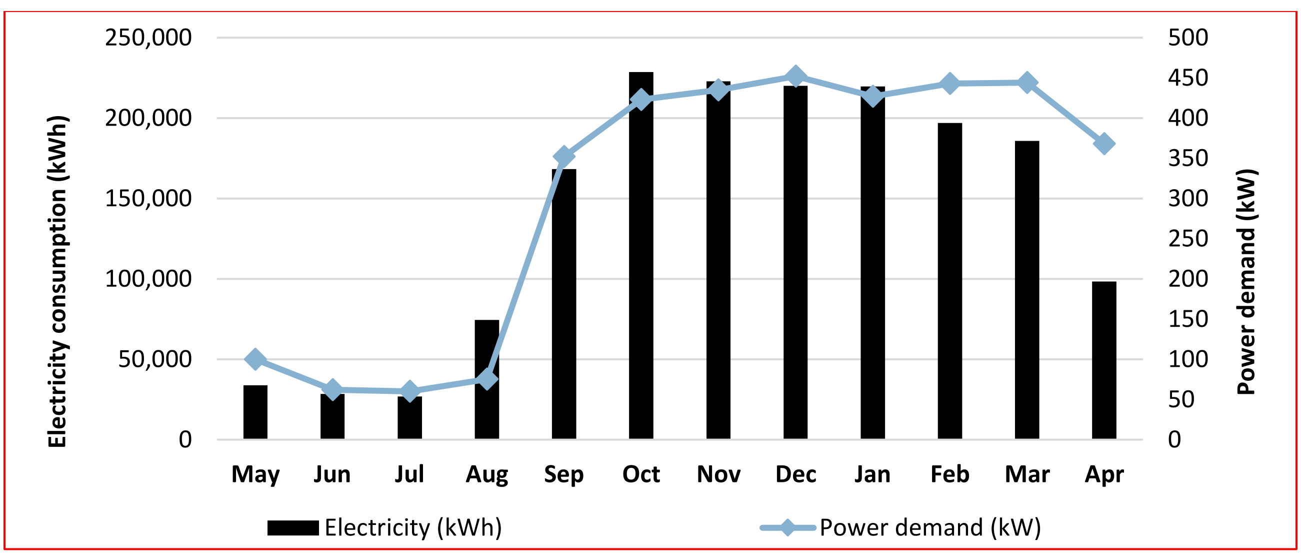


Figure 4-5 Monthly Electricity Consumption and Demand

The electricity consumption does not correlate with degree days – heating and/or cooling. Heating loads are addressed mainly by natural gas. Building cooling is not a significant load. The main variable affecting the electricity is the ice plant and which ice pads have ice in. This was modeled as a production variable, call *Ice days* where the number of days that each arena had ice was input. Regression analysis found a linear correlation between electricity consumption and ice days.

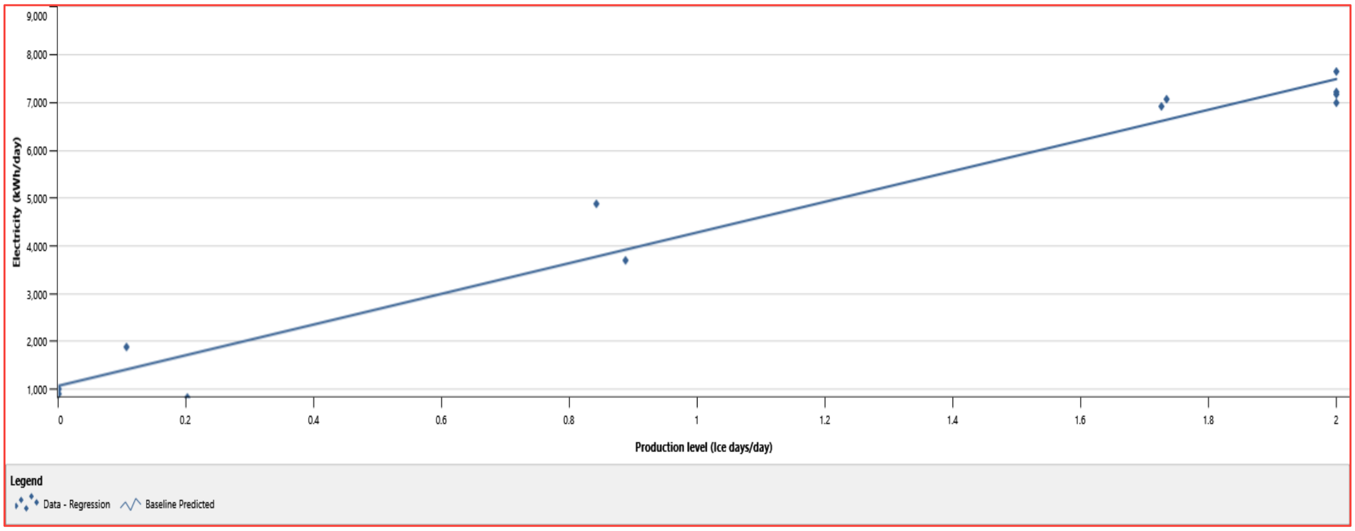


Figure 4-6 Electricity Consumption vs Ice Days

Equation

Data table	Electricity consumption - 5130700
Dependent variable (Y)	Electricity (kWh)
Independent variable (x)	Production level (Ice days)
Method	Daily
Weighted	Yes

Regression results

$Y = 3,209.2682 * x + 1,073.2459$

$R^2 = 0.9672$

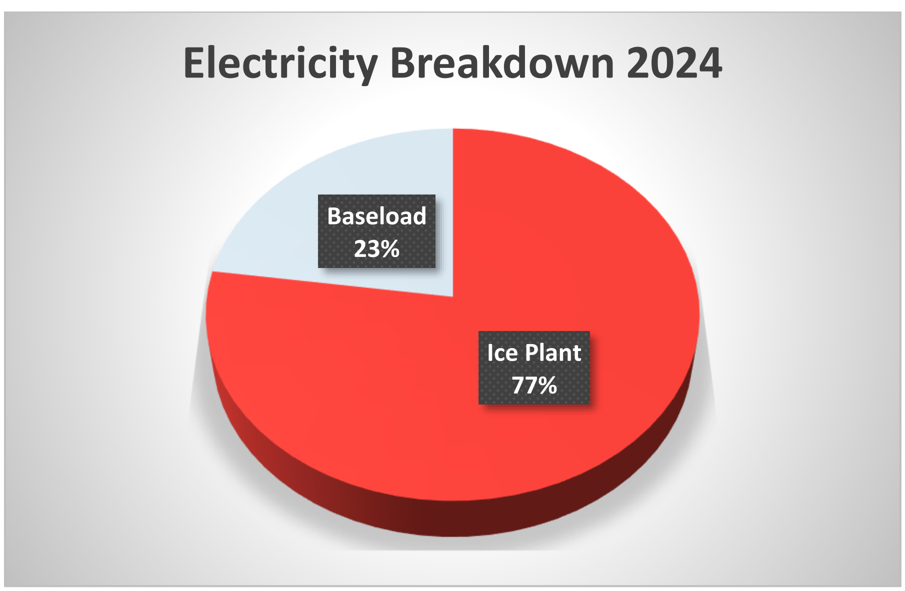


Figure 4-7 Electricity Regression Breakdown

Interval Data

Hourly meter interval data was obtained from BC Hydro and analyzed. Data was only available from January 1 to June 6, 2025. The data shows the sharp drop in usage when the ice plant shuts down in April.

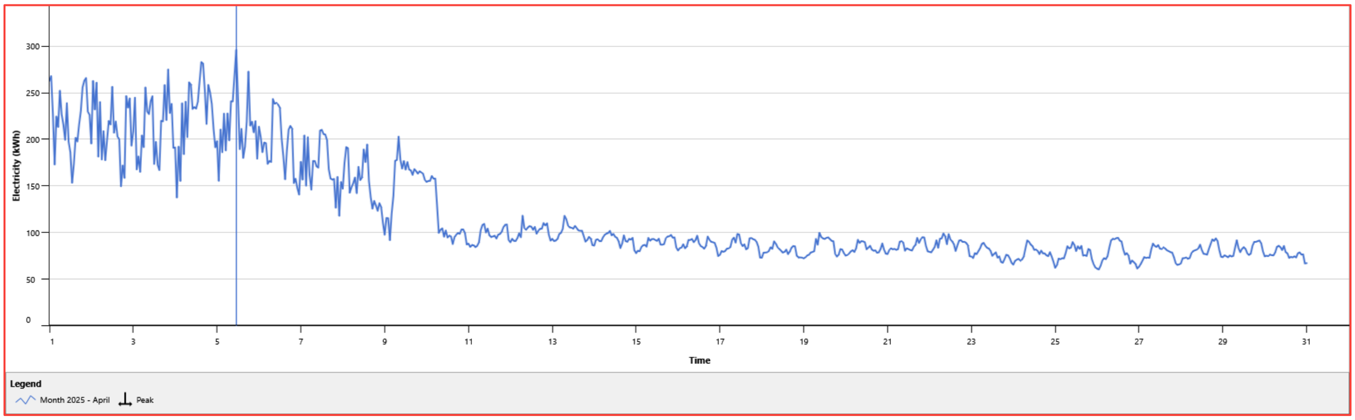


Figure 4-8 Electricity Interval Data April 2025

Review of weekly data does not find any regular daily profiles, either in the winter when the ice plant is on or in the spring when the ice plant is shut down.

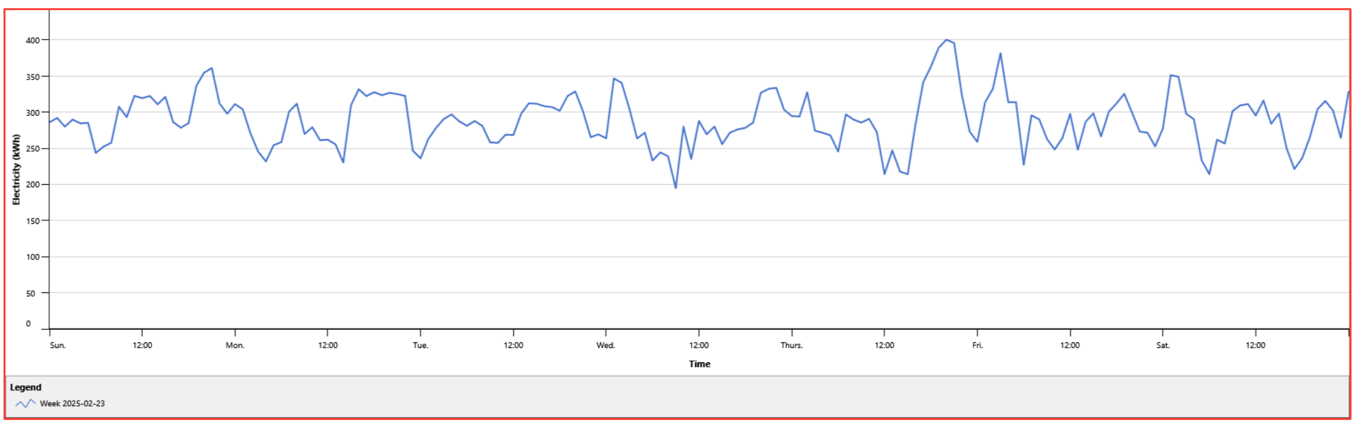


Figure 4-9 Electricity Interval Data Week Starting Feb 23, 2025

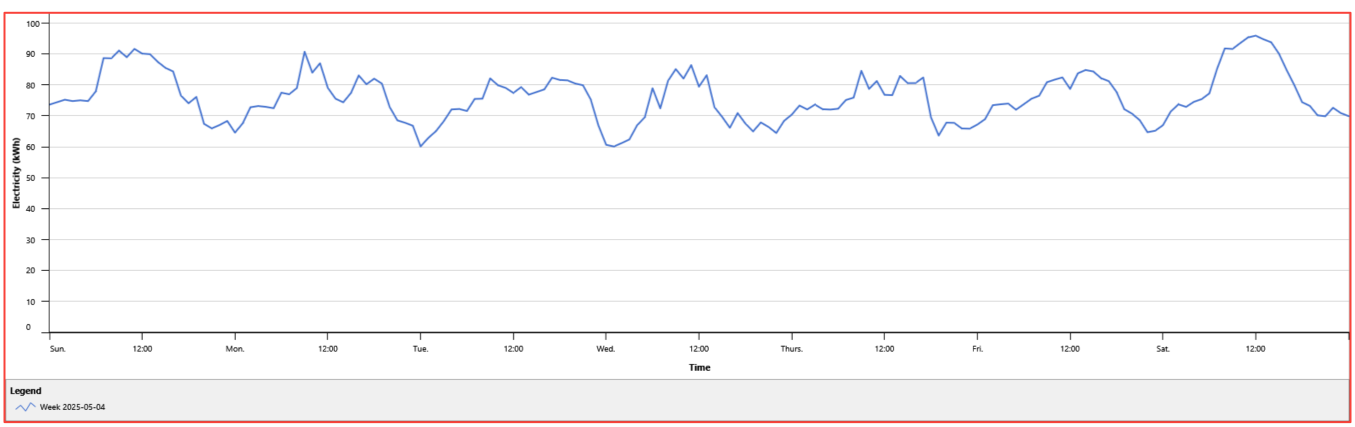


Figure 4-10 Electricity Interval Data Week Starting June 4, 2025

Heatmap
The interval data was also graphed as a heatmap, where all of interval data is displayed. The top right shows the beginning, Jan 1, ending in the bottom right with June 6. The days of the week run along the bottom.

Dark squares indicate high consumption; lighter squares indicate lower consumption. The graph shows no discernable pattern, indicating that little to no equipment is off during unoccupied hours. The building uses the same energy at night as during the day which is unusual. There is no difference between weekdays and weekends, which is expected for an arena. Lighter squares begin in April, when the ice plant shuts down.

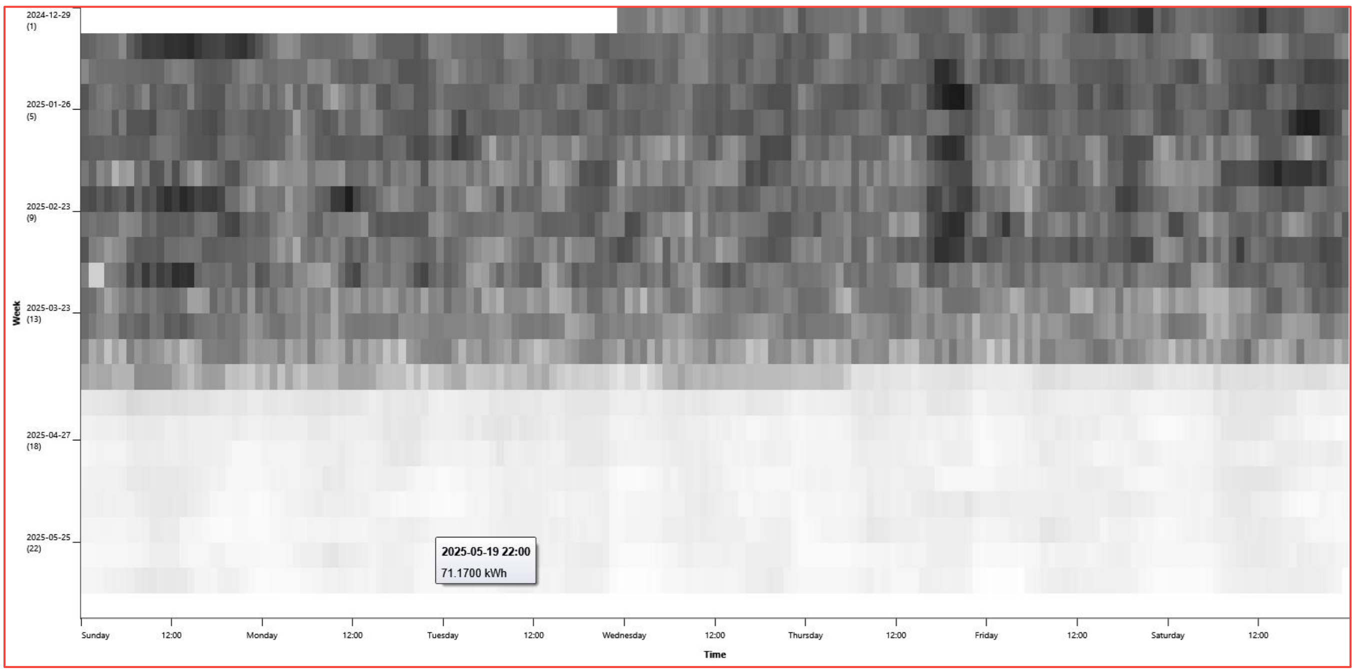


Figure 4-11 Heatmap of Electricity Interval Data January to June 2025

An example of clear daily scheduling of equipment is seen in the Esquimalt Recreation Centre heatmap. Dark and light bands indicate operation of equipment.

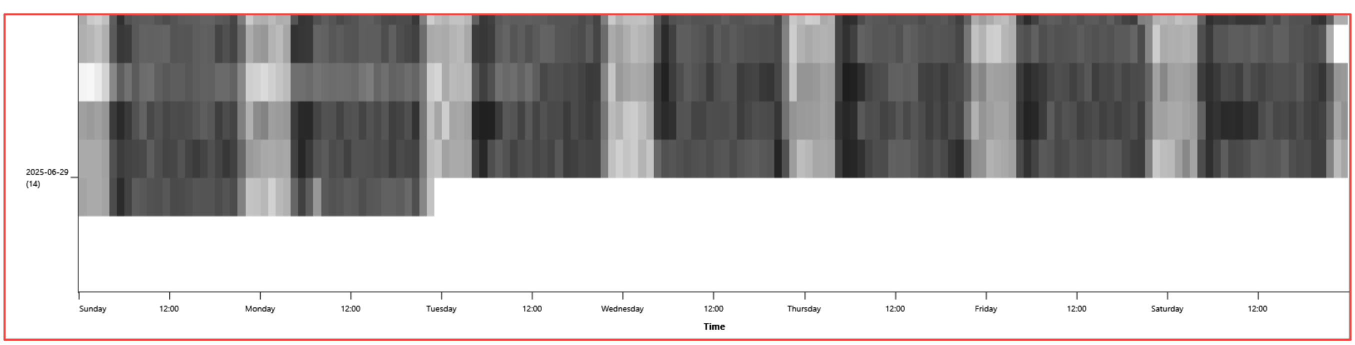


Figure 4-12 Example Recreation Centre Heatmap of Electricity Interval Data

4.1.4 NATURAL GAS

Natural gas consumption at the Archie Browning Sports Centre was assessed starting from September 2022. The data is shown below with a starting month of August to match the ice plant operation. The consumption dramatically decreased starting in August 2024, opposite to electricity, due to the replacement of the natural gas fired dehumidifier with a new electric unit. Given this change, the baseline was selected as May 2024 to April 2025. The Archie Browning Sports Centre consumed 2,166 GJ of natural gas in that time at a cost of $28,338.

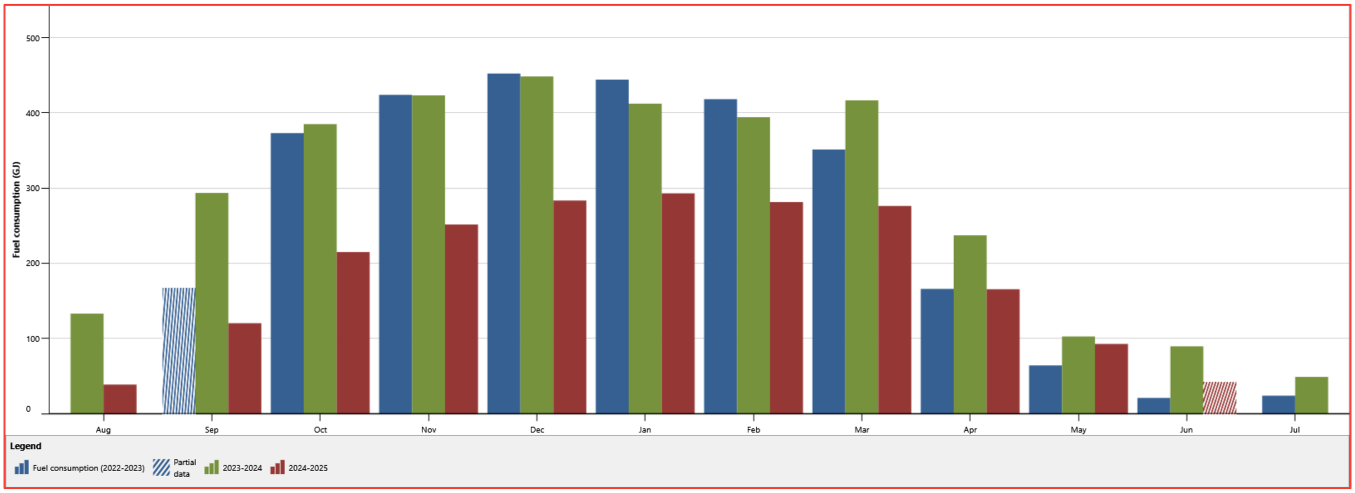


Figure 4-13 Monthly Natural Gas Consumption September 2022 to April 2025

The natural gas consumption is related to weather or heating degree days. It is also affected by the operation of the ice plant. When the ice plant is are operating and the arenas have ice, natural gas usage increases due to DHW loads and ice resurfacing (Zamboni) water.

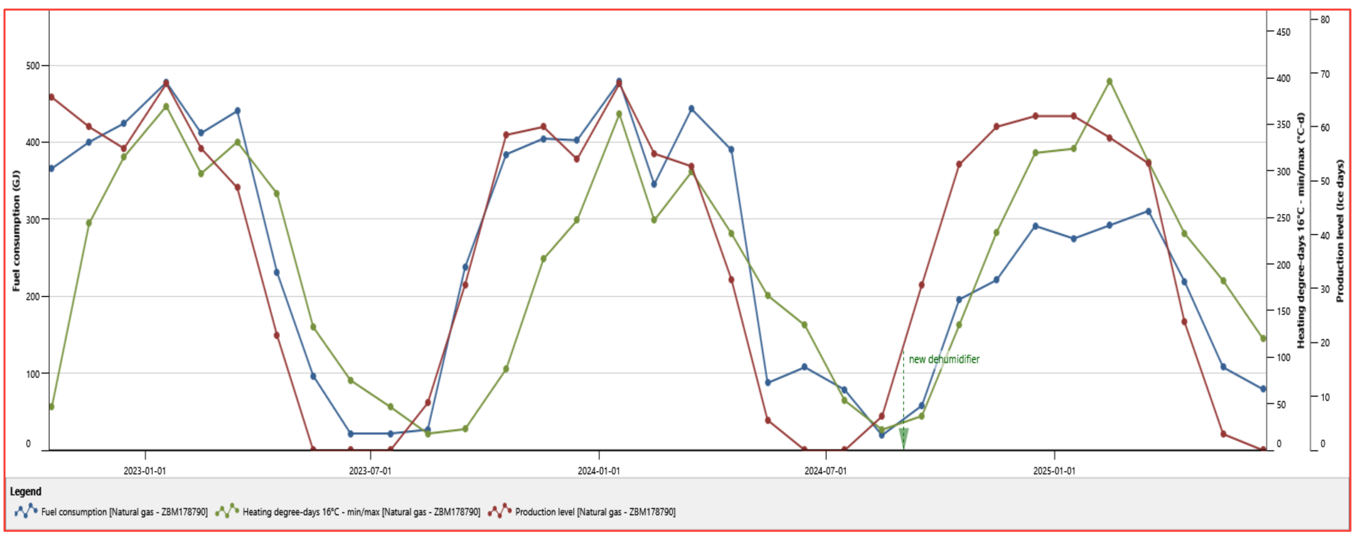
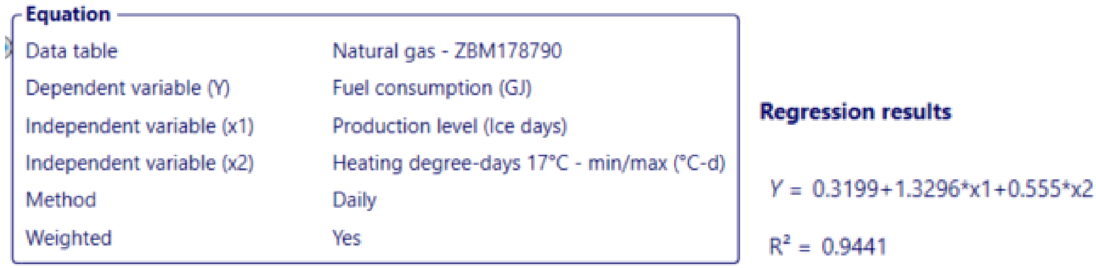


Figure 4-14 Monthly Natural Gas Consumption, HDD and Ice Days

A regression analysis finds a very good correlation between natural gas consumption and HDD and Ice Days. The results indicate that approximately of the consumption 69% building heating, 25% is related to the operation of the ice plant and 6% is baseload.



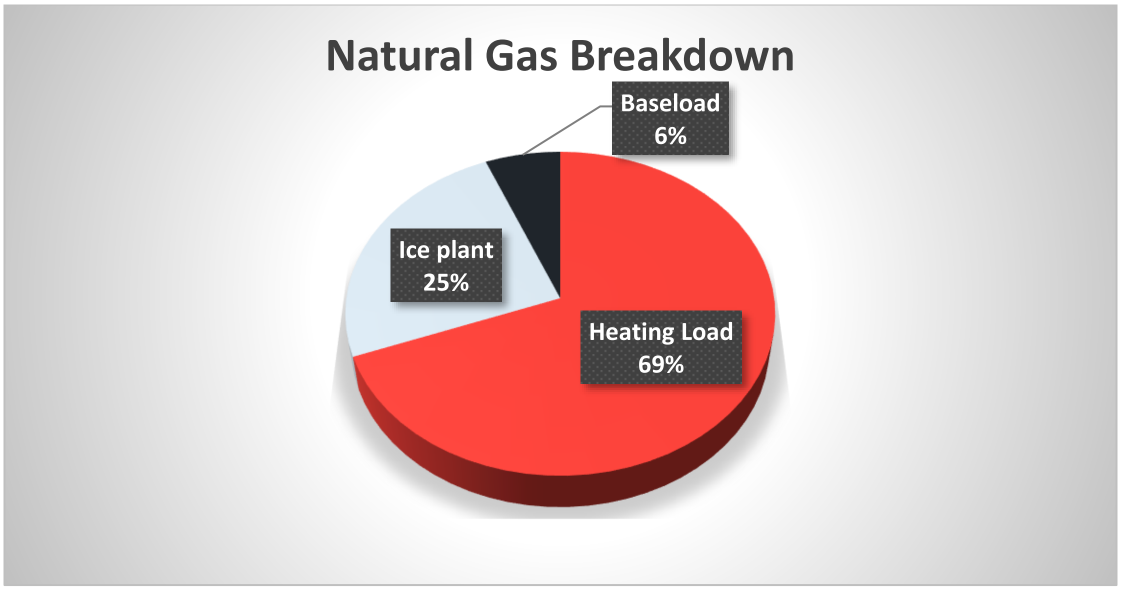


Figure 4-15 Natural Gas Regression Breakdown

4.1.5 WATER

The Archie Browning Sports Centre consumes water provided by the City of Victoria. Water is only invoiced 3 times per year, generally every 120 days. Water usage increased dramatically starting in the summer of 2024 due to issues with the replacement condenser. Once-through cooling was done with city water until the issue was resolved in the winter of 2025. The period from May 2023 - April 2024 was selected as water baseline is to avoid excess water consumption issues. In that time period, the Archie Browning Sports Centre consumed 3,329 100ft^3 or 9,426 m^3 at a cost of $17,642.

Table 4-4 4–5 Water Invoice Data (Oct 2021 – Feb 2025)

Begin	End	Duration (Days)	Water Consumption (100 ft^3)	Water Consumption (m^3)
2021-10-22	2022-02-15	117	1388	3,930
2022-02-16	2022-06-16	121	533	1,509
2022-06-17	2022-10-24	130	818	2,316
2022-10-25	2023-02-14	113	1281	3,627
2023-02-15	2023-06-16	122	692	1,960
2023-06-17	2023-10-24	130	899	2,546
2023-10-25	2024-02-21	120	1641	4,647
2024-02-22	2024-06-18	118	893	2,529
2024-06-19	2024-10-16	120	1771	5,015

2024-10-17	2025-02-18	125	2538	7,187

With total floor area of 6,050 m^2, this total annual water consumption amounts to a water use intensity of 1.56 m^3/m^2 and water cost index of $2.92/$m^2$.

Water consumption is strongly related to the operation of the ice plant. Water is used to create and maintain the ice pads. It is also used in ice resurfacing (Zamboni) water and to assist in the ice melting pit. A regression analysis finds a very good correlation between water consumption and Ice Days. The results indicate that approximately 67% of the water consumption is related to the operation of the ice plant and 33% is baseload.

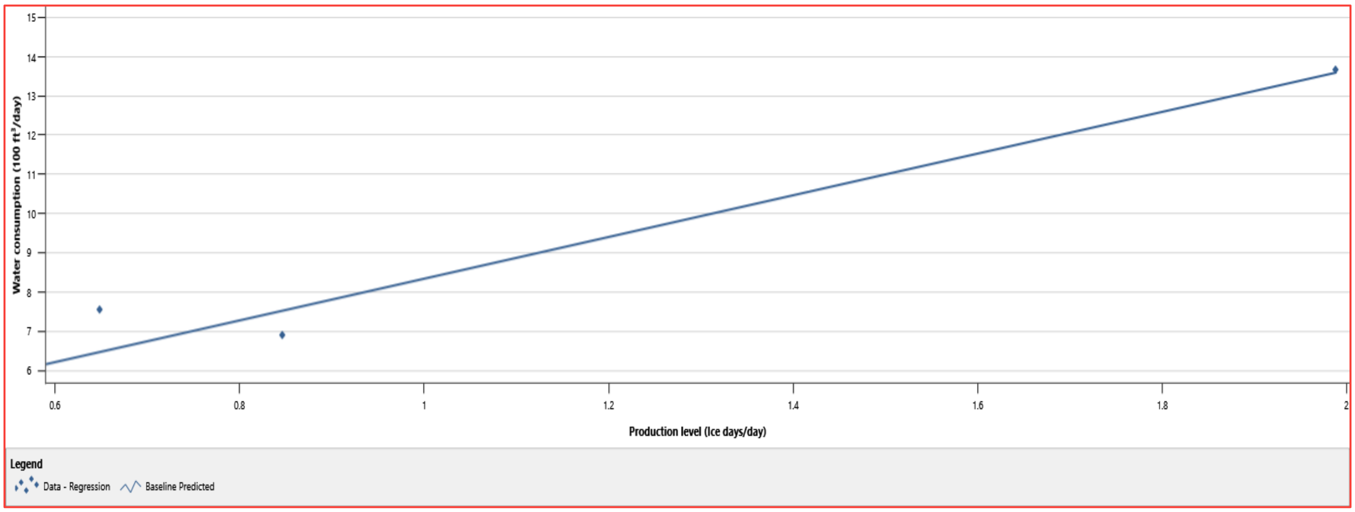


Figure 4-16 Water Consumption vs Ice Days

Equation

Data table	Water consumption - Municipal - A-60874275
Dependent variable (Y)	Water consumption (100 ft³)
Independent variable (x)	Production level (Ice days)
Method	Daily
Weighted	Yes

Regression results

$Y = 5.3124*x+3.03$

$R^2 = 0.9522$

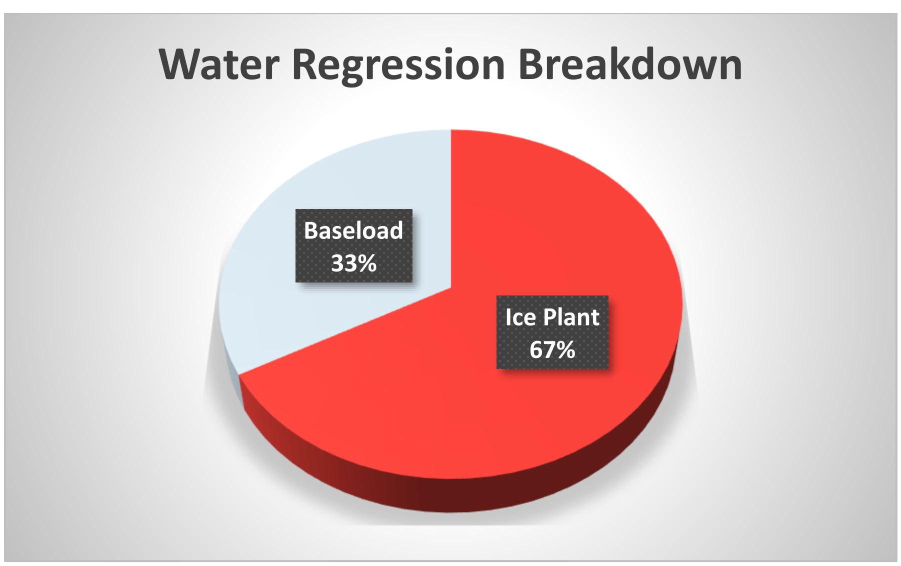


Figure 4-17 Water Regression Breakdown

Working with the water regression and the water audit, the end use breakdown was estimated. Water is used for domestic water fixtures such as the taps, showers and toilets. Water is also used for ice resurfacing or the Zamboni. The ice resurfacing water is estimated based on the reported number of report floods and the amount of water used in each flood. This is not a precise calculation; there can be a large margin of error. Water is also consumed by the rooftop condenser in evaporation as well as ice maintenance, cleaning, etc. Again, the exact amount is difficult to calculate. Lastly, water is used to assist the snow melting pit. The snow melting pit uses heat recovered from the ice plant to melt the snow in the pit. But there is a problem that the coil is not able to keep up with the accumulation when the arena is busy. A hand operated hose is used to spray hot water on the snow to complete the snow melting. The amount of water used in the snow melting pit is not known since it is done manually and varies widely.

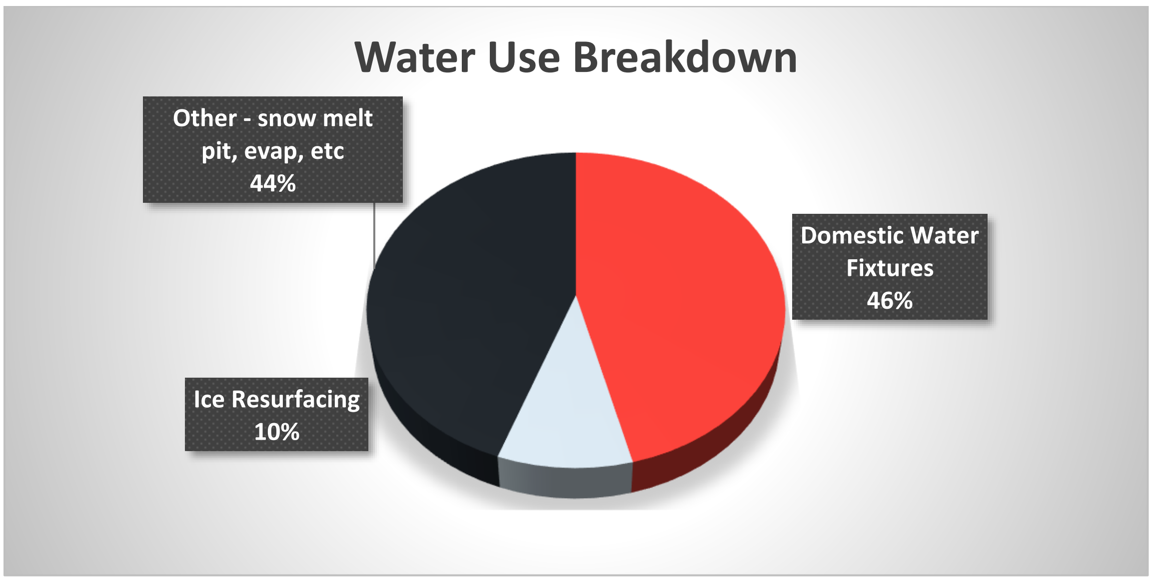


Figure 4-18 Water Use Breakdown by Sub-System

4.2 ENERGY PERFORMANCE BENCHMARKING

For context, we have compared the building's energy use intensity (EUI) with the 2019 Survey of Commercial and Institutional Energy Use for Recreation Centres of 27.6 ekWh/ft^2. The EUI of the Archie Browning Sports Centre is worse than this average. This means that the building uses more energy for its size than the majority of Canadian recreation centres.

But average for recreation centres includes facilities that do not have ice rinks. Instead, the EUI was compared to a database of similar recreation centres with ice pads that has an average EUI of 40 ekWh/ft^2. The EUI of the Archie Browning Sports Centre is less than that average, indicating that the facility's energy use is not out of line for this type of facility.

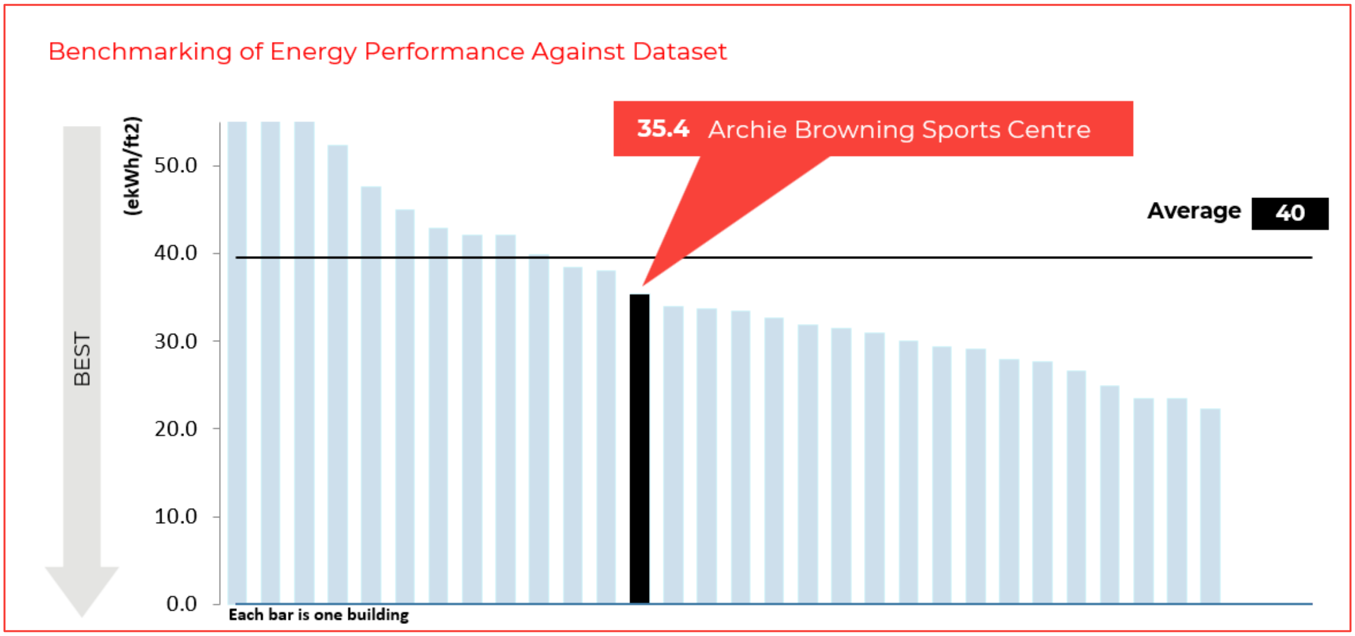


Figure 4-19 Archie Browning Sports Centre EUI Compared to Similar Facilities

4.3 END-USE-BREAKDOWN

The following graph shows the estimated energy end-use breakdown for the Archie Browning Sports Centre.

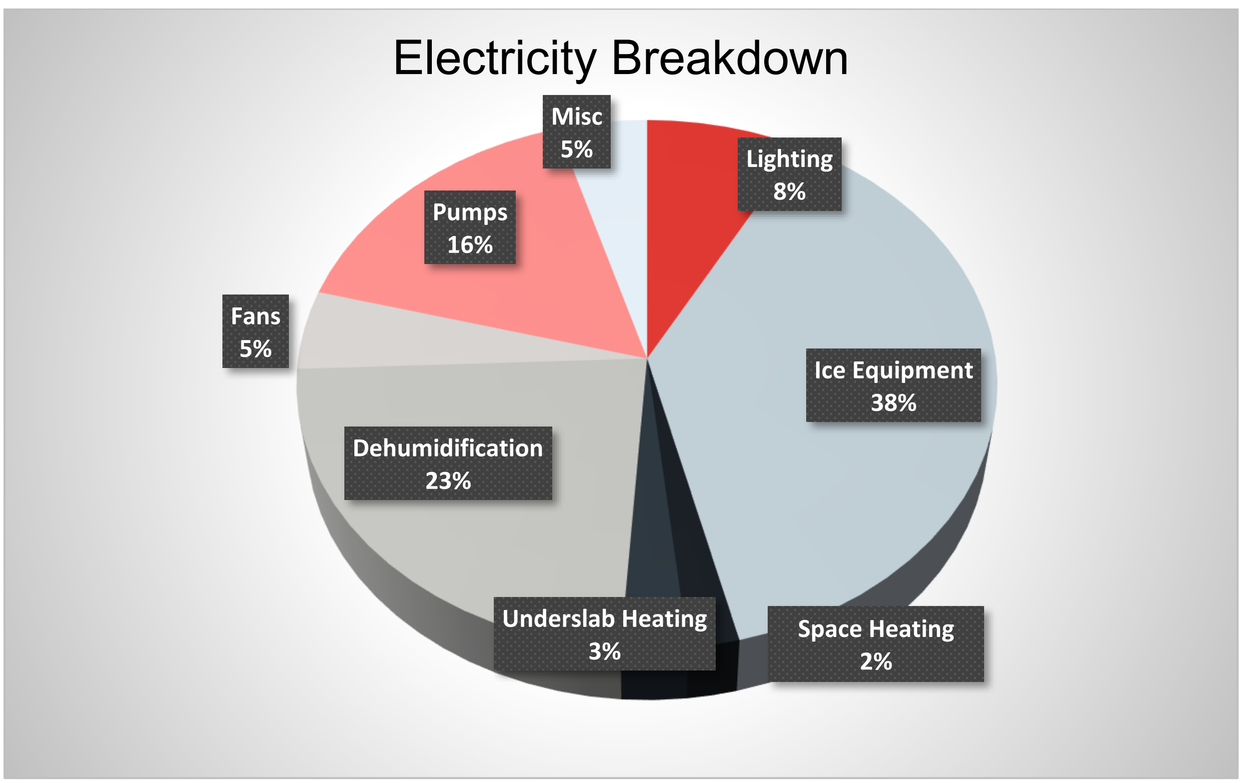


Figure 4-20 Electricity End Use Breakdown

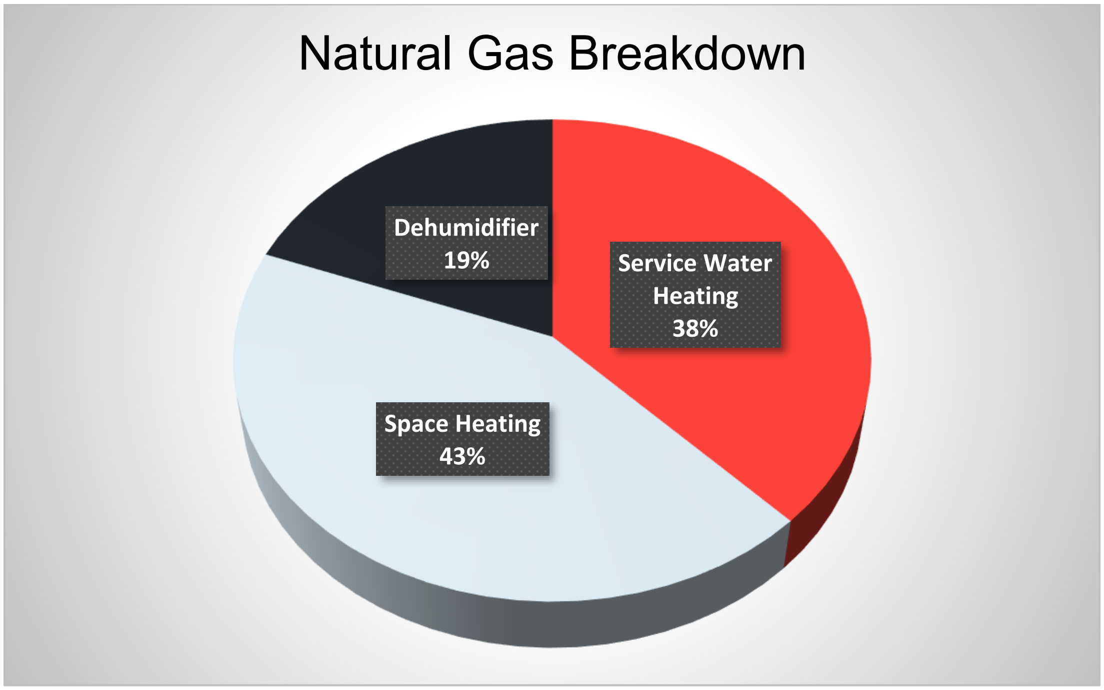


Figure 4-21 Natural Gas End Use Breakdown

5 KEY FINDINGS

The key findings of the Building Retrofit Study are captured below. These also include measures proposed by Polar Engineering in their report, *Heat Recovery and Gas Conservation Study.* The findings from our investigation have been divided into the following categories:

1. Business as usual or **BAU** measures

   This is scheduled or anticipated work that will impact energy usage and GHG emissions but is not necessarily optimized. It is like-for-like or standard equipment replacements in some cases. In other cases, it is necessary work or upgrades due to equipment failures. These measures include

   - Heating Boiler Replacement
   - Curling Dehumidifier DH-2 Replacement

2. Energy Conservation Measures

   There are energy conservation measures or **ECMs** that are not in the BAU.
   - REALice De-oxygenerator
   - BAS Recommissioning

   The Polar Engineering report proposed measure **Bundle 1**
   - Brine header and piping replacement that includes new underfloor heating from the ice plant
   - Snowmelt Pit Heat Recovery

   The Polar Engineering report proposed measure **Bundle 2**
   - Site-specific Heatpump
   - Arena Dehumidifier Energy Recovery
   - Boiler Replacement
   - Low-Flow Showerheads

3. GHG Reduction Strategies

   These are measures and specific strategies to reduce GHG emissions.

   - Heat Pump Boiler
   - PV Panels

6 BUSINESS AS USUAL MEASURES

Business as usual or BAU measures are scheduled or anticipated work that will impact energy usage and also GHG emissions but is not necessarily optimized. It is like-for-like or standard equipment replacements that are typically done for equipment that is approaching its end of life or not functioning properly.

6.1 REPLACE HEATING BOILERS

6.1.1 OPPORTUNITY

The heating plant consists of two natural gas-fired, atmospheric boilers, B-1 and B-2. These supply hot water for heating the building and for the DHW. It was reported that the boilers have been performing well. While the two boilers have had overhauls and upgrades over the years, they have exceeded their typical service life and general replacement is anticipated within the next few years.

6.1.2 SCOPE OF MEASURE

This measure proposes replacing the boilers with equivalent-capacity units that are high efficiency condensing boilers. This is similar to work that was done at the Esquimalt Recreation Centre in 2024.

Table 6-1 Savings

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
57,000 ekWh/yr	2%	$1,700 /yr	10 tCO2e	8%	$216,000	NA

6.2 REPLACE CURLING DEHUMIDIFIER

6.2.1 OPPORTUNITY

There are two outdoor desiccant dehumidifier units; one unit, DH-1, serves the hockey rink and the other, DH-2, serves the curling rink. The dehumidifier unit DH-1 serving the hockey rink was replaced in 2024 with a packaged electric unit. This unit was sized with capacity to serve both the arena and curling rink but is currently only used for the arena. It was intended to replace the dedicated curling dehumidifier unit when it reaches end-of-life.

The curling rink dehumidifier unit DH-2 is a Munters unit from 2011. The unit includes a natural gas burner providing a heating capacity of 100 MBH and a desiccant wheel. The unit's casing is rusting and showing signs of general weathering from years of weather exposure. No major issues were reported regarding capacity or operation during the site review.

6.2.2 SCOPE OF MEASURE

The DH-2 unit is old and approaching the end of its useful life. It is expected to be replaced with a packaged electric unit similar to DH-1 serving the hockey rink or to be served by DH-1.

Since the DH-2 unit is smaller, the impact is expected to be less than with the DH-1 unit replacement in 2024.

Table 6-2 Savings

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
24,500 ekWh/yr	1%	-$2,500 /yr	20 tCO2e	15%	$383,000	NA

7 ENERGY CONSERVATION MEASURES

There are new energy conservation measures or ECMs that are not included the BCA. There are also the bundles of measures from the Polar Engineering report, later in this section.

7.1 REALICE DE-OXYGENERATOR

7.1.1 OPPORTUNITY

Currently, ice resurfacing is done using domestic hot water.

7.1.2 SCOPE OF MEASURE

REALice is a commercial product that facilitates ice resurfacing using regular water, not hot water. It removes the micro air bubbles that are in the water, similar to water heated in a boiler to 60°C. REALice treated water is also denser, takes less energy to freeze and to keep frozen.

Using unheated water for ice resurfacing results in a significant reduction in water heating costs.

Figure 7-1 REALice Spray Nozzles

Table 7-1 REALice De-Oxygenerator Savings

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
75,000 ekWh/yr	3%	$2,700 /yr	12 tCO2e	9%	$38,400	4.7 years

7.2 BAS RECOMMISSIONING

7.2.1 OPPORTUNITY

The BAS controls and schedules major HVAC equipment in the building. But there are areas where local heat pumps have been added that may not be in sync with the perimeter heating or similar inefficiencies. All equipment should be on DDC controls where possible to improve occupant comfort and energy efficiency.

7.2.2 SCOPE OF MEASURE

Over time, inefficiencies or poor operating practices can creep into the control systems setpoints and sequencing. We recommend recommissioning the HVAC equipment and controls. This would consist of reviewing the overall operation of the systems and identifying energy-saving opportunities. We recommend regular re-commissioning and BAS upgrades to keep pace with changing technology, including software and head-end system upgrades and partial point device replacements.

Energy saving strategies include unoccupied setback of space temperatures, scheduling where possible and sequencing heat pumps over hot water heating, etc.

Table 7-2 BAS Recommissioning Savings

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
46,000 ekWh/yr	2%	$2,500 /yr	2 tCO2e	2%	$10,000	3.9 years

Bundle 1

There are measures proposed by Polar Engineering in their report, *Heat Recovery and Gas Conservation Study.* Bundle 1 from this report includes

- Underfloor heat recovery
- Snowmelt pit heat recovery.

These measures have been put forward and are anticipated to be done in 2026 or 2027.

7.3 UNDERFLOOR HEAT RECOVERY

7.3.1 OPPORTUNITY

The brine piping network within the hockey and curling rink slabs is original and reported to be leaking. Efforts have been made to address the leaks using an additive but this has not corrected the problem. The additive has required that the brine pumps operate continuously, including during the summer months. Underfloor or under-slab heating is accomplished using electric resistance coils.

7.3.2 SCOPE OF MEASURE

There is a planned project to replace the arena brine piping and underfloor heating. The proposed system for the underfloor heating is a hydronic loop using heat recovered from the ice plant ammonia compressors, essentially free heat. The new piping system will not require continuous brine pump operation. These aspects are expected to save electricity.

Table 7-3 Underfloor Heat Recovery Savings

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
100,000 ekWh/yr	4%	$6,500 /yr	1 tCO2e	1%	$1,500,000	NA

7.4 SNOWMELT PIT HEAT RECOVERY

7.4.1 OPPORTUNITY

The snowmelt pit is intended to melt snow using a coil that is fed from a small heat exchanger connected to the DHW heating boiler. There is also a small electric boiler connected to the snowmelt piping for makeup heat; however, this boiler is at end-of-life and it is non-operational or operating at minimal capacity.

There is also a backup DHW spray system that is used when the snow builds up in the pit. This back up system is used very often as the heating system unable to keep up with snowmelt loads when the arena is in full use.

7.4.2 SCOPE OF MEASURE

It is proposed to integrate the snow melt pit with the heat recovery system for the underfloor system. This will capture waste heat from the ice plant to a low-temperature heat recovery coil in the snowmelt pit. The coil will be customized to fit the site-specific dimensions of the snowmelt pit.

Table 7-4 Snowmelt Pit Heat Recovery Savings

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
100,000 ekWh/yr	4%	$3,600 /yr	18 tCO2e	13%	$134,000	37 years

This includes 264 m3 of water savings.

Bundle 2

The report also presents a Bundle 2 that includes measures

- Site-specific heatpump
- Arena dehumidifier preheat coil
- Boiler replacement
- Low-flow showerheads.

It is reported that this bundle may be considered in future but is not budgeted at this time.

7.5 SITE-SPECIFIC HEATPUMP

7.5.1 OPPORTUNITY

This measure is described in detail in the Polar Engineering report. It includes installing a custom heat pump system or site-specific heatpump (SSHP) in the boiler plant that is integrated with the ammonia refrigeration plant to heat the building and the DHW loads. The savings may be reduced by other measures that reduce the boiler heating loads.

Table 7-5 Site-specific Heatpump Savings

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
200,000 ekWh/yr	7%	$2,700 /yr	55 tCO2e	41%	$382,000	NA

7.6 ARENA DEHUMIDIFIER PREHEAT COIL

7.6.1 OPPORTUNITY

This measure is described in detail in the Polar Engineering report. It proposed to install a preheat coil in the arena dehumidification unit DH-1 fed from the SSHP system. This would offset the electrical consumption of the internal heating element by preheating the reactivation airstream.

Table 7-6 Arena Dehumidifier Preheat Coil Savings

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
84,500 ekWh/yr	4%	$5,500 /yr	1 tCO2e	1%	$76,000	14 years

7.7 BOILER REPLACEMENT

7.7.1 OPPORTUNITY

This measure is described in detail in the Polar Engineering report. Similar to the BAU measure, this measure proposes replacing the existing boilers with new condensing boilers. It also includes a additional DHW storage tank to address issues with inadequate supply during peak times.

Table 7-7 Boiler Replacement

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
6,700 ekWh/yr	0%	$200 /yr	1 tCO2e	1%	$193,500	NA

7.8 LOW-FLOW SHOWERHEADS

7.8.1 OPPORTUNITY

This measure is described in detail in the Polar Engineering report. It includes replacing the existing showerheads with low-flow fixtures. This reduces water consumption and DHW loads.

Table 7-8 Low-flow Showerheads

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
20,000 ekWh/yr	1%	$500 /yr	4 tCO2e	3%	$20,000	40 years

8 GHG REDUCTION MEASURES

The vast majority of the GHG emissions (82%) come from natural gas consuming equipment. Substantial reductions can only be achieved by measures that reduce or eliminate this equipment.

Table 8-1 List of Natural Gas Consuming Equipment

SYSTEM ID	DESCRIPTION
Boiler 1	Natural Gas fired hot water boiler – for building heating
Boiler 2	Natural Gas fired hot water boiler – DHW, ice re-surfacing, snow melting
DH-2	Munters Desiccant dehumidifier for the curling rink

The curling rink dehumidifier DH-2 is expected to be replaced in the near future and is listed in the BAU measures.

These are measures and specific strategies to reduce GHG emissions

8.1 HEAT PUMP BOILERS

8.1.1 OPPORTUNITY

If the measures in Bundle 2 are not implemented, then it is recommended to supplement the boiler plant with a heat pump boiler. This boiler can provide the required heating water efficiently while the natural gas boilers remain as backup. This will save energy and reduce GHG emissions. This may require upgrades to the electrical service which are not included in the costs shown here.

Table 8-2 Install Heat Pump Boiler

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
186,000 ekWh/yr	8%	$2,400 /yr	50 tCO2e	37%	$1,100,000	NA

8.2 PV PANELS

8.2.1 OPPORTUNITY

The roof area of the building is mostly empty and not shaded or obstructed by other structures. Installing PV panels on the roof areas would provide clean electricity for the site. The roof area could accommodate approximately 243 kW of PV panels. Calculations are based simulated model using Helioscope software.

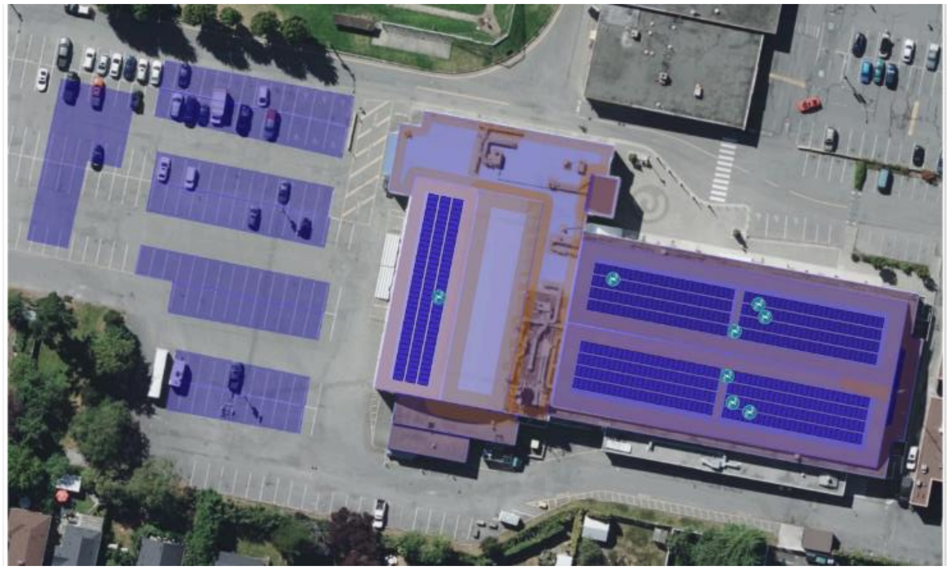


Figure 8-1 Potential PV Panel Layout

Table 8-3 PV Panels

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
235,800 ekWh/yr	10%	$15,400 /yr	3 tCO2e	2%	$560,000	36 years

8.3 WORKSHOP SUMMARY

The measures and GHG reduction scenarios were presented and reviewed in a final workshop in January 2026. The following items and actions were noted.

- The measures in Polar Engineering's Bundle 1 have been requested and are expected to be implemented in the near future. These are expected to save energy and reduce GHG emissions. The measures are
  - Underfloor heat recovery
  - Snowmelt pit heat recovery
- The measures in Polar Engineering's Bundle 2 have been reviewed but are not put forward at this time. This is reasonable approach. It is good to implement the first bundle and other measures first, then gage the overall savings before proceeding with further measures.
- Other BCA measures are not anticipated or put forward at this time. These include the heat boiler replacement and curling rink dehumidifier replacement. The heating boilers are operating appropriately and do not require any immediate action. Similarly, the curling rink dehumidifier is functioning properly. Both items are very costly to replace.
- Although it was reported that the new arena dehumidifier, DH-1, has the capacity to provide both rinks - the hockey arena and the curling rink - it is not certain that the unit could keep up with the loads and perform effectively.
- With regard to the heating boilers, it is recommended to reduce the heating loads first then consider redesigning the plant. Reducing the loading is accomplished by
  - retrofitting the snowmelt pit to function properly without hand watering

- applying de-oxygenerator for the ice resurfacing water, removing this from the heating boiler loads
- implementing measures on the DHW fixtures to reduce DHW consumption

- It was reported that measures on the DHW loop and fixtures are under consideration. Currently, the showerheads are manually operated and do not automatically shut off. It is anecdotally reported that occupants turn on the showers and leave them running while changing, wasting water. Fitting the showers with low-flow shower heads that automatically shut off will reduce DHW, saving water and natural gas. Vandalism of the showerheads has prevented the application of low-flow showerheads in the past.
- Also under consideration is re-piping the boiler plant such that either boiler can supply the DHW loop or the building heating. In addition, the DHW loop would be isolated so that it be controlled to a more appropriate temperature. This would improve flexibility and efficiency.
- It is reported that the electrical service is approaching its capacity. Any major additions to the electrical loads, such as a heat pump boiler or electric dehumidifier, may exceed the current capacity. Expanding the electrical service is under consideration.
- It was mentioned that a new Zamboni is expected to be added to by 2030. Purchasing an EV Zamboni is under consideration. This would be subject to availability of a charging station and electrical capacity.

9 GHG REDUCTION STRATEGIES

Esquimalt Council has made climate action a strategic priority, declared a climate emergency, and set ambitious targets to reduce corporate greenhouse gas emissions (GHGs).

As part of this report, it is required to develop and evaluate the following six GHG reduction pathway scenarios:

1) Short-term retrofit (5 years) – Achieving a 45% GHG reduction from **2010** levels.
2) Medium-term retrofit (10 years) – Achieving a 50% GHG reduction from **2023** levels.
3) Long-term retrofit (20 years) – Achieving an 80% GHG reduction from **2023** levels (near net-zero).
4) Short-term deep retrofit (5 years) – Achieving a 50% GHG reduction from **2023** levels.
5) Maximum site potential – Identifying the greatest possible GHG reductions, regardless of cost.
6) Optimized outcome – Balanced approach of aggressive GHG reduction with asset management objectives.

From the **2010** Energy Audit report, the GHG emissions were **337.7 tCO2e**.

From the utility data, the **2023** GHG emissions were **182** tCO2e.

The most current GHG emissions were **136** tCO2e. The arena natural gas fired desiccant dehumidifier was replaced in 2024 with a new all-electric unit. This resulted in a reduction in natural gas consumption but an increase in electricity which is seen in the emissions reduction since 2023.

9.1 GHG REDUCTION SCENARIOS

9.1.1 SCENARIO 1

The first GHG reduction pathway scenario is

1) Short-term retrofit (5 years) – Achieving a **45%** GHG reduction from **2010** levels.

From the **2010** Energy Audit report, the GHG emissions were **337.7 tCO2e**.

The most current GHG emissions were **136** tCO2e which is a **60%** reduction in emissions since 2010 – achieving the target of the first scenario. No further measures are necessary to achieve this target.

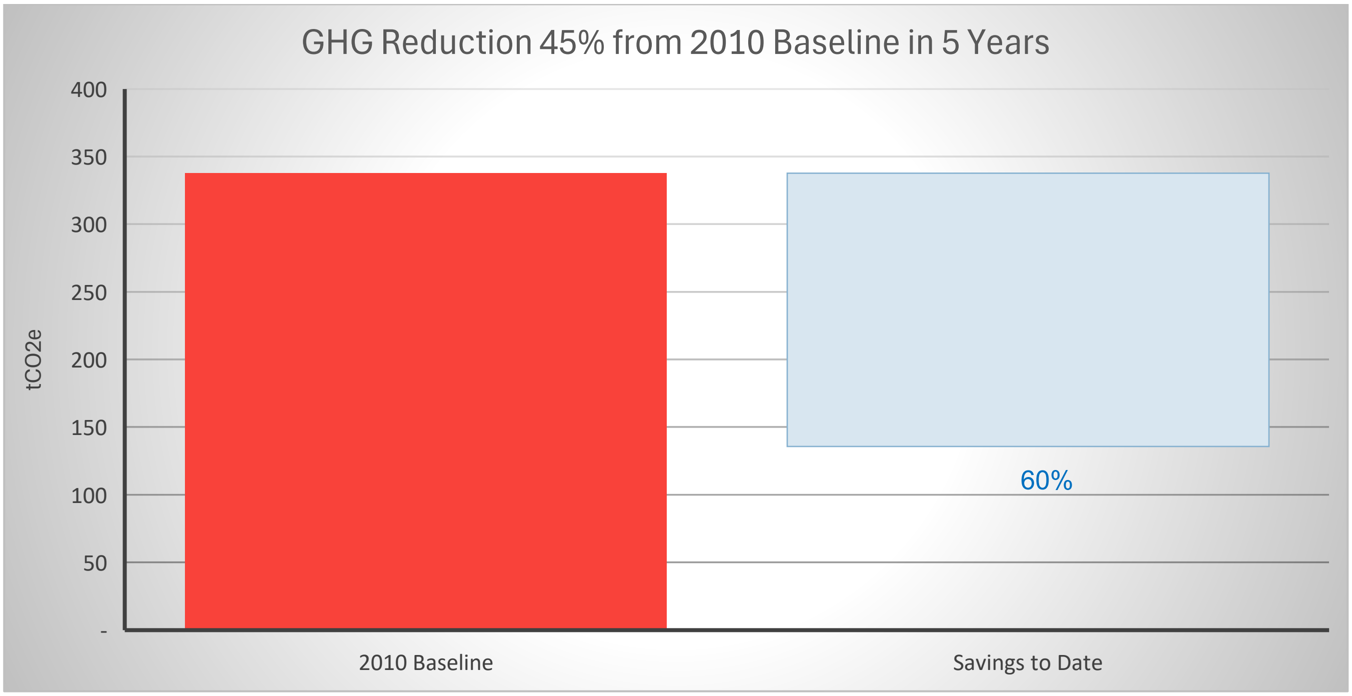


Figure 9-1 GHG Reduction Scenario 1

9.1.2 SCENARIO 2

The second GHG reduction pathway scenario is

2) Medium-term retrofit (10 years) – Achieving a **50%** GHG reduction from 2023 levels.

Based on the utility data, the **2023** GHG emissions were **182** tCO2e, establishing the baseline for this scenario. The most recent emissions total **136** tCO2e representing a **25%** reduction already achieved through previously implemented measures and operational improvements.

To close the remaining gap and reach the target, additional actions are required. The proposed pathway integrates a combination of equipment upgrades, business-as-usual (BAU) lifecycle replacements, and grid-related emissions reductions. The following pathway to low GHG emissions includes

- BAU measures including underfloor heat recovery and snowmelt pit heat recovery
- Heating Boiler Replacement
- Curling Dehumidifier DH-2 Replacement
- Roof replacement – Phase 1
- GHG reductions from lower grid emissions factors, as projected by ECCC. As projected by Environment and Climate Change Canada (ECCC), the continued decarbonization of the provincial electricity grid further contributes to emissions reductions over the next decade.

When combined, these measures collectively achieve a **54% reduction from the 2023 baseline**, surpassing the original 50% target and positioning the facility on a strong trajectory toward long-term decarbonization.

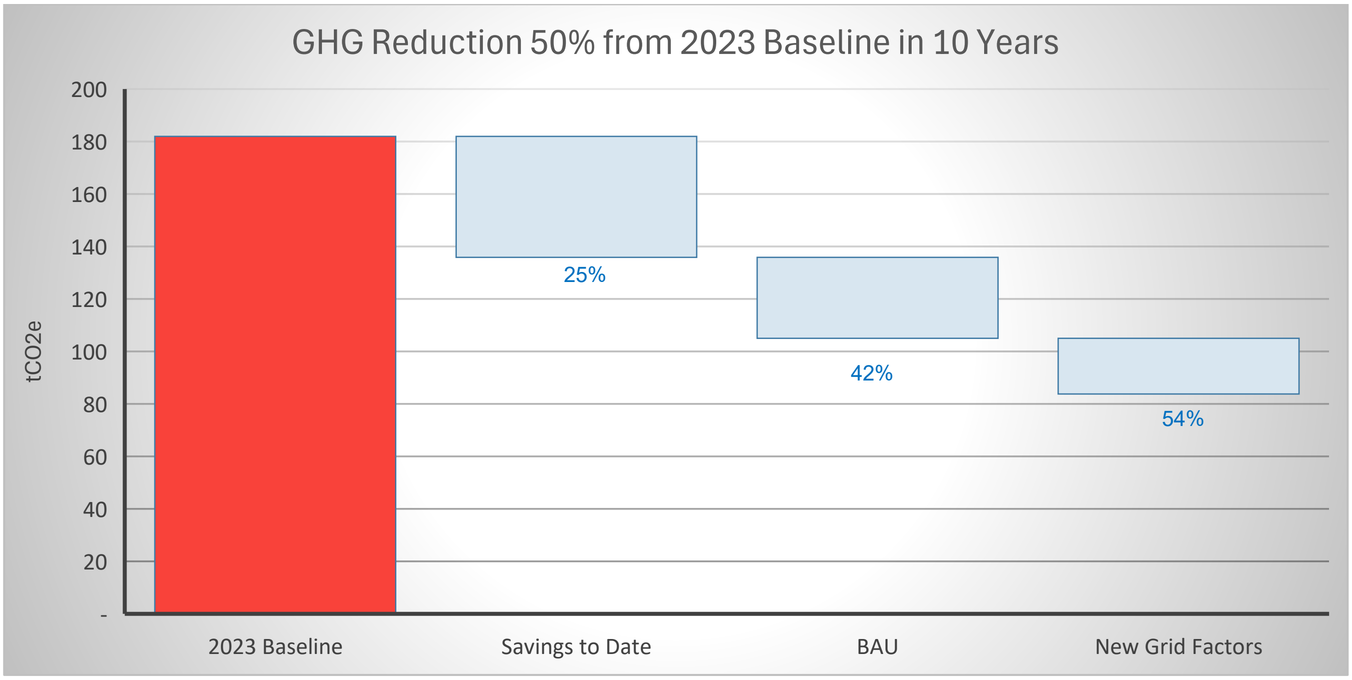


Figure 9-2 GHG Reduction Scenario 2

Figure 9-3 illustrates the Mid Term (10-Year) Retrofit Scenario/Pathway by showing both the timing of capital investments and the resulting evolution of building greenhouse gas (GHG) emissions over time. The figure combines a bar chart and dashed line to distinguish between financial implementation and emissions performance outcomes.

The vertical bars represent the capital cost of different sets of measures implemented in specific years over the scenario horizon. Each bar corresponds to a given implementation year and reflects the aggregate cost of the measures scheduled for that year, grouped by measure type (e.g., business-as-usual upgrades, retrofit measures, or other capital interventions). The bar chart therefore illustrates when investments occur and how capital spending is distributed over time, rather than emissions reductions directly.

The dashed line represents the annual GHG emissions of the building for each year, expressed in absolute emissions (tCO_2e). This emissions trajectory changes over time as a result of two combined effects:

1. Implementation of measures shown in the bars, which reduce on-site fuel consumption or improve system efficiency
2. Changes in electricity grid emission factors, reflecting the projected decarbonization of the provincial electricity supply over time.

As measures are implemented in specific years, step-changes in the dashed line indicate the incremental emissions reductions attributable to those measures. Between implementation years, gradual declines in the dashed line reflect reductions driven by grid decarbonization, even in the absence of new on-site interventions.

By presenting costs and emissions together, Figure 9-3 demonstrates how capital investments translate into emissions reductions over time. The figure shows that, through a combination of scheduled capital upgrades and declining grid emission intensity, building GHG emissions decrease steadily and ultimately exceed the Scenario 2 target of a 50% reduction from the 2023 baseline, reaching approximately a 54% reduction by the end of the medium-term period.

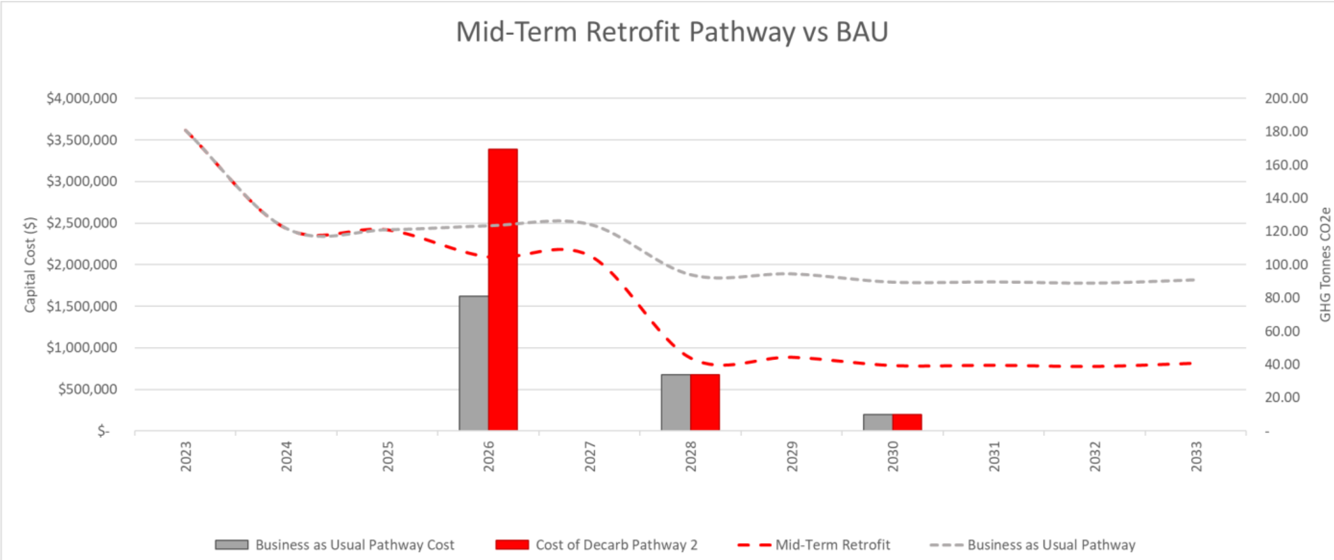


Figure 9-3 GHG Reduction Scenario 2 Pathway vs BAU

9.1.3 SCENARIO 3

The third GHG reduction pathway scenario outlines a long-term, transformative approach

3) Long-term retrofit (20 years) – Achieving an 80% GHG reduction from 2023 levels (near net-zero).

The 2023 utility data establishes a baseline of **182** tCO2e. The most current GHG emissions were **136** tCO2e which is a **25%** reduction in emissions since 2023. However, reaching the long-term target requires a more comprehensive and coordinated set of retrofit actions extending over a 20-year time horizon. This scenario integrates deep decarbonization strategies, system replacements, and progressive electrification, layered on top of ongoing grid decarbonization driven by federal policy.

Further measures are required to achieve the goal. The following pathway to low GHG emissions includes

- GHG reductions from lower grid emissions factors, as projected by ECCC. Ongoing decarbonization of the provincial electricity grid, as projected by Environment and Climate Change Canada (ECCC), plays a foundational role in this scenario. As fossil-fuel-based generation phases out and renewable capacity expands, the carbon intensity of electricity continues to decline. These improvements significantly enhance the GHG impact of electrification measures, particularly those involving the displacement of natural-gas-based systems.
- ECMs - De-oxygenerator and BAS recommissioning. Targeted ECMs provide meaningful GHG reductions by improving system efficiency, reducing parasitic loads, and ensuring equipment operates at optimal performance. BAS recommissioning also establishes better control over HVAC scheduling, setpoints, and ventilation rates, reducing unnecessary heating or cooling. These measures support both short-term performance and long-term decarbonization readiness.
- Measures in Bundle 1
- Heat Pump Boiler

When combined, the above measures achieve **an 82% reduction from the 2023 baseline**, surpassing the 80% long-term target and placing the facility on a trajectory consistent with near-net-zero operation. The long-term retrofit scenario thus provides a robust and future-focused pathway, balancing strategic system replacements, operational improvements, and the evolving carbon intensity of the provincial electricity grid.

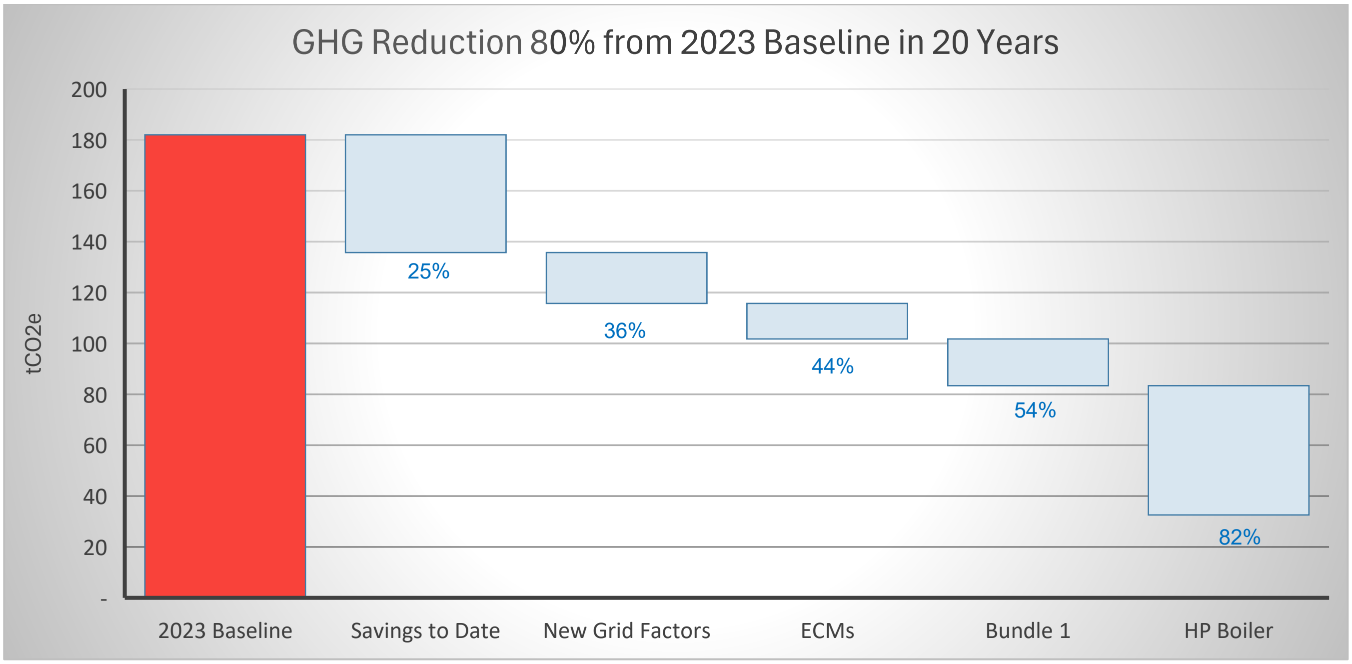


Figure 9-4 GHG Reduction Scenario 3

Figure 9-5 compares the long-term retrofit pathway to the business as usual (BAU) pathway by illustrating the relationship between capital investment timing and resulting greenhouse gas (GHG) emissions over the 20-year study period.
The bars represent annual capital costs associated with each pathway, while the dashed lines show the corresponding annual GHG emissions (tCO_2e). Grey bars and dashed lines represent the BAU pathway, and red bars and dashed lines represent the long-term retrofit pathway.

Under the BAU pathway, capital expenditures are primarily associated with asset renewal and lifecycle replacements. While these investments maintain building functionality, the associated GHG emissions decline only gradually over time. Most of the emissions reduction in the BAU case is driven by projected reductions in electricity grid emission factors, rather than by significant on-site decarbonization.

In contrast, the long term retrofit pathway shows larger capital investments earlier in the study period, reflecting the implementation of major decarbonization measures. These investments result in clear step changes in building GHG emissions, visible as sharp declines in the red dashed line following key implementation years. After these measures are in place, emissions continue to decrease more gradually as grid decarbonization further lowers electricity-related emissions.

Overall, the figure demonstrates that while both pathways benefit from grid decarbonization, the long-term retrofit pathway achieves substantially lower and more sustained GHG emissions by coupling strategic capital investments with system-level fuel switching and efficiency improvements. This highlights the importance of early and targeted investment to achieve deep, long-term emissions reductions beyond what can be realized through BAU actions alone.

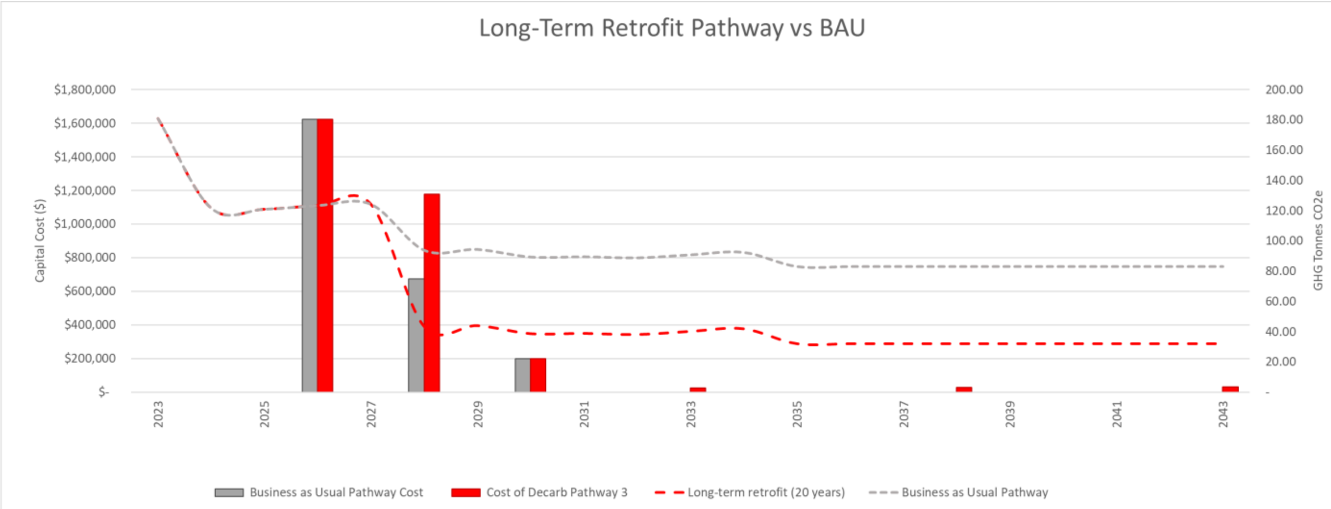


Figure 9-5 GHG Reduction Scenario 3 Pathway vs BAU

9.1.4 SCENARIO 4

The fourth GHG reduction pathway scenario is

4) Short-term deep retrofit (5 years) – Achieving a 50% GHG reduction from **2023** levels.

From the utility data, the **2023** GHG emissions were **182** tCO2e. The most current GHG emissions were **136** tCO2e which is a **25%** reduction in emissions since 2023. While this improvement demonstrates meaningful early progress, the short-term target requires additional, high-impact measures that can be deployed quickly and effectively.

Scenario 4 focuses on impactful, time-sensitive interventions that deliver immediate emissions reductions while enhancing operational efficiency. The following pathway to low GHG emissions includes

- GHG reductions from lower grid emissions factors, as projected by ECCC
- ECMs - De-oxygenerator and BAS recommissioning
- Measures in Bundle 1

By combining grid-related reductions, system recommissioning, ECMs, and the targeted upgrades in Bundle 1, Scenario 4 achieves a **51% reduction from the 2023 baseline**, exceeding the short-term target while remaining practical for a five-year implementation window.

Scenario 4 demonstrates that meaningful near-term decarbonization is achievable through a combination of operational improvements, targeted equipment upgrades, and the accelerating decarbonization of the electricity grid. By layering low-disruption interventions with strategic system enhancements, this pathway provides a high-impact, cost-efficient blueprint for your facility if seeking rapid emissions reductions without immediately committing to full-scale capital transformation.

This short-term deep retrofit scenario also serves as a critical bridge to medium and long-term strategies. The measures implemented here not only deliver immediate carbon benefits but also prepare the facility for deeper electrification, broader retrofit opportunities, and future ready asset performance. As a result, Scenario 4 establishes a strong foundation for ongoing decarbonization while offering quick wins and measurable progress in the early years of a broader climate action plan.

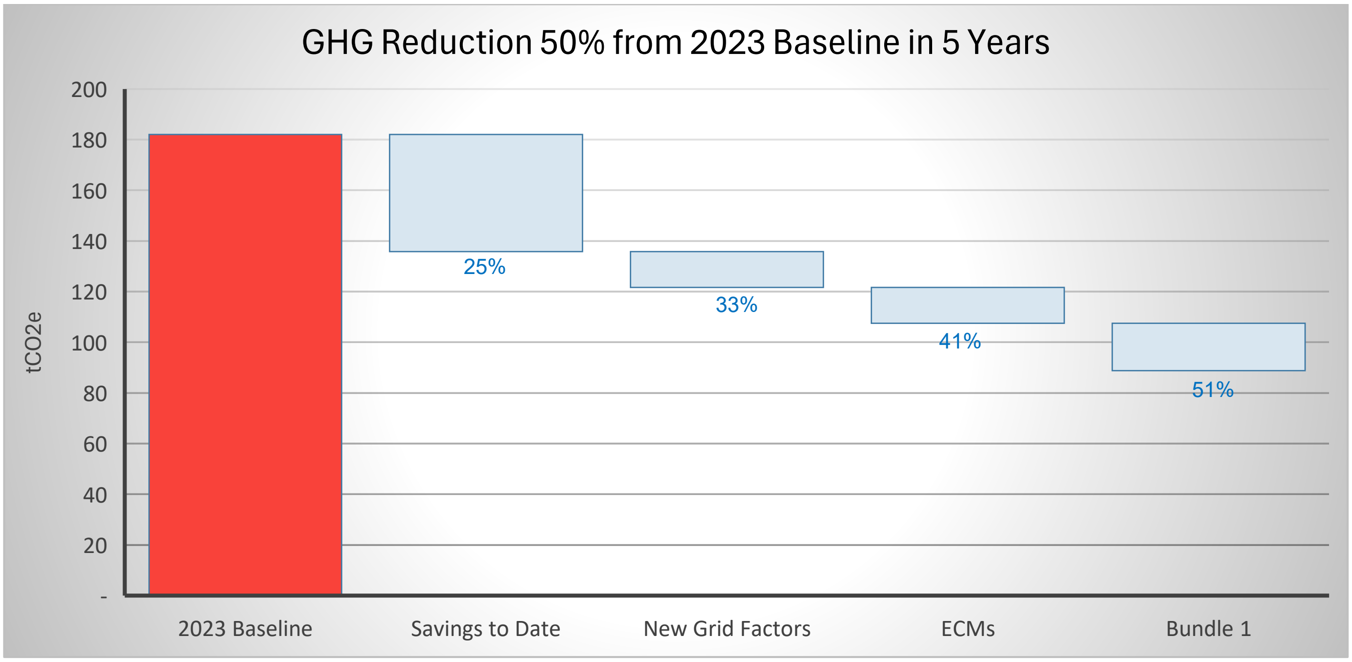


Figure 9-6 GHG Reduction Scenario 4

Figure 9-6 illustrates the short-term deep retrofit pathway in comparison to the business as usual (BAU) pathway, highlighting how accelerated capital investment influences greenhouse gas (GHG) emissions over a compressed, five-year timeframe.

Consistent with earlier figures, the bars indicate annual capital expenditures, while the dashed lines show the resulting annual GHG emissions (tCO_2e) for each pathway. The BAU pathway is shown in grey, and the short-term deep retrofit pathway is shown in red.

In the BAU case, capital spending is limited to planned asset renewal activities. Emissions decline gradually under this pathway, with reductions occurring primarily as a result of projected improvements in electricity grid emission factors rather than substantive changes to on-site systems.

The short term deep retrofit pathway, by contrast, is characterized by intensive, front loaded capital investment, reflecting the rapid deployment of multiple high-impact decarbonization measures within a short period. These investments drive immediate and significant reductions in GHG emissions, evident as steep downward shifts in the red dashed line following major implementation years. This contrasts with the more gradual emissions trajectory observed under the BAU pathway.

Overall, the figure demonstrates that the short-term deep retrofit pathway prioritizes speed of emissions reduction, achieving meaningful GHG savings much earlier than the BAU approach. While this pathway requires higher near-term capital outlays, it enables rapid progress toward short-term climate targets and accelerates the transition toward lower-emissions operation.

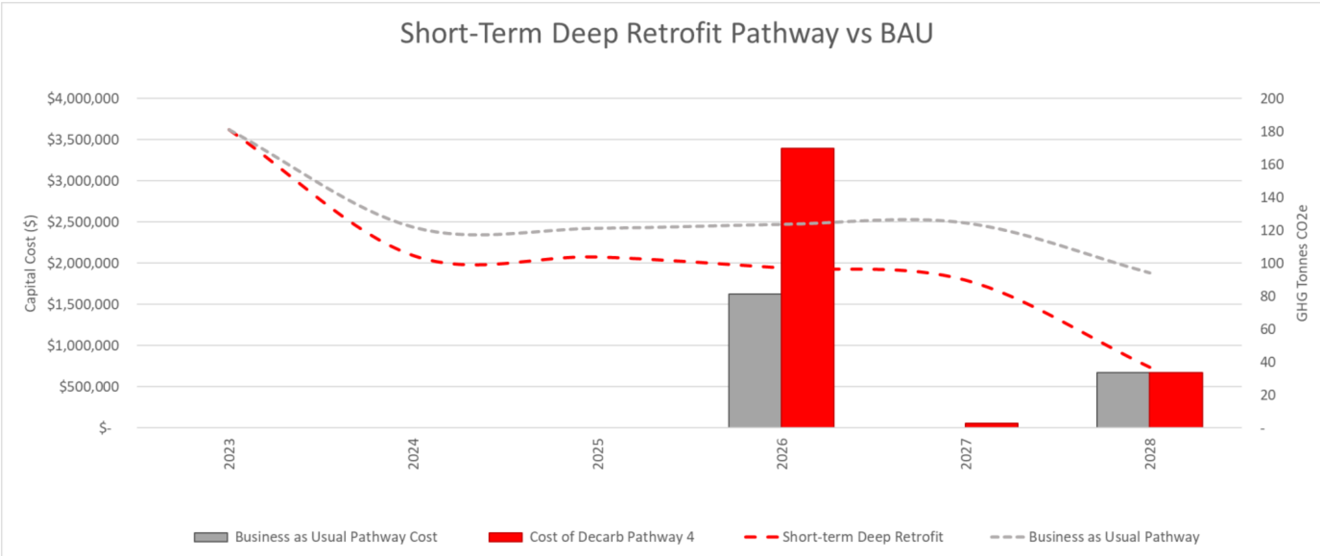


Figure 9-7 GHG Reduction Scenario 4 Pathway vs BAU

9.1.5 SCENARIO 5

The fifth GHG reduction pathway scenario is

5) Maximum site potential – Identifying the greatest possible GHG reductions, regardless of cost.

Unlike other scenarios that balance financial feasibility with emissions reductions, this scenario focuses exclusively on achieving the **maximum technical potential** for on-site GHG abatement.

From the utility data, the **2023** GHG emissions were **182** tCO2e. The most current GHG emissions were **136** tCO2e which is a **25%** reduction in emissions since 2023. While this progress is notable, much deeper reductions are required to reach the full potential of the site. Scenario 5 therefore layers multiple high-impact measures into a comprehensive decarbonization package that addresses equipment efficiency, fuel switching, grid decarbonization, and on-site renewable generation.

Further measures are required to achieve the goal. The following pathway to low GHG emissions includes

- BAU measures
- GHG reductions from lower grid emissions factors, as projected by ECCC
- ECMs - De-oxygenerator and BAS recommissioning
- Measures in Bundle 1
- Measures in Bundle 2
- PV Panels

When combined, the full suite of measures in Scenario 5 achieves an **89% reduction from the 2023 baseline**, representing the highest emissions reduction outcome of all scenarios. This performance approaches near-net-zero territory and reflects the site's maximum achievable decarbonization potential under current technology and infrastructure constraints.

Scenario 5 demonstrates what is possible when financial constraints are removed and the focus shifts entirely to technical feasibility and maximum carbon abatement. By combining comprehensive electrification, deep efficiency improvements, and on-site renewable energy generation, this scenario pushes the building toward the limits of its decarbonization capacity. While the level of investment required may exceed typical capital planning norms, Scenario 5 offers critical value for long-term climate strategy, including:

- A clear understanding of the building's absolute GHG reduction potential
- A benchmark for evaluating all other scenarios

- Insight into which measures deliver the greatest marginal carbon benefits
- A roadmap for future opportunities should policy, budgets, or funding mechanisms evolve

Ultimately, this scenario highlights a forward-looking vision of what a fully decarbonized, resilient, and future-ready facility could achieve, serving as both a technical reference point and an aspirational target for long-term planning.

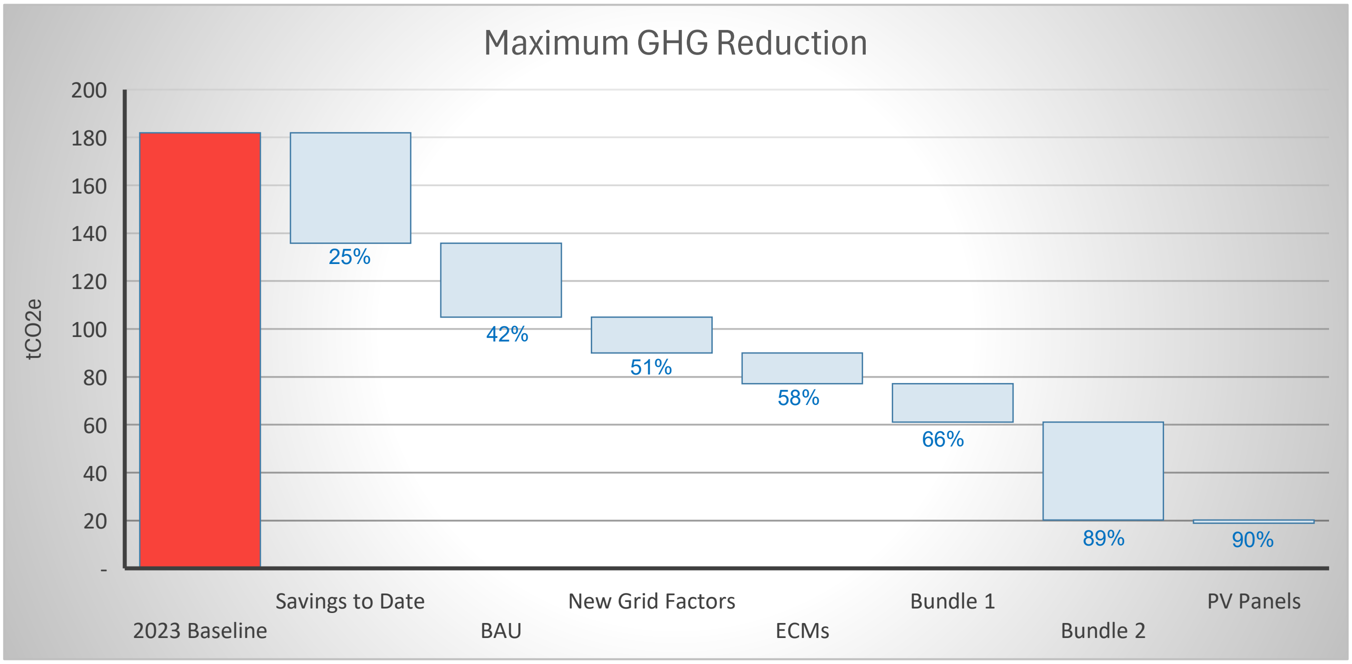


Figure 9-8 GHG Reduction Scenario 5

Figure 9-9 presents the maximum site potential pathway in comparison to the business as usual (BAU) pathway, illustrating the highest level of greenhouse gas (GHG) reduction that can be achieved at the site using all technically feasible decarbonization measures, including on site renewable energy generation.

As with previous pathway figures, the bars show annual capital costs and the dashed lines represent annual GHG emissions (tCO_2e). The BAU pathway is shown in grey, while the maximum site potential pathway is shown in red.
The BAU pathway reflects planned asset renewal activities only and results in a moderate decline in emissions over time. These reductions are driven largely by improvements in electricity grid emission factors, with limited on-site fuel switching or electrification.

The maximum site potential pathway, by contrast, incorporates the full suite of available measures, including energy conservation measures, Bundles 1 and 2, heat pump technologies, and installation of rooftop photovoltaic (PV) panels. This pathway represents the upper bound of achievable GHG reductions under current site conditions and technology constraints. Capital investments are concentrated in the early years to enable comprehensive system upgrades and electrification, followed by smaller investments as remaining measures are completed.

These investments result in substantial and sustained reductions in GHG emissions, visible as a sharp and lasting decline in the red dashed line. Following implementation of the full measure set, emissions reach their lowest achievable level and remain well below the BAU trajectory for the remainder of the study period. Continued grid decarbonization further enhances the emissions performance of the electrified systems.

Overall, the figure demonstrates that the maximum site potential pathway delivers the greatest absolute GHG reduction of all scenarios, approaching near net zero operation. While this pathway requires the highest capital investment, it establishes a benchmark for the site's technical decarbonization limits and provides a reference point against which more cost-constrained or phased pathways can be evaluated.

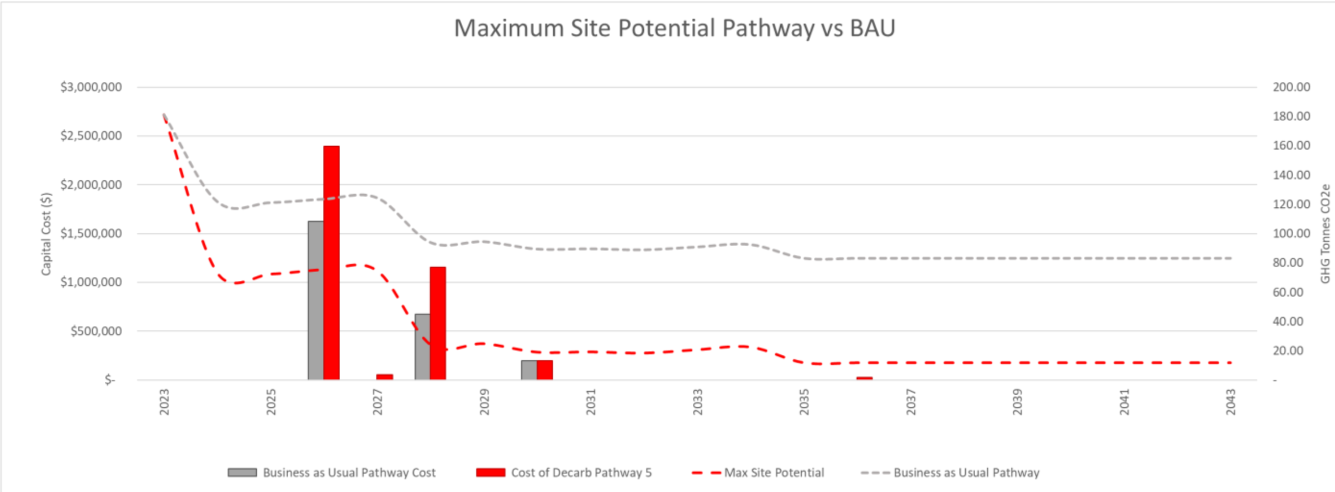


Figure 9-9 GHG Reduction Scenario 5 Pathway vs BAU

9.1.6 SCENARIO 6

The sixth GHG reduction pathway scenario is

6) Optimized outcome – Balanced approach of aggressive GHG reduction with asset management objectives.

Unlike the Maximum Site Potential scenario, which pursues emissions reductions regardless of capital cost, this scenario aims to achieve substantial GHG reductions while maintaining financial responsibility, operational continuity, and alignment with natural capital renewal cycles. This balanced perspective makes Scenario 6 particularly valuable for long-term planning, ensuring that GHG reductions are achieved efficiently without imposing undue financial or operational strain.

From the utility data, the **2023** GHG emissions were **182** tCO2e. The most current GHG emissions were **136** tCO2e which is a **25%** reduction in emissions since 2023. While this progress demonstrates positive momentum, further targeted interventions are required to meet the optimized pathway target.

Scenario 6 incorporates a curated set of measures chosen for their strong GHG reduction impact *and* their compatibility with asset renewal objectives. The following pathway to low GHG emissions includes

- GHG reductions from lower grid emissions factors, as projected by ECCC
- ECMs - De-oxygenerator and BAS recommissioning
- Measures in Bundle 1
- Measures in Bundle 2

When integrated, these measures collectively achieve an **81% reduction in GHG emissions from the 2023 baseline**, representing a near-optimal balance between environmental performance, capital investment, asset lifecycle considerations, and operational resilience. This makes Scenario 6 a compelling approach the facility is seeking deep decarbonization without pursuing the highest-cost measures associated with maximum site potential.

Scenario 6 offers a strategic, balanced decarbonization pathway that maximizes emissions reductions while respecting the realities of capital budgeting, asset planning, and operational continuity. By combining efficiency improvements, targeted system upgrades, and the benefits of a decarbonizing electricity grid, this optimized pathway delivers a robust **81% reduction,** only slightly below the absolute maximum achievable but with significantly improved cost-effectiveness and alignment with long-term infrastructure needs.

This scenario provides:

- A high-impact yet financially responsible decarbonization roadmap
- Strong synergy between current asset renewal priorities and GHG reduction measures
- A future-ready platform for deeper electrification and renewable integration
- A pragmatic balance between technical feasibility and long-term value

Ultimately, Scenario 6 serves as a high-value pathway, delivering substantial carbon reductions while maintaining operational practicality and safeguarding long-term asset performance, making it one of the most implementable and resilient strategies within the full suite of pathways.

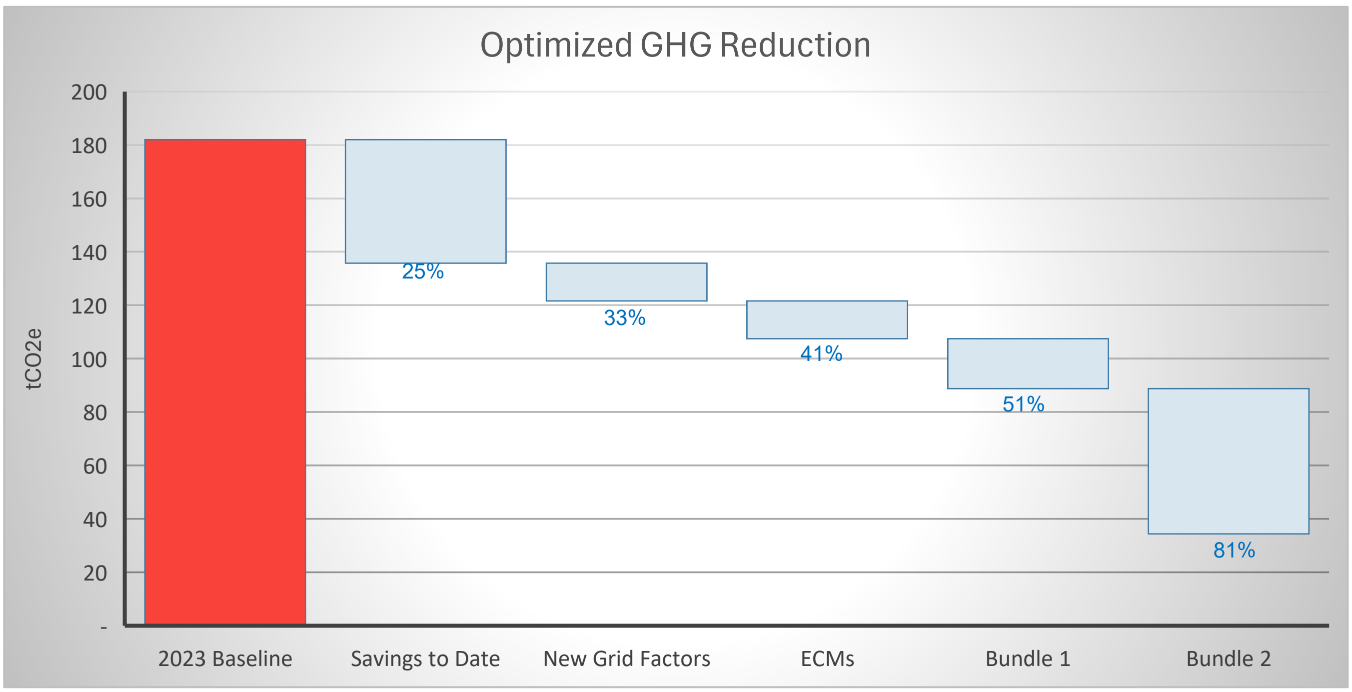


Figure 9-10 GHG Reduction Scenario 6

Figure 9-11 presents the optimized outcome pathway in comparison to the business as usual (BAU) pathway, illustrating a balanced decarbonization approach that prioritizes substantial greenhouse gas (GHG) reductions while maintaining financial and implementation feasibility.

As with the preceding pathway figures, the bars represent annual capital costs, and the dashed lines show annual GHG emissions (tCO_2e). Grey bars and dashed lines correspond to the BAU pathway, while red bars and dashed lines represent the optimized outcome pathway.

Under the BAU pathway, capital investments are limited to scheduled asset renewals, resulting in a modest and gradual reduction in emissions over time. Most of the emissions decline in this case is attributable to projected reductions in electricity grid emission factors, rather than targeted on-site decarbonization measures.

The optimized outcome pathway, by contrast, selectively incorporates high-impact and cost effective measures from across the available options, including energy conservation measures and selected elements of Bundles 1 and 2. This pathway intentionally excludes the highest-cost measures with lower marginal GHG benefits, focusing instead on interventions that offer a strong balance between emissions reduction, capital cost, and alignment with asset lifecycle planning.

Capital investments under this pathway are concentrated in key implementation years, producing clear step changes in GHG emissions, while avoiding the very high upfront costs associated with the maximum site potential scenario. Following implementation, emissions remain significantly lower than the BAU trajectory, with continued improvement driven by grid decarbonization.

Overall, the figure demonstrates that the optimized outcome pathway achieves deep and sustained GHG reductions, approaching near net zero performance, while remaining more practical and financially achievable than the maximum site potential pathway. This scenario represents a realistic and balanced decarbonization strategy, providing a strong foundation for long term emissions reduction while respecting capital constraints, operational considerations, and asset management objectives.

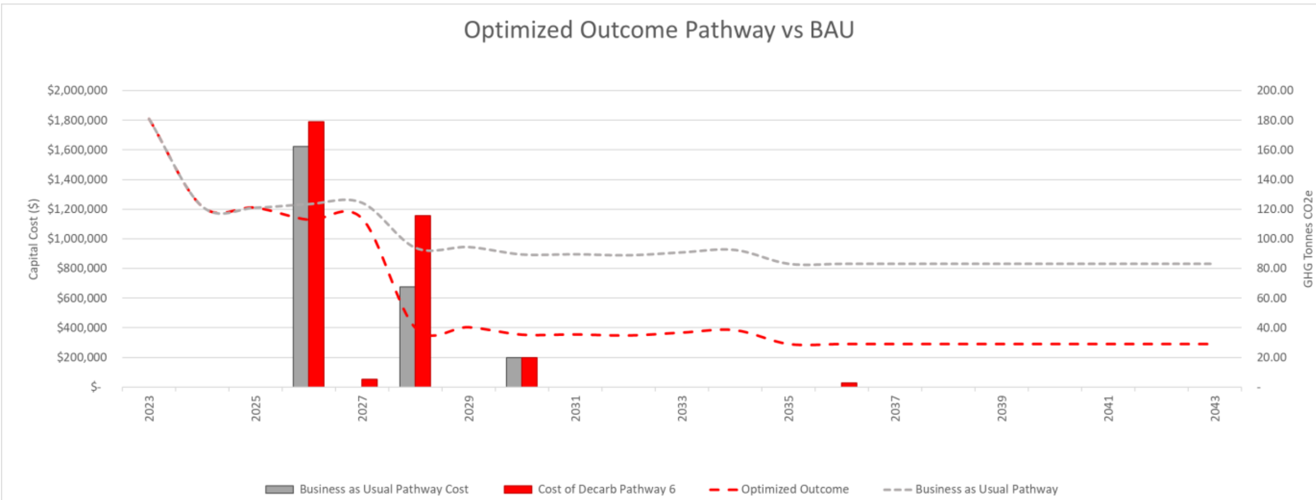


Figure 9-11 GHG Reduction Scenario 6 Pathway vs BAU

9.2 LIFE CYCLE COST ANALYSIS (LCCA)

An Incremental Life Cycle Cost Analysis (ILCC) was conducted to evaluate the financial performance of the proposed decarbonization pathways relative to the Business-as-Usual (BAU) approach. ILCC is used as the primary financial metric because it captures the total cost impact of design and retrofit decisions over the study period, rather than focusing solely on upfront capital costs or simple payback.

This approach is particularly well-suited to long-term decarbonization planning, where higher initial investments may result in lower operating costs, avoided future replacements, and improved cost-effectiveness when assessed over the full life cycle.

LCCA Methodology and Assumptions

The ILCC analysis incorporates the following key elements:

- First (capital) costs associated with each pathway;
- A 20-year study period, with construction assumed to begin in 2026;
- Utility costs, including electricity and natural gas, with appropriate escalation rates;
- System service life estimates and associated replacement or residual values within the study period; and
- Standard inflation and discount rates to reflect the time value of money.

Residual values are accounted for such that equipment with service lives longer or shorter than the study period is assigned a linearly depreciated residual value at the end of the analysis period. All results are presented in 2025 dollars, escalated using the rates summarized in Table below.

Table 9-1 LCC Assumptions

Rate Name	Value (%)
Energy Inflation (ENER)	2.00%
Long Term Construction Costs (Capital Costs) Escalation (LTCC)	2.00%
Operations and Maintenance Escalation (O&M)	2.00%
Discount Rate (DISC)	2.00%

An incremental LCC approach is applied rather than a comparative LCC. This means that absolute life-cycle costs are not calculated; instead, the analysis focuses on the difference in life-cycle cost between each pathway and the BAU baseline. This approach provides results that are equally valid for decision-making while avoiding unnecessary complexity.

LCCA Results and Interpretation

The summary results of the LCCA are presented in the table below.

Table 9-2 LCCA Results

PATHWAY	ABSOLUTE CAPITAL COST ($M)	STUDY LIFE CYCLE COST NPV ($M)	LCC PER TONNE REDUCED ($/TONNE)
Business as Usual Pathway (5 Years)	$1.50	$0.79	$9,108
Short-Term Deep Retrofit	$3.18	$ 0.98	$940
Business as Usual Pathway (10 Years)	$2.27	$ 2.03	$22,552
Mid-Term Retrofit	$3.90	$2.63	$4,249
Business as Usual Pathway (20 Years)	$2.27	$4.26	$43,588
Long-Term retrofit (20 years)	$2.97	$4.66	$1,977
Max Site Potential	$3.48	$4.61	$1,973
Optimized Outcome	$2.92	$4.38	$559

Several key insights emerge from these results:

- Business-as-Usual pathways perform poorly on a cost per tonne basis, particularly over longer time horizons. While BAU capital costs are lower upfront, the resulting GHG reductions are limited, leading to very high life-cycle costs per tonne of emissions reduced.
- The Short-Term Deep Retrofit pathway demonstrates strong cost-effectiveness ($940/tonne), reflecting the rapid emissions reductions achieved through front-loaded investment. However, this pathway requires the highest near-term capital commitment, which may present implementation challenges despite favorable economics.
- The Medium-Term and Long-Term Retrofit pathways significantly outperform BAU on a life-cycle basis, confirming that strategic decarbonization investments are more cost effective than deferring action. These pathways benefit from both emissions reductions and avoided future operating costs.
- The Maximum Site Potential pathway achieves near net zero performance and strong cost effectiveness relative to BAU, but it does so with the highest overall capital investment, reflecting the inclusion of all technically feasible measures, including PV.
- The Optimized Outcome pathway delivers the lowest life cycle cost per tonne of GHG reduced ($559/tonne) of all scenarios. This pathway balances meaningful emissions reductions with disciplined capital spending, selectively prioritizing measures that provide the greatest emissions benefit per dollar invested.

The LCCA demonstrates that decarbonization pathways are not only environmentally beneficial but financially advantageous over the long term. While BAU approaches minimize short term capital expenditures, they result in substantially higher costs per unit of emissions reduced and expose the facility to long-term energy price and carbon risk.

Among all scenarios evaluated, the Optimized Outcome pathway represents the most cost effective and practical option, delivering deep GHG reductions at the lowest life cycle cost per tonne while remaining aligned with capital planning, asset renewal cycles, and implementation feasibility. This pathway provides a strong economic and environmental foundation for long term decision making and represents a compelling balance between ambition and affordability.

9.3 TIMELINE

Based on the building condition assessment and discussions with staff, the following timeline is expected for the measures.

Table 9-3 Timeline for Measures

GROUP	MEASURE	YEAR OF IMPLEMENTATION
BAU	Replace Heating Boilers	2028
	Replace DH-2	2028
Bundle 1	Underfloor heat recovery	2026
	Snowmelt Pit Heat Recovery	2026
ECMs	REALice De-oxygenerator	2027
	BAS Recommissioning	2027
Bundle 2	Site-specific heatpump	2028
	Arena dehumidifier preheat coil	2028
	Boiler Replacement	2028
	Low-flow showerheads	2028

10 REJECTED MEASURES

10.1 ROOF REPLACEMENT

10.1.1 OPPORTUNITY

The flat roofs are scheduled for phased replacement. The oldest sections around the Hockey Arena office areas are approaching the end of their useful life and are expected to be replaced in the near future. The eastern sections of the roof are expected to be replaced in the medium term, and the newer western and central areas in the later term, near year 2045.

Phase1
This roof surrounds the main barrel roof of the hockey arena along its north, east, and west elevations. These sections are surfaced with older 2-ply SBS modified bitumen membranes and exhibit clear signs of aging and deterioration, including surface alligatoring, membrane cracking, and multiple localized patch repairs. Based on visual review and observed deterioration patterns, these flat roofs have reached end-of-life condition and replacement is recommended in the short term.

10.1.2 SCOPE OF MEASURE

The roof replacement is expected in the near future and will reduce the heating load and save energy. But the savings are small compared to the capital cost.

Table 10-1 Savings

ENERGY SAVINGS	% ENERGY SAVINGS	COST SAVINGS	GHG SAVINGS	% GHG SAVINGS	OPINION OF COST	SIMPLE PAYBACK
58,000 ekWh/yr	3%	$2,600 /yr	6 tCO2e	5%	$2,000,000	NA

11 RECOMMENDATIONS

11.1 SUMMARY OF SAVINGS

The energy conservation measures are sorted into the groups below. Due to the interactive effects between the measures, the total savings may not be the absolute total of all the measures combined. Some measures reduce the building loads which in turn reduces energy consumed by equipment or systems. Once the ECMs are decided or the pathway determined, then reviewing the savings for interactive effects is recommended.

Energy Conservation Measures
- REALice De-oxygenerator
- BAS Recommissioning

Polar Engineering **Bundle 1**
- Brine header and piping replacement that includes new underfloor heating from the ice plant
- Snowmelt Pit Heat Recovery

Polar Engineering **Bundle 2**
- Site-specific Heatpump
- Arena Dehumidifier Energy Recovery
- Boiler Replacement
- Low-Flow Showerheads

Table 11-1 – Summary of Savings

MEASURE		POTENTIAL SAVINGS			COST/PAYBACK	
#	ENERGY CONSERVATION MEASURE	Energy (ekWh[1]/Yr)	Utility Cost ($/Yr)	Emissions Reduction (tCO_2e/Yr)	Opinion Of Cost	Simple Payback (years)
Energy Conservation Measures						
7.1	REALice De-oxygenerator	75,000	$2,700	12	$38,400	5
7.2	BAS Recommissioning	46,000	$2,500	2	$10,000	4
	Totals (Rounded)	**121,000**	**$5,200**	**14**	**$48,400**	**9.3**
Polar Engineering Bundle 1						
7.3	Underfloor Heat Recovery	100,000	$6,500	1	$1,500,000	231
7.4	Snowmelt Pit Heat Recovery	100,000	$3,600	18	$342,500	95
	Totals (Rounded)	**200,000**	**$10,100**	**19**	**$1,842,500**	**182.4**
Polar Engineering Bundle 2						
7.5	Site-specific Heatpump	200,000	$2,700	55	$382,000	141
7.6	Arena dehumidifier preheat coil	84,500	$5,500	1	$76,000	14
7.7	Boiler Replacement	6,700	$200	1	$193,500	968
7.8	Low-Flow Showerheads	20,000	$500	4	$20,000	40
	Totals (Rounded)	**311,200**	**$8,900**	**61**	**$671,500**	**75**
GHG Reduction Measures						
8.1	Heat Pump Boilers	186,000	$2,400	50	$1,100,000	458
8.2	PV Panels	235,800	$15,400	3	$560,000	36
	Totals (Rounded)	**421,800**	**$17,800**	**53**	**$1,660,000**	**93.3**

11.2 NEXT STEPS

This report presents measures that can reduce energy use and GHG emissions at your building. We recommend the following next steps:

1. **Review the proposed measures** listed in the Master List of Findings (Appendix A);
2. **Decide which measures to implement** and your implementation timeline;
3. **Select your incentive program enrolment strategy**. The preferred incentive program for this property will depend on the measures you choose to implement, and the timeline for implementation.
4. **Decide how implementation will be managed** (and engage support, if desired);
5. **Implement operational measures** that are quick or low-cost. Many operational measures can be implemented soon, to quickly improve building energy performance. This could result in additional LEED points for energy performance (EAc1: Optimize Energy Efficiency Performance). Plan to verify that measures are completed and that the expected benefit is achieved;
6. **Implement retrofit measures, or add them to your capital plan** if they cannot be completed in the current capital year. Develop a formal scope of work and request quotes for more detailed or costly measures. You may need to prepare engineering designs and/or specifications, develop bid documents for competitive quotes, manage construction review and/or contract administration, commission systems, verify installation as intended, train operators on system changes, and measure performance improvement;
7. **Train operators** on system changes and update building documentation; and
8. **Measure performance improvement** and verify measures are completed as planned.

WSP can provide the expertise and services that will lead to successful completion of any or all of these operational and retrofit measures. We trust this report meets your needs and would be pleased to discuss our findings further with you at your convenience. We would also very much like to help you implement these measures, and look forward to taking these next steps with you.

APPENDIX

A MASTER LIST OF FINDINGS

APPENDIX A

MEASURE				POTENTIAL SAVINGS			COST/PAYBACK	
#	ENERGY CONSERVATION MEASURE	Electricity kWh	Natural Gas GJ	Energy (Rounded) (ekWh[1]/Yr)	Utility Cost ($/Yr)	Emissions Reduction (tCO_2e/Yr)	Opinion Of Cost	Simple Payback (years)
Energy Conservation Measures								
7.1	REALice De-oxygenerator	12,644	225	75,000	$2,700	12	$38,400	5
7.2	BAS Recommissioning	34,084	43	46,000	$2,500	2	$10,000	4
	Totals	46,728	268	**121,000**	**$5,200**	**14**	**$48,400**	**9.3**
Polar Engineering Bundle 1								
7.3	Underfloor Heat Recovery	99,384	0	100,000	$6,500	1	$1,500,000	231
7.4	Snowmelt Pit Heat Recovery	3,700	350	100,000	$3,600	18	$342,500	95
	Totals	103,084	350	**200,000**	**$10,100**	**19**	**$1,842,500**	**182.4**
Polar Engineering Bundle 2								
7.5	Site-specific Heatpump	-97,546	1,096	200,000	$2,700	55	$382,000	141
7.6	Arena dehumidifier preheat coil	84,511	0	84,500	$5,500	1	$76,000	14
7.7	Boiler Replacement	0	24	6,700	$200	1	$193,500	968
7.8	Low-Flow Showerheads	0	69	20,000	$500	4	$20,000	40
	Totals	-13,035	1,188	**311,200**	**$8,900**	**61**	**$671,500**	**75**
GHG Reduction Measures								
8.1	Heat Pump Boilers	-87,791	986	186,000	$2,400	50	$1,100,000	458
8.2	PV Panels	235,800	0	235,800	$15,400	3	$560,000	36
	Totals	148,009	986	**421,800**	**$17,800**	**53**	**$1,660,000**	**93.3**

APPENDIX

B METHODOLOGY

APPENDIX B

METHODOLOGY

Work completed for this assessment included:

1. Preliminary System Review: We performed this review prior to visiting the site using existing mechanical, electrical, and structural drawings and report. We review past equipment maintenance, repair, and replacement details;
2. Facility Walkthrough: Our team was on site to assess the current condition of equipment and associated components;
3. Fossil-fuelled asset : We developmented an asset inventory profile including model and serial numbers, age, installation date, capacities, dimensions, photographs, etc;
4. Identification : We Identified key issues relevant to project scope related to the state of current fossil-fuelled assets;
5. Analysis: We performed various calculations to estimate both the potential of electrification and implementation costs associated with potential fuel switching measures; and
6. Reporting: We summarized our findings and the recommended next steps in this report.

APPENDIX

C MEASUREMENT AND VERIFICATION OPTIONS

APPENDIX C

MEASUREMENT AND VERIFICATION OPTIONS

For each measure presented in this report, we recommend a measurement and verification approach based on the International Performance Measurement and Verification Protocol (IPMVP): Concepts and Options for Determining Energy and Water Savings. The Protocol defines techniques for reviewing and confirming savings in various situations. The following is an excerpt from the Protocol which outlines the four primary M&V options available:

OPTION A. PARTIALLY MEASURED RETROFIT ISOLATION: Savings are determined by partial field measurement of the energy use of the system(s) to which an ECM was applied; separate from the energy use of the rest of the facility. Measurements may be either short-term or continuous. Partial measurement means that some but not all parameter(s) may be stipulated, if the total impact of possible stipulation error(s) is not significant to the resultant savings. Careful review of ECM design and installation will ensure that stipulated values fairly represent the probable actual value. Stipulations should be shown in the M&V Plan along with analysis of the significance of the error they may introduce.

OPTION B. RETROFIT ISOLATION: Savings are determined by field measurement of the energy use of the systems to which the ECM was applied; separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.

OPTION C. WHOLE FACILITY: Savings are determined by measuring energy use at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period.

OPTION D. CALIBRATED SIMULATION: Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in calibrated simulation.

APPENDIX

D LIMITATIONS

APPENDIX D

LIMITATIONS

WSP Canada Inc. is the “Consultant” referenced throughout this document.

- The scope of our work and related responsibilities related to our work are defined in our project authorization (“Conditions of Assignment”).
- Any user accepts that decisions made, or actions taken based upon interpretation of our work are the responsibility of only the parties directly involved in the decisions or actions.
- No party other than the Client shall rely on the Consultant’s work without the express written consent of the Consultant, and then only to the extent of the specific terms in that consent. Any use which a third party makes of this work, or any reliance on or decisions made based on it, are the responsibility of such third parties. Any third party user of this report specifically denies any right to any claims, whether in contract, tort and/or any other cause of action in law, against the Consultant (including Sub-Consultants, their officers, agents and employees).The work reflects the Consultant’s best judgement in light of the information reviewed by them at the time of preparation. It is not a certification of compliance with past or present regulations. Unless otherwise agreed in writing by the Consultant, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity; it is written to be read in its entirety.
- Only the specific information identified has been reviewed. No physical or destructive testing and no design calculations have been performed unless specifically recorded. Conditions existing but not recorded were not apparent given the level of study undertaken. Only conditions actually seen during examination of representative samples can be said to have been appraised and comments on the balance of the conditions are assumptions based upon extrapolation. Therefore, this work does not eliminate uncertainty regarding the potential for existing or future costs, hazards or losses in connection with a property. We can perform further investigation on items of concern if so required.
- The Consultant is not responsible for, or obligated to identify, mistakes or insufficiencies in the information obtained from the various sources, or to verify the accuracy of the information.
- No statements by the Consultant are given as or shall be interpreted as opinions for legal, environmental or health findings. The Consultant is not investigating or providing advice about pollutants, contaminants or hazardous materials.
- The Client and other users of this report expressly deny any right to any claim against the Consultant, including claims arising from personal injury related to pollutants, contaminants or hazardous materials, including but not limited to asbestos, mould, mildew or other fungus.
- Budget figures are our opinion of a probable current dollar value of the work and are provided for approximate budget purposes only. Accurate figures can only be obtained by establishing a scope of work and receiving quotes from suitable contractors.
- Time frames given for undertaking work represent our opinion of when to budget for the work. Failure of the item, or the optimum repair/replacement process, may vary from our estimate.