

PATHWAY TO DECARBONIZATION FEASIBILITY STUDY

CITY OF TEMISKAMING SHORES

SHELLEY HERBERT-SHEA MEMORIAL ARENA
400 Ferguson Avenue, Haileybury, ON

WalterFedy Project No: 2023-0734-10

July 21, 2025



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Project Number: 2023-0734-10

July 21, 2025

Mathew Bahm
Director of Recreation
City of Temiskaming Shores
325 Farr Drive
Haileybury, ON POJ 1K0

Dear Mathew,

RE: Pathway to Decarbonization Feasibility Study

WalterFedy is pleased to submit the attached Pathway to Decarbonization Feasibility Study report to the City of Temiskaming Shores. This study covers the agreed-upon scope and provides a Pathway to Decarbonization Feasibility Study for the Shelley Herbert-Shea Memorial Arena, which is located at 400 Ferguson Avenue in Haileybury, ON. Certain parts of this report are designed to be viewed in digital/PDF format. This approach will enable the reader to zoom in on images and navigate the document using the provided hyperlinks.

The report was completed based on the information provided by the City of Temiskaming Shores, using the supplied and collected data, engineering judgment, and various analysis tools to arrive at the final recommendations.

All of which is respectfully submitted,

WALTERFEDY



Jordan Mansfield, P.Eng., M.Eng., CEM, CMVP
Energy Engineer
Energy and Carbon Solutions

jmansfield@walterfedy.com
519 576 2150 x 336

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EXECUTIVE SUMMARY

WalterFedy was engaged by the City of Temiskaming Shores to complete a Pathway to Decarbonization Feasibility Study for the Shelley Herbert-Shea Memorial Arena. The objective of this engagement is to identify and analyze measures that reduce utility use, GHG emissions, and utility costs at the Shelley Herbert-Shea Memorial Arena, and to analyze various GHG Reduction Pathways consisting of combinations of measures. Based on these analyses, the objective is also to recommend the preferred GHG Reduction Pathway for implementation. To achieve this objective, the following steps were taken.

1. **Facility description.** The existing conditions of the facility were reviewed through available documentation and a site survey completed on 2024-04-16 to gain an understanding of the facility and its operations. A facility description, summarizing findings, is provided in Section 2.
2. **Utility use baseline.** Metered utility data provided by the City of Temiskaming Shores was reviewed to understand historical utility use trends, and to establish the utility use baseline for the Shelley Herbert-Shea Memorial Arena. Findings are documented in Section 3.
3. **Energy model development.** A calibrated energy model was developed from a bottom-up hourly analysis considering historical weather patterns, and the insight gained from reviewing the facility's existing conditions and historical utility use data. Findings are documented in Section 4.
4. **Measure analysis.** Measures intended to achieve the City of Temiskaming Shores's goals were identified and analyzed. Analysis includes conceptual design development and utility analysis quantifying utility use impacts, GHG emissions and utility costs for each measure. Findings are documented in Section 5.
5. **Scenario analysis.** Scenario analysis was completed to estimate the costs and benefits expected from implementing various combinations (i.e. scenarios) of the measures that were individually analyzed in Section 5, accounting for the interactive effects between measures within each scenario. Findings are documented in Section 6.

All analysis was completed using the calibrated energy model, which matches metered yearly electricity and natural gas utilities used by the Shelley Herbert-Shea Memorial Arena by precisely capturing existing conditions of the building within the model. The model tracks each utility end use for every hour of a complete year.

Based on the analysis completed and discussions with the client, the GHG reduction pathway that is recommended for implementation is as follows.

- **Organizational goal alignment**

The recommended plan scenario composition is presented in Figure 1, which is a measure implementation timeline plot indicating which measures were assumed to be implemented in which plan scenarios and when, and the estimated project cost of each measure. The measures are also colour-coded according to measure group.

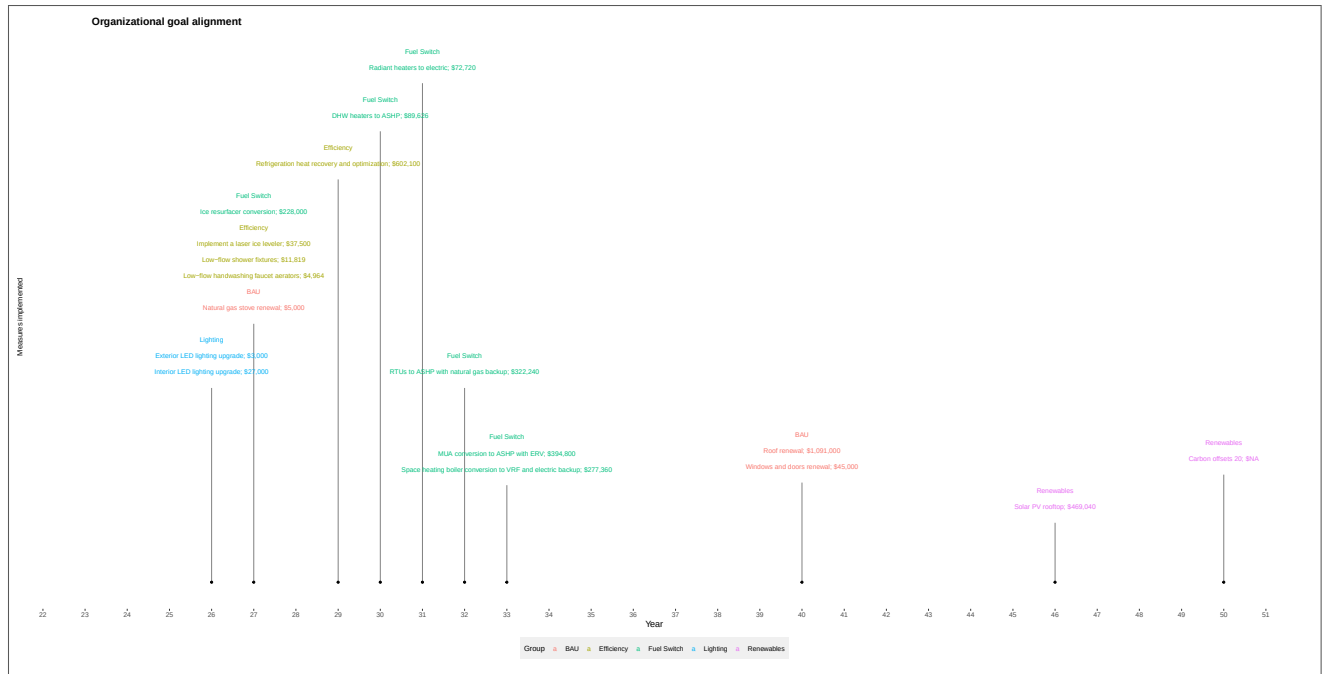


Figure 1: Recommended plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

The following plots in Figure 2 show the results for the recommended GHG reduction pathway.

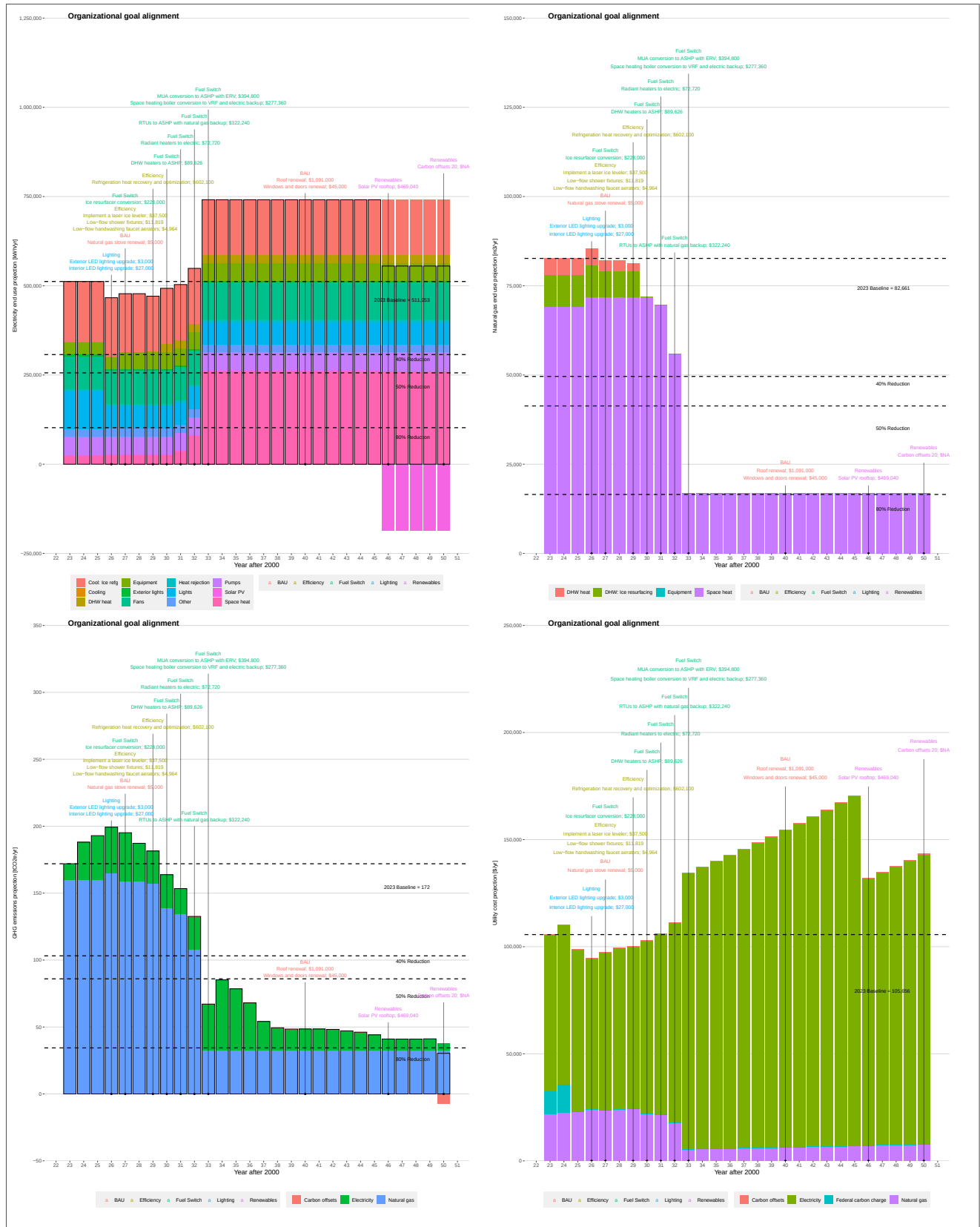


Figure 2: Recommended scenario performance

Table 1 summarizes the performance of all the plan scenarios with respect to utility use, GHG emissions, utility cost, and financial metrics. The recommended plan scenario is in **bold**. The first half of Table 1 represents the estimated performance in the final year (2050) of the evaluation period. The second half of Table 1 represents the estimated cumulative performance across the entire evaluation period (present to 2050). All final year dollar values are in the value of today's currency. All cumulative dollar values presented in Table 1 are calculated as the simple sum of expenditures over the evaluation period, except for the life cycle cost, which is discounted to present value (as illustrated in Figure 2).

Table 1: Recommended plan scenario performance summary

Section	Description	Unit	Minimum performance scenario	Aggressive deep retrofit	Comprehensive	Organizational goal alignment	Business as usual
Utility use final	Electricity use	[kWh/yr]	576,772	576,772	497,391	555,249	511,953
	Electricity monthly peak (av)	[kW]	124	124	109	121	105
	Electricity yearly peak (max)	[kW]	181	181	155	165	125
	Natural gas use	[m3/yr]	13,986	13,986	10,705	16,908	82,661
GHG emissions final	Electricity GHGs	[tCO2e/yr]	5.5	5.5	4.7	5.3	4.9
	Natural gas GHGs	[tCO2e/yr]	27	27	21	33	160
	Carbon offsets GHGs	[tCO2e/yr]	0.0	0.0	0.0	-7.6	0.0
	Total GHGs	[tCO2e/yr]	33	33	25	30	168
Utility cost final	Electricity utility cost	[\$/yr]	140,617	140,617	121,264	135,370	124,814
	Natural gas utility cost	[\$/yr]	6,330	6,330	4,845	7,653	37,412
	Carbon offsets utility cost	[\$/yr]	0	0	0	471	0
	Federal carbon charge	[\$/yr]	0.00	0.00	0.00	0.00	0.00
	Total utility cost	[\$/yr]	146,947	146,947	126,109	143,493	164,825
Utility use cumulative	Electricity use	[kWh]	15,606,031	15,967,855	16,086,604	17,383,067	14,334,680
	Natural gas use	[m3]	1,050,394	760,345	1,200,407	1,080,482	2,314,498
GHG emissions cumulative	Electricity GHGs	[tCO2e]	563	579	562	614	525
	Natural gas GHGs	[tCO2e]	2,030	1,469	2,320	2,088	4,472
	Carbon offsets GHGs	[tCO2e]	0.0	0.0	0.0	-7.6	0.0
	Total GHGs	[tCO2e]	2,608	2,063	2,897	2,709	5,103
Utility cost cumulative	Electricity utility cost	[\$]	2,972,830	3,027,774	3,069,712	3,323,267	2,709,459
	Natural gas utility cost	[\$]	328,273	239,593	375,939	341,203	812,100
	Carbon offsets utility cost	[\$]	0	0	0	471	0
	Federal carbon charge	[\$]	23,708	23,708	23,708	23,708	23,708
	Total utility cost	[\$]	3,331,088	3,297,352	3,475,636	3,694,926	3,601,688
Financial cumulative	Project cost	[\$]	5,085,440	4,843,013	12,954,793	5,110,770	2,131,423
	Replacement cost	[\$]	1,334,328	1,736,507	901,334	1,234,005	431,551
	Life cycle cost	[\$]	4,392,473	4,780,129	4,443,067	4,357,038	3,075,092

1 INTRODUCTION

1.1 Overview

WalterFedy was engaged by the City of Temiskaming Shores to complete a Pathway to Decarbonization Feasibility Study for the Shelley Herbert-Shea Memorial Arena. This engagement aims to identify a recommended Greenhouse gas (GHG) reduction pathway by examining GHG reduction measures and various scenario developments. Based on a review of the Request For Proposal Document, the City's Corporate Greenhouse Gas Reduction Plan (GHGRP), and the Federation of Canadian Municipalities (FCM) Community Buildings Retrofit (CBR) funding program, the following scenarios will be developed:

- **Business as usual:** To follow the existing capital renewal plan and replace equipment at the end of its life with like-for-like equipment, meeting minimum energy-efficiency requirements of ASHRAE 90.1.
- **Minimum performance:** To achieve a 50% reduction in operational GHG emissions within 10 years and 80% within 20 years. This scenario addresses the minimum performance scenario of FCM's CBR program.
- **Aggressive deep retrofit:** Implement the same measures as in the minimum performance scenario but achieve an 80% reduction in GHG emissions within five years. This scenario addresses the additional scenario requirement of FCM's CBR program.
- **Organizational goal alignment:** To reduce emissions by 40% GHG emissions from 2019 levels by 2033 and 80% reduction by 2050 of on-site emissions. The remaining 20% is to be addressed through carbon offsets, as noted in the City's GHGRP.
- **Comprehensive:** To understand the limit of GHG reductions possible by implementing all measures with the greatest reduction on GHG emissions that are mutually exclusive.

1.2 Background

1.2.1 Corporate Greenhouse Gas Reduction Plan

The City of Temiskaming Shores has been dedicated to taking a leading role in the battle against climate change. As a committed member of the Partners for Climate Protection (PCP) program, they achieved Milestone 3 in May 2023 by creating the City's Corporate Greenhouse Gas Reduction Plan. The plan includes ambitious targets, aiming for a 40% reduction below 2019 levels by 2033 and striving for net zero emissions operations by 2050. After conducting an inventory of its greenhouse gas (GHG) emissions in 2019, the City discovered that its buildings and facilities accounted for 813 tCO₂e, representing 41.6% of its total GHG emissions inventory. A significant portion of these GHG emissions comes from natural gas, which makes up 41.7% of all energy sources for the City. To reach these sustainability goals, the City has implemented several measures, including:

- Establishing a Climate Action Committee
- Implementing a Climate Lens with regular reporting
- Utilizing a combination of EnergyCAP and ENERGY STAR Portfolio Manager to monitor and report building utility use, including electricity, natural gas, and propane
- Transitioning its fleet to biodiesel
- Initiating decarbonization studies of its buildings

This study will contribute to the decarbonization studies of its buildings. The Shelley Herbert-Shea Memorial Arena is one of fourteen buildings being examined. Of these fourteen buildings, they represent over 77% of the buildings and facilities GHG emissions. In particular, the Shelley Herbert-Shea Memorial Arena represented 62 tCO₂e in 2019, or 3.2% of the overall inventory.

1.2.2 Asset Management Plan

The City of Temiskaming Shores released Version 1.2 of their Asset Management Plan in 2024, providing a framework for prioritizing and optimizing asset management efforts from 2024 to 2034. The building and facility

assets are estimated to have a total replacement cost of \$76,178,722, with City Hall alone having an estimated replacement cost of \$8,613,308. The average annual financial requirements, including capital and operational expenditures, is \$2,153,014. Furthermore, the 2031 budget will see a significant increase in capital needs, nearing \$44 million. In 2032, this figure will exceed \$25 million, and in 2033, it will be more than \$5 million. Figure 2 summarizes the asset management data for the Shelley Herbert-Shea Memorial Arena.

Table 2: Asset management summary for this facility

Group	Metric	Unit	Value
Financial	Content Value Estimated	[\$]	918,955
	Building Land Tank	[\$]	14,775,606
	Replacement Cost	[\$]	15,694,561
Information	Install Date	[yr]	1970
	Age	[yrs]	55
Condition Rating	Structure Condition Score	[-]	3.6
	Final Condition Score	[-]	3.6
Risk	Probability of Failure	[-]	2
	Consequence of Failure	[-]	5
	Risk Score	[-]	2.6

1.3 Contact information

Contact information for WalterFedy (the Consultant) and City of Temiskaming Shores (the Client) is provided in Table 3.

Table 3: Contact information

Description	Consultant	Client
Organization	WalterFedy	City of Temiskaming Shores
Address	Suite 111, 675 Queen St South	325 Farr Drive
Location	Kitchener, ON	Haileybury, ON
Postal code	N2M 1A1	P0J 1K0
Contact name	Jordan Mansfield	Mathew Bahm
Credentials	P.Eng., M.Eng., CEM, CMVP	-
Title	Energy Engineer	Director of Recreation
Phone	519 576 2150 x 336	705 672 3363 x 4106
Email	jmansfield@walterfedy.com	mbahm@temiskamingshores.ca

2 FACILITY DESCRIPTION

2.1 Facility description methodology

The facility was reviewed and described according to the following methodology. The intent of reviewing and describing the facility is to understand the pertinent operations and systems in the facility that use utilities so that the baseline (i.e. existing) utility use can be accurately quantified.

1. **Facility document review.** Facility documents from the following list were reviewed, if available. Further information on available documentation are available in Section 2.3.
 - Building drawings.
 - Building automation system graphics and points lists.
 - Previously completed Engineering studies, including Energy Audits, Feasibility Studies, and Building Condition Assessments.
 - Historical utility use data.
 - Other documentation made available by the City of Temiskaming Shores.
2. **Site survey.** A site survey was completed on 2024-04-16 to review the energy systems applicable to the desired retrofit scenario.

2.2 Facility overview

An overview of the Shelley Herbert-Shea Memorial Arena is provided in Table 4.

Table 4: Facility overview

Description	Unit	Value
Name	[-]	Shelley Herbert-Shea Memorial Arena
Address	[-]	400 Ferguson Avenue
Location	[-]	Haileybury, ON
Type	[-]	Arena
Construction year	[-]	1970
Gross floor area	[m2]	3,253
Gross floor area	[ft2]	35,020

An aerial view of the Shelley Herbert-Shea Memorial Arena is provided in Figure 3.



Figure 3: Shelley Herbert-Shea Memorial Arena aerial view

2.3 Building information

Renovations

The following renovations are known:

- **Roof renovation (2013):** the roof on the west side was replaced. No additional insulation was added.
- **Evaporative condenser replacement (2016):** the evaporative condenser was replaced along with the condenser pump and loop, and a VFD was added.
- **Roof renovation (2016):** the roof area that used to contain the cooling tower was replaced.
- **LED replacement over ice surface (2018):** 45 high bay LED fixtures were installed over the ice surface.
- **Dehumidifier replacement (2020):** the existing electric dehumidifier was replaced with a new electric equivalent.
- **Roof renovation (2020):** an RFP document indicated a partial roof replacement at this facility. However, the drawings referenced in the RFP were not made available.
- **Chiller replacement (2022)**

Additions

- **Changeroom addition (1984)**

Energy use not within the gross floor area

The following energy use is located outside the gross floor area of this building:

- Building-mounted exterior light fixtures

Utility bill responsibility

Utility bill responsibility is as follows:

- Natural gas meters: the City
- Electricity meter: the City
- Propane: the City

Commissioning history

No commissioning history has been documented.

Previous studies

The following is a summary of known previous studies:

- Energy audits: None
- Engineering studies: Structural roof review by EXP; Infrared Thermographic Roof Inspection by Garland Canada Inc.
- Building condition assessments: None

Documentation availability

In conjunction with the site survey, the following documents are being used to help us better understand this facility:

- Roof plan, April 2020.

- Floor plans, c. 2003, PDF.
- Floor plans, c. 1999, CAD.
- Mechanical and Electrical drawings, 2003.
- Dressing room addition drawing, April 1984.

2.4 Space use

Type summary

The following spaces were identified during the site survey and documentation review.

- Changerooms
- Art classrooms
- Multi-purpose room
- Bleachers
- Concession Stand
- Ice Arena
- Ice Resurfacer Room
- Kitchen
- Lobby
- Mechanical & electrical room
- Office
- Stairwell
- Storage
- Washrooms

Occupancy scheduling

The facility operation hours are typically based on rentals. During the site visit, a dance class occurred in the banquet hall. However, the ice was out, and no other occupants were present.

Based on the GFA, it is assumed that this building has a peak occupancy of 326 people.

Space use breakdown

A space use breakdown, which was estimated via calibrated measurements performed on available facility floor plans, is presented in Table 5.

Table 5: Space use summary

Space name	Floor area of space	HVAC System	Data source
-	[m2]	-	-
Main Lobby	133.6	F1	Assumption.
West changerooms	295.8	Hydronic heating and MUA1	Assumption.
Figure skating changeroom	93.2	Hydronic heating only	Assumption.
Palette and Brush Club	85.9	Hydronic heating only	Assumption.
54's Changeroom	111.4	Hydronic heating only	Assumption.
Mechanical Rooms	138.0	No conditioned	Assumption.
Washrooms	88.3	Electric or hydronic baseboards	Assumption.
Concession	55.6	Electric baseboards	Assumption.
Kitchen	43.1	Electric baseboards	Assumption.
Banquet Hall	299.6	RTU1 and RTU2	Assumption.
Ice Rink	2,022.3	DH1 plus infrared heating	Assumption.
Storage	392.1	Hydronic heating	Assumption.
Other	296.6	Electric or hydronic baseboards	Assumption.

Space use documentation

Space use documentation, including available drawings and photos taken during the site survey, is provided in the following images. Most drawings in this report are high-quality, embedded PDF documents, enabling the reader to review details by zooming in on the figures.



Figure 4: 54s Changeroom



Figure 5: Banquet hall

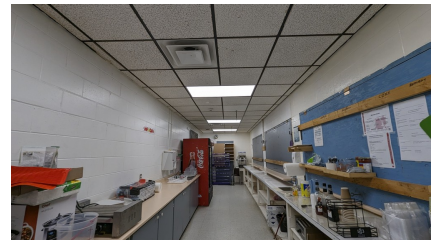


Figure 6: Concession

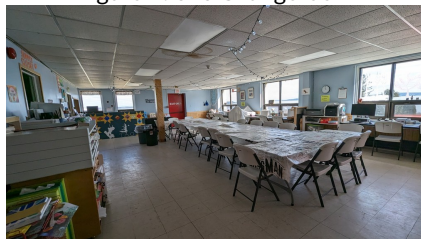


Figure 7: Open Studio Libre

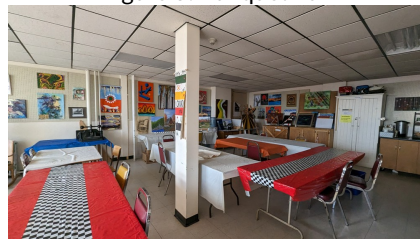


Figure 8: Palette and brush room

2.5 Building Envelope

Building envelope area data summary

Building envelope areas are summarized in Table 6.

Table 6: Building envelope summary

Area of roof	Area of exterior walls net	Area of exterior walls	Area of exterior windows	Area of exterior doors
[m2]	[m2]	[m2]	[m2]	[m2]
4,196	2,823	2,764	32.4	27.3

Overview

No architectural drawings were available, and therefore there is no detailed information on building assemblies.

Roof

- The exterior layer of the roof is modified bitumen membrane, which was replaced in 2020. It's assumed that no additional insulation was added at this time.
- The overall roof assembly is assumed to have a U-Value of 0.5679 W/m2K.
- The roof was in good condition, as it was replaced in 2020. There was standing water on the roof. However, it was determined that the catch basins were blocked. Staff cleared the catch basins and water was draining properly.

Opaque Walls (above ground)

- The exterior walls comprised either an outer layer of metal siding or concrete block.
- The overall wall assembly is assumed to have a U-Value of 0.5679 W/m2K.
- The wall condition of the metal siding and concrete block was fair, with notable damage in certain spots.

Fenestration

Windows

- It appears most windows are double-pane aluminum windows.
- Windows appears to be in good condition, with no noticeable issues.
- The overall U-Value is assumed to be 3.786 W/m2K for the window system with a SHGC of 0.35.

Doors

- The facility has swing doors with glazing, hollow metal, and one overhead door.
- The overall fenestration-to-wall ratio is estimated to be 2%.

Overall Enclosure Tightness

It is difficult to determine a building's infiltration rate without performing a blower door test. However, an infiltration rate is required for energy modelling purposes. Based on the site survey, an infiltration rate of 0.35 Lps/m2 of the above-grade building envelope area will be assumed here.

Building Envelope documentation

Building envelope documentation, including available drawings and photos from the site survey, is provided in the following images.



Figure 9: Attic above the Open Studio Libre



Figure 10: Awning window in the palette and brush room



Figure 11: Doorsweep replacement of the southwest entrance required



Figure 12: Damage to metal siding on east elevation



Figure 13: East elevation window



Figure 14: East elevation door with glazing



Figure 15: East entrance



Figure 16: Extruded polystyrene



Figure 17: Fire exit for the Studio Libre



Figure 18: Gap present at bottom of main entrance door



Figure 19: Hollow metal doors to ice rink



Figure 20: Main entrance



Figure 21: Metal siding



Figure 22: North facade



Figure 23: Roof over the arena



Figure 24: Spalling of the foundation



Figure 25: Standing water on the roof
due to plugged CB

2.6 HVAC

HVAC equipment summary

HVAC systems are summarized in Table 7, Table 8, Table 9, and Table 10.

Table 7: Air distribution systems summary

Tag	Make	Model	Serves	Design flow	Motor output	Data source
-	-	-	-	[cfm]	[hp]	-
MUA1	KeepRite	E7G-RT25C2C01H31 A20B3	West changerooms	3,000	1.00	Assumption.
RTU1	Lennox	GCS16-953-200-4J	Banquet hall - west	1,500	1.50	Assumption.
RTU2	Lennox	GCS16-953-200-4J	Banquet hall - east	1,500	1.50	Assumption.
F1	Payne Heating and Cooling	PG95SAS60120 DBAA	Main lobby	1,000	0.75	Assumption.
DH1	CIMCO	Desicon ET	Ice rink	3,000	10.00	Assumption.
REF1	-	-	Ice rink	2,000	1.50	Assumption.
REF2	-	-	Ice rink	2,000	1.50	Assumption.
EF01	-	-	54's dressing room	500	0.50	Assumption.
EF02	-	-	54's dressing room	500	0.06	Assumption.
EF03	-	-	Studio Libre Kitchen	500	0.25	Assumption.
EF04	-	-	Changeroom hallway	500	0.17	Assumption.
EF05	-	-	Ice plant room	500	0.17	Assumption.
EF06	-	-	Ice resurfacer room	500	0.17	Assumption.
EF07	-	-	Ice resurfacer room	500	0.17	Assumption.
EF08	-	-	DHW mechanical room	500	0.17	Assumption.
EF09	PVC	Domex	Changeroom 5 and 6	500	0.17	Assumption.
EF10	PVC	Domex	Changeroom 3 and 4	500	0.17	Assumption.
EF11	PVC	Domex	Changeroom 1 and 2	500	0.17	Assumption.
EF12	PVC	Domex	Referee changeroom	500	0.17	Assumption.
EF13	-	-	Banquet hall kitchen	500	0.17	Assumption.
EF14	-	-	Second floor washrooms	500	0.17	Assumption.

Table 8: Water distribution systems summary

Tag	Serves	Flow	Head	Motor output	Data source
-	-	[gpm]	[ft]	[hp]	-
BP1	Front entrance	-	-	0.26	Nameplate
BP2	Changerooms (figure skating & 54ers), art and pilot club, bathrooms, and Studio Libre	-	-	1.00	Assumption.
BP3	Not in service	-	-	1.00	Assumption.
BP4	Changerooms	-	-	0.50	Nameplate
DP1	DHW storage tank	-	-	0.17	Assumption.
DP3	Ice resurfacers storage tank	-	-	0.17	Assumption.
DP4	Hydronic unit heaters	-	-	0.17	Assumption.
DP5	DHW circulation	-	-	0.17	Assumption.
DP6	DHW circulation	-	-	0.17	Assumption.
CP1	Cooling brine loop	750	50	20.00	Nameplate
CP2	Underfloor heating	-	-	2.00	Nameplate
CP3	Spray pump for evaporative condenser	150	40	3.00	Nameplate

Table 9: Heating systems summary

Tag	Serves	Utility	Efficiency	Output	Data source
-	-	-	[decimal]	[btuh]	-
B1	Boiler 1	Natural gas	0.75	489,000	Assumption
B2	Boiler 2	Natural gas	0.81	346,000	Nameplate
B3	Boiler 3	Natural gas	0.81	346,000	Nameplate.
MUA1_HEAT	MUA1	Natural gas	0.79	197,500	Nameplate.
RTU1_HEAT	RTU1	Natural gas	0.80	160,000	Nameplate.
RTU2_HEAT	RTU2	Natural gas	0.80	160,000	Nameplate.
F1_HEAT	F1	Natural gas	0.97	117,000	Nameplate
DHW1	DHW	Natural gas	0.80	159,920	Nameplate.
DHW2	No longer used	Natural gas	-	-	-
DHW3	DHW	Natural gas	-	-	-
DHW4	Ice resurfacers	Natural gas	-	-	-
INF_HTRS	Bleachers	Natural gas	0.50	225,000	Assumption.
EL_BSBD	Various	Electricity	-	-	-

Table 10: Cooling systems summary

Tag	Serves	Efficiency	Output	Data source
-	-	[decimal]	[ton]	-
RTU1_COOL	RTU1	4.0	7	Assumption.
RTU2_COOL	RTU2	4.0	7	Assumption.
C1	Ice plant	3.1	20	Assumption.
C2	Ice plant	3.1	33	Assumption.
DH1	Ice rink	-	-	-

System type

The facility utilizes one MUA, one furnace, one dehumidifier, two RTUs (a third unit above the banquet hall is defunct), and various exhaust fans for mechanical ventilation. Supplementary heating is provided via electric or hydronic baseboards throughout the building. The ice rink has unit heaters above the ice. However, they are no longer used. Lastly, infrared heaters are above the bleachers. A summary of this system is as follows:

- MUA1, serving the changerooms, is a make-up air unit complete with natural gas burners. There are exhaust fans in the changerooms as well, but they do not appear to be interlocked with MUA1. No cooling is on this unit, given the ice rink is not used during the cooling season.
- The condensing, natural gas-fired furnace serves the front lobby and has only heating.
- The dehumidifier in the ice arena was replaced in 2020 and is fully electric.
- Two RTUs serving the banquet hall are equipped with natural gas burners and DX cooling.

There is electric baseboard heating in the following spaces:

- Main lobby (staff indicated that these baseboards are not working)
- 1st floor washrooms
- SW stairwell and presumably the SE stairwell
- Concession
- 1st floor offices
- Girl's changeroom
- Banquet hall kitchen
- Banquet hall (staff indicated that these baseboards are not working)

There is hydronic baseboard heating only (i.e., no mechanical ventilation) in the following spaces:

- 54's dressing room
- Figure skating changeroom
- Art club
- The east stairwell
- Studio Libre
- Second floor women's and men's washroom
- West changerooms
- West changerooms corridor

The bleachers have natural gas-fired infrared heating that is in poor condition.

The ice rink is equipped with two exhaust fans (REF1 and REF2) located on the north elevation. They are interlocked with two supply air dampers on the roof.

Central Plant

One non-condensing boiler provides hot water to radiators throughout the building. This boiler used to be a coal boiler and was retrofitted to use natural gas.

There are also two more non-condensing boilers that primarily serve DHW. However, they do serve two hydronic unit heaters, one in the DHW mechanical room and the other in the ice resurfacers room.

Distribution system

A total of 9 pumps circulate hot water throughout the building for space heating or DHW use. All pumps are minor in size and do not have a VFD. Duplicate tags are assigned within the building. To differentiate, pumps that are located in the basement boiler room are denoted as BP, and pumps in the DHW mechanical room beside the ice resurfer are denoted as DP. For the ice plant (see the Process and plug loads section), they are labelled as CP. A summary of the pumps are noted below:

- BP1 serves the hydronic unit heaters located at the front entrance.
- BP2 serves the 54's changeroom, art club, figure skating changeroom, east stairwell, Studio Libre, and second floor washrooms.
- BP3 is no longer operational. Its unclear what it used to serve.
- BP4 serves the changerooms on the west side of the building.
- DP1 serves the storage tank for DHW.
- DP3 serves the storage tank for the ice resurfer.
- DP4 is assumed to serve the hydronic unit heaters (one in the DHW mechanical room and the other in the ice resurfer room).
- DP5 and DP6 are in parallel and are used for circulating DHW.

The air distribution throughout the building uses a single-duct approach to the corresponding zone.

Controls

Existing BAS System

Staff indicated that there was a BAS present at this facility. However, they are unable to access it. Furthermore, the company that installed the system is no longer in business, and there appear to be no known businesses that have taken on this system architecture. It was also unclear what equipment, if any, is controlled by this unit.

Miscellaneous

The following components were noted during the site survey:

- BP1 is controlled by a thermostat located in the front entrance. However, a photo of the thermostat was not taken.
- BP2 is controlled by a thermostat located in the east stairwell. This type of thermostat is typical for a furnace application. However, it is being used to control a pump. The fan option was set to ON which would suggest then that the pump is ON continuously. This observation aligns with the fact that it was 79F but the temperature setpoint was 70F. Furthermore, the location of the thermostat is not within any of the spaces it intends to condition.
- It's unclear how BP4 is controlled for heating the changerooms. It's presumed that the pump operates continuously.
- F1 is controlled by a thermostat located in the main lobby. It was set to 67F and was reading 68F during the site visit. The fan mode was set to ON. The thermostat appeared to have a schedule but it was set to a HOLD.
- There was an old Honeywell thermostat located in the main lobby as well. It's presumed to control the electric baseboard heaters in the space. However, staff indicated that this thermostat no longer works.
- RTU1 and RTU2 are controlled by thermostats in the banquet hall. RTU2 was set to 60F with a temperature of 67F. This difference is most likely due to a dance class ending shortly before a walkthrough of the space. RTU1 had a setpoint of 66, and the temperature was reading 67F. However, staff indicated that the RTU requires a new board and was not working at the time of the site visit.
- It's unclear what is controlling MUA1. Given that it's an MUA, it is presumed to run continuously during hockey season.

- It's unclear what is controlling the infrared heaters. It's presumed that they are seldomly used, and on a timer.
- Controls for the dehumidifier were not readily available. It's assumed that the unit is used to maintain at RH of 60%.
- Most exhaust fans were manually controlled. The exhaust fans in the changerooms and washrooms were ON during the site visit. It's presumed that they operate continuously.

HVAC system documentation

HVAC system documentation, including available drawings and photos from the site survey, is provided in the following images.



Figure 26: B1



Figure 27: BP1



Figure 28: B2 and B3



Figure 29: BP2 - Thermostat

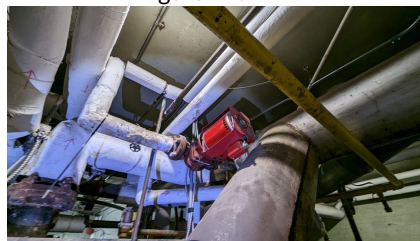


Figure 30: BP2



Figure 31: BP3



Figure 32: BP4

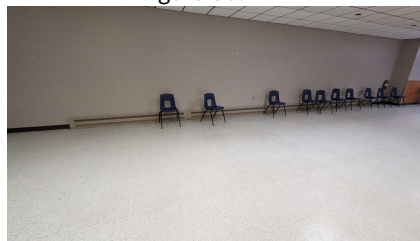


Figure 33: Banquet baseboard heaters are not working



Figure 34: Baseboard heater in Open Studio Libre

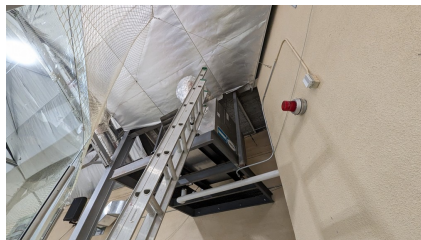


Figure 35: DH1 - Dehumidification unit

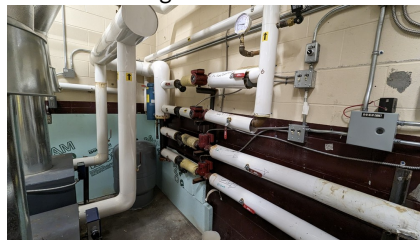


Figure 36: DP1, DP3, DP5, and DP6 in the DHW mechanical room



Figure 37: DP4



Figure 38: EF01 - 54s changeroom



Figure 39: EF02 - 54s changeroom



Figure 40: EF03



Figure 41: EF04 - changeroom hallway

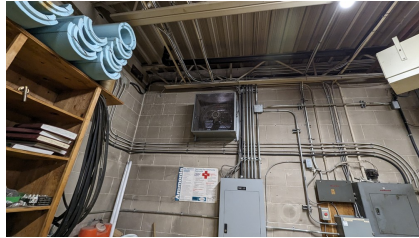


Figure 42: EF05 - ice plant mechanical room



Figure 43: EF06 - ice resurfacers room

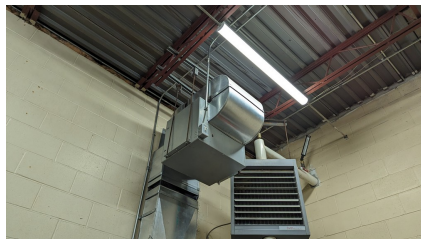


Figure 44: EF07 - ice resurfacers room



Figure 45: EF08 - DHW mechanical room



Figure 46: EF09



Figure 47: EF10



Figure 48: EF11



Figure 49: EF12



Figure 50: EF13



Figure 51: EF14

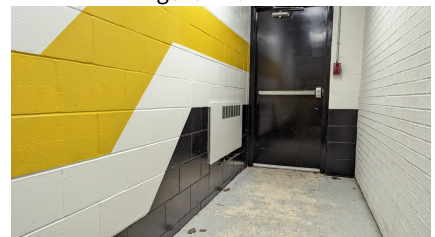


Figure 52: Electric baseboard heater outside ice plant mechanical room



Figure 53: Electric cabinet heater in southwest stairwell



Figure 54: Exhaust fans for the arena



Figure 55: F1



Figure 56: F1 thermostat



Figure 57: Gas detector controlling SSF1,2 and REF1,2



Figure 58: Hydronic baseboard heater in the referee changeroom



Figure 59: Infrared heaters over stands



Figure 60: Infrared heaters in stands are in poor condition

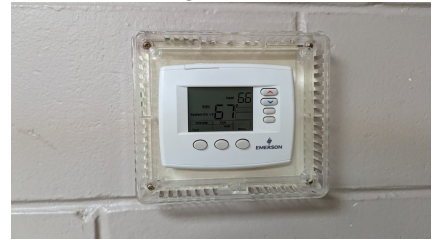


Figure 61: MUA1 - thermostat



Figure 62: MUA1 - changerooms



Figure 63: MUA1 - VFD appears to not be working

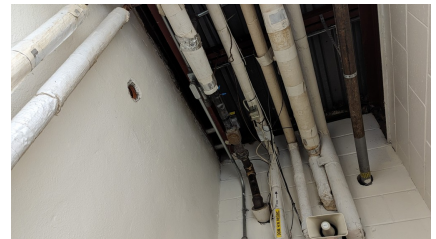


Figure 64: Missing insulation in changeroom corridor



Figure 65: REF1 and REF2



Figure 66: RTU1 - return



Figure 67: RTU1 - thermostat



Figure 68: RTU1



Figure 69: RTU2



Figure 70: Radiator in east entrance



Figure 71: Radiator in the stairwell



Figure 72: Radiator in 54s Changeroom

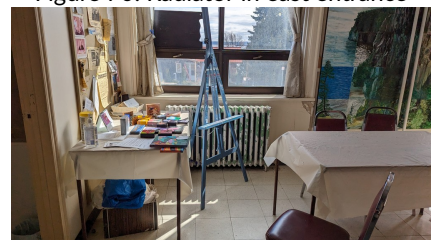


Figure 73: Radiator in palette and brush room



Figure 74: Radiator in the figure skating coach's room



Figure 75: Rangehood - Open Studio Libre



Figure 76: RTU no longer in use



Figure 77: SSF1



Figure 78: Thermostat in main lobby no longer used



Figure 79: UH1 and UH2 - front entrance



Figure 80: UH3 - ice resurfer room



Figure 81: UH4 - mechanical room



Figure 82: UH5 - gas-fired unit heater in area no longer used



Figure 83: UH6 - gas-fired unit heater in area no longer used



Figure 84: UH7 - electric - ice plant room

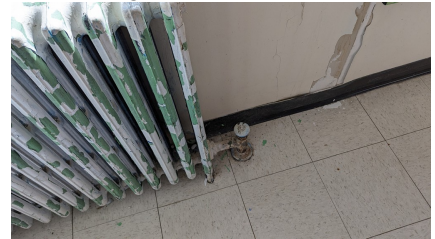


Figure 85: Valve on radiator



Figure 86: Windows open in the 2nd floor women's washroom

2.7 Domestic hot water

Overview

Two non-condensing boilers with storage tanks serve the west changerooms and the ice resurfacers. Both tanks had a storage volume of 56 USG for DHW. The basement boiler room had a natural gas-fired DHW heater with a storage size of 76 USG. This tank is presumed to serve the east side of the building. Lastly, there was a DHW heater located in the banquet hall kitchen. However, staff indicated that this tank is no longer used.

The two non-condensing boilers were controlled by a Tekmar control unit. The supply temperature was 185F.

Piping in the ice plant room was capped. It's assumed that this piping used to interface with the condenser loop of the ice plant as a means to preheat DHW.

Domestic Hot Water documentation

Domestic Hot Water documentation, including available drawings and photos from the site survey, is provided in the following images.

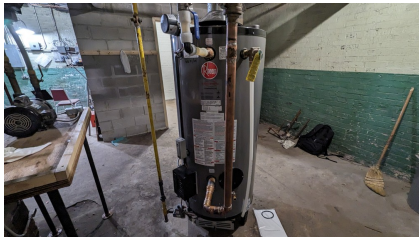


Figure 87: DHW1



Figure 88: DHW2



Figure 89: DHW3 and DHW4



Figure 90: Missing insulation on DHW pipe

2.8 Lighting

Lighting system summary

Lighting systems are summarized in Table 11.

Table 11: Lighting systems summary

Space name	Floor area of space	Light power density	Light power input	Data source
-	[m ²]	[W/m ²]	[W]	-
Main Lobby	133.6	9.8	1,309	Assumption.
West changerooms	295.8	9.8	2,899	Assumption.
Figure skating changeroom	93.2	9.8	913	Assumption.
Palette and Brush Club	85.9	9.8	842	Assumption.
54's Changeroom	111.4	9.8	1,092	Assumption.
Mechanical Rooms	138.0	9.8	1,352	Assumption.
Washrooms	88.3	9.8	865	Assumption.
Concession	55.6	9.8	545	Assumption.
Kitchen	43.1	9.8	422	Assumption.
Banquet Hall	299.6	9.8	2,936	Assumption.
Ice Rink	2,022.3	9.8	19,819	Assumption.
Storage	392.1	9.8	3,843	Assumption.
Other	296.6	9.8	2,907	Assumption.

Interior lighting

Fixtures

The following interior light fixtures were observed during the site survey:

- Type A: standard light socket, LED lamp, ceiling-mounted
- Type B: 2'x4' recessed, 4 lamp, 15W, 120V, LED lamp retrofitted
- Type B1: 2'x4' recessed, 4 lamp, 32W, 120V, T8 fluorescent
- Type C: 1'x4' recessed, 2 lamp, T8 fluorescent, possibly magnetic ballast
- Type C1: 1'x4' recessed, 2 lamp, 40W, T12 fluorescent
- Type D: 1'x4' suspended, 2 lamp, 15W lamp, LED lamp retrofitted
- Type E: 1'x4' surface-mounted, 2 lamp, 40W, T12 fluorescent
- Type F: high bay LED
- Type G: 1'x4' suspended, 2 lamp, T8 fluorescent
- Type H: surface-mounted fixture in the shower
- Type I: 1'x4' surface-mounted, 2 lamp, T8 fluorescent
- Type J: strip LED

Controls

Interior lighting is mostly controlled through ceiling-mounted occupancy sensors (washrooms and changerooms) and manual switches. Numerous spaces had their lights ON in unoccupied spaces. It's unclear if this observation was a typical representation of the lighting schedule or if it is typically turned off when not in use.

There was a lighting controller in the electrical room for non-ice rink areas. However, it is unclear if this system still works. There was also a lighting controller for the ice rink.

Exterior lighting

Fixtures

The following exterior light fixtures were observed during the site survey:

- Type L: Wall pack, LED, 30 W assumed
- Type M: downlight, MH
- Type N: LED flood light
- Type O: Downlight

Controls

Most exterior fixtures appear to have a dedicated photocell sensor on the fixture. There were no timer boxes spotted that controlled exterior lighting.

Lighting system documentation

Lighting system documentation, including available drawings and photos taken during the site survey, is provided in the following images.



Figure 91: Light controls in the ice plant room



Figure 92: Lighting controls



Figure 93: Occupancy sensor in dressing room 1



Figure 94: Occupancy sensor in men's washroom on first floor



Figure 95: Time clock for arena lighting



Figure 96: Type A - standard socket with LED lamp



Figure 97: Type B1 - T8 lamps



Figure 98: Type B - LED lamps



Figure 99: Type C1 - T12 lamp



Figure 100: Type C - T8 lamps



Figure 101: Type D - LED lamps

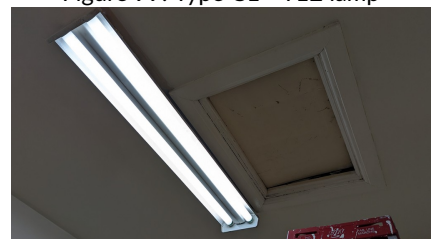


Figure 102: Type E - T12 lamps



Figure 103: Type F - high bay LED

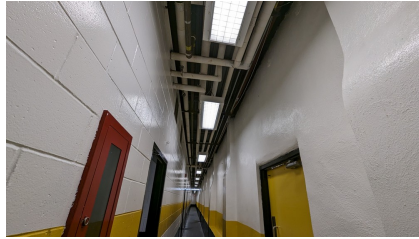


Figure 104: Type G - T8 lighting



Figure 105: Type H - shower fixture

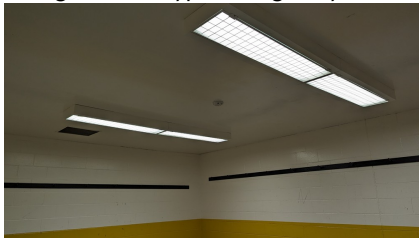


Figure 106: Type I - surface-mounted fixtures

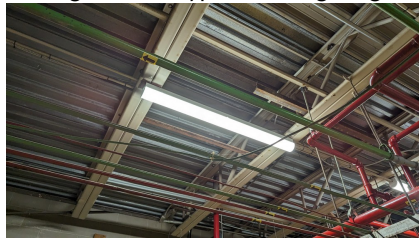


Figure 107: Type J - strip LED fixture



Figure 108: Type L - wall pack

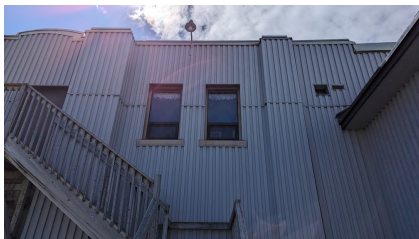


Figure 109: Type M - downlight



Figure 110: Type N - flood

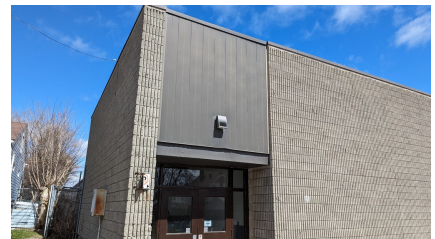


Figure 111: Type O - downlight

2.9 Process and plug loads

Process - General

Various process loads are present at the facility, including:

- 1 x Stove - electric
- 2 x Stoves - natural gas. One located in the Studio Libre kitchen, and the other in the banquet hall kitchen.
- Glass grinders
- Power tools (e.g., mitre saw)
- Hand dryers

Ice plant

The ice plant has an estimated 280 TR (tons of refrigeration) based on a COP of approximately 3.1. A summary of the system is as follows:

- Two reciprocating compressors, C1 and C2, have capacities of 50 HP and 30 HP, respectively.
- There is one brine chiller that was replaced in c. 2022.
- The ammonia hot gas is cooled via an evaporative condenser.
- There is a VFD present that is presumed to modulate the fan speed on the cooling tower. This approach is a common strategy to improve system efficiency through a floating head pressure approach.
- CP1 serves the cooling brine loop for the ice rink.
- CP2 serves the underfloor heating to prevent ice heave. The underfloor heating loop gets its heat from the ammonia hot gas via a heat exchanger.
- CP3 is a spray pump for the evaporative condenser.
- There is no heat recovery on this system. There appears to be piping from the DHW that suggests there used to be DHW pre-heat. However, this is no longer the case.
- Ice temperature readouts were not available given that the ice was out during the site visit in April 2024.
- A low emissivity ceiling has already been installed.

Ice resurfacer

- The facility has one ice resurfacer that operates on propane.
- The ice resurfacer utilizes a manual ice leveller.
- The ice resurfacer water is heated to approximately 140F. There is a dedicated storage tank for the ice resurfacer water that appeared to be still operational (140F readout on the thermometer) when the ice was out.

Plug loads

Various plug loads are present at the facility, including:

- Office equipment (printers)
- 3D printer
- Sound system for the banquet hall
- Personal computers
- Appliances (e.g., refrigerator, coolers, microwave, etc.)
- Vending machines

Process and plug loads documentation

Process and plug loads documentation, including available drawings and photos from the site survey, is provided in the following images.

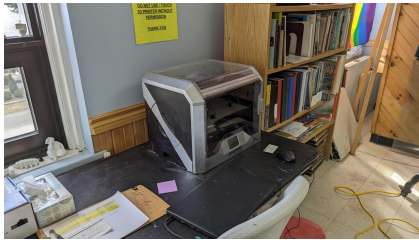


Figure 112: 3D printer



Figure 113: Banquest sound system



Figure 114: Bar coolers



Figure 115: Brine expansion tanks



Figure 116: CP1 - cooling brine pump



Figure 117: CP2 - underfloor heating

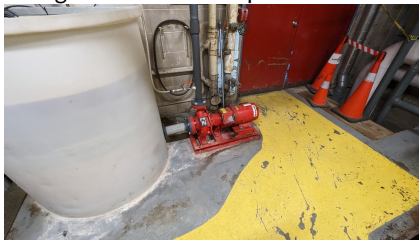


Figure 118: CP3 - condenser pump



Figure 119: Compressor 1



Figure 120: Compressor 2



Figure 121: Concession appliances



Figure 122: Control panel for ice plant



Figure 123: Electric stove in the banquet kitchen



Figure 124: Evaporative condenser



Figure 125: Evaporative condenser water tank



Figure 126: former area of washer and dryer in 54s



Figure 127: Gas stove in the banquet kitchen



Figure 128: Gas stove and refrigerator in the Open Studio Libre



Figure 129: Glass grinders



Figure 130: HX2 - for underfloor heating



Figure 131: Hand dryers



Figure 132: Ice plant chiller and surge drum



Figure 133: Ice resurfacer



Figure 134: Low emissivity room over ice rink



Figure 135: Manual ice leveller and propane fuelled ice resurfacer



Figure 136: Microwave in kitchen



Figure 137: Mitre saw



Figure 138: Open Studio Libre computer



Figure 139: Open Studio Libre equipment



Figure 140: Printer in the figure skaters room



Figure 141: Refrigerator and microwave in ice resurfacer room



Figure 142: The ice was out as of April 2024



Figure 143: Vending machines



Figure 144: VFD for condenser fan

2.10 Water fixtures

Water fixture summary

Water fixtures at Shelley Herbert-Shea Memorial Arena are summarized in Table 12.

Table 12: Water fixture summary

Serves	Unit count	Flow	Volume	Data source
-	-	[gpm]	[gpc]	-
Kitchen faucets	3	2.2	-	Assumption.
Washroom faucets	14	2.2	-	Aerators.
Toilets	10	-	1.6	Assumption.
Urinals	2	-	1.0	Assumption.
Washroom faucets	16	1.5	-	Assumption.

Overview

A summary of water fixtures is as follows:

- Handwashing faucets. Most were manually controlled and aerators rated for 2.2 gpm.
- Kitchen sinks.
- Toilets.
- Urinals.
- Showers. Flow rates range from 1.25 gpm to 2 gpm from sampled showerheads.

Water fixture documentation

Water fixture documentation, including available drawings and photos taken during the site survey, is provided in the following images.



Figure 145: 2nd floor toilet



Figure 146: 2nd floor faucets



Figure 147: Bar sink

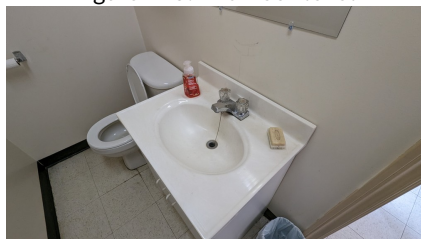


Figure 148: Faucet in palette and brush room

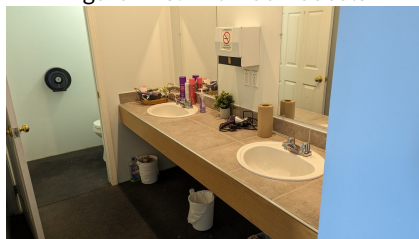


Figure 149: Faucets in the figure skater changeroom



Figure 150: Handwashing faucets in the women's washroom



Figure 151: Janitorial sink



Figure 152: Kitchen sink in banquet kitchen



Figure 153: Open Studio Libre faucet



Figure 154: Open Studio Libre - kitchen sink



Figure 155: Referee faucet

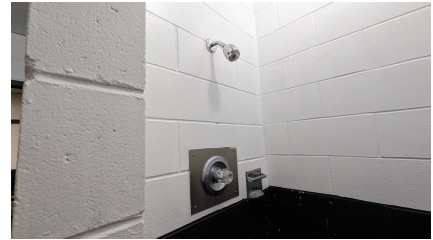


Figure 156: Referee shower



Figure 157: Second kitchen sink in Open Studio Libre



Figure 158: Showers in the 54s changeroom



Figure 159: Toilet - 54s changeroom



Figure 160: Toilet in the palette and brush room



Figure 161: Toilet in the figure skater changeroom



Figure 162: Urinal - 2nd floor washrooms

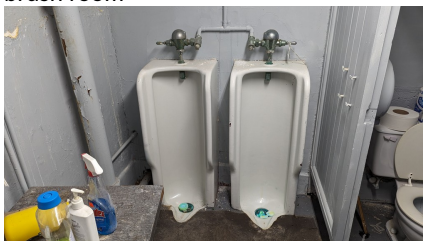


Figure 163: Urinals in 54s changeroom



Figure 164: Washroom sink for 54s changeroom



Figure 165: Water fountain



Figure 166: Water spout

2.11 Utility services

Utility services summary

Overview

The building utilizes electricity from Hydro One Networks Inc. and natural gas from Enbridge.

The one electricity meter operates on a General Service - Demand rate structure.

There are two natural gas meters at this facility. The first meter (2695894) is located on the south side of the building. The second meter (2936280) is located on the north side. There are no drawings available to delineate which meter serves each equipment.

Utility services documentation

Utility services documentation, including available drawings and photos from the site survey, is provided in the following images.



Figure 167: Electricity meter



Figure 168: Natural gas meter on the north elevation



Figure 169: Natural gas meter on the south elevation



Figure 170: Propane storage

2.12 Onsite energy sources

Overview

There are no stationary generators or renewable energy systems present at this facility.

2.13 Electrical infrastructure

Overview

The building is fed from a pole-mounted transformer bank across the road. The feed appears to be 4-500 MCM going into the main 600 V/347 V switchgear, with an assumed 400A main disconnect. The existing system is 400A at 600 V - 3Ph service running at a maximum load of 153 kW, which is approximately 46% of the full load of 332 kW of the building. The main incoming panel, DP1, has no available breaker space.

Panel summary

The eight panels were observed while on site. Their information is summarized below:

- Panel A. Serves P4, furnace 3, 54s receptacles, lights, east unit heaters, dressing rooms 1-4, ladies room, men's washroom, and banquet room panel.
- Panel B (boiler room). Serves P1, 54s, boiler, north-end hallway heater fan and south-end hallway heater fan.
- Panel B (changeroom). Serves magnetic holders, heaters, skate sharpener, exhaust fan in banquet hall, radiant heat over bleachers, fire alarm, hand dryers, receptacles, and lights.
- Panel C. Serves P2, P3, and boiler switch.
- Open Studio Libre Panel. Serves lighting, receptacles, and the rangehood.
- Panel DP1. Serves electric heat, RTUs, the resurrector, and lights.
- Panel PA. Serves receptacles, exhaust fans, ice resurfacer unit heater, lights, VFD for the resurrector, and heaters over the ice.
- Panel LP2. Serves the boiler, circulation pumps, F2, EF2, time clock, EF1, receptacle, lights, score clock, heater in referee booth, exterior lights, dehumidifier, ice resurfacer, SSF1, SSF2, EF3, EF4, EF5, and propane monitor.

Electrical infrastructure documentation

Electrical infrastructure documentation, including available drawings and photos from the site survey, is provided in the following images.



Figure 171: 75 kVA transformer in ice plant room



Figure 172: DP1



Figure 173: Electrical room

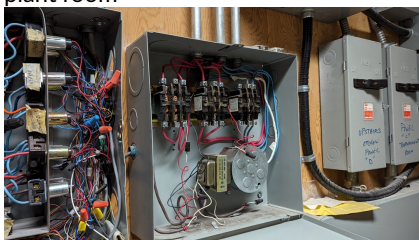


Figure 174: Heater relays



Figure 175: Lighting panel in ice plant room



Figure 176: Open Studio Libre Panel



Figure 177: Panel A

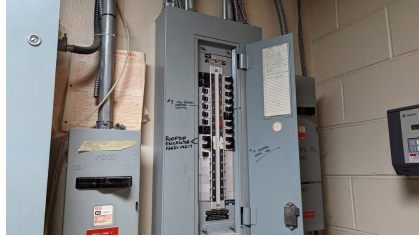


Figure 178: Panel A (electric room)



Figure 179: Panel B (changeroom)



Figure 180: Panel B (boiler room)



Figure 181: Panel C



Figure 182: Panel in the ice plant room



Figure 183: Panel LP2



Figure 184: T25 - in boiler room



Figure 185: T37 - in boiler room



Figure 186: T37 - in electrical room

3 UTILITY USE ANALYSIS

3.1 Utility analysis methodology

The utility use analysis was completed according to the following methodology. Note that the results achieved from applying this methodology are presented in the same order in Sections 3.2 through 3.9.

1. **Utility analysis assumptions.** Assumptions applied in the utility use analysis were identified and summarized in Section 3.2.
2. **Metered utility use.** Metered utility use data, as available, were analyzed and summarized in a subsection corresponding to the utility. Metered utility use data were available for the following utilities for Shelley Herbert-Shea Memorial Arena.
 - Electricity; see Section 3.3.
 - Natural gas; see Section 3.4.
 - Propane; see Section 3.5.
3. **Utility use baseline.** The utility use baseline was summarized in Section 3.6, and includes the following.
 - **Baseline year:** A baseline year was determined as the most recent year with the fewest anomalies in facility operations and utility metering. The baseline year was used to establish the historical weather data used for the energy model development, as explained in Section 4.1. If valid metered utility data was available for the baseline year, then the metered utility use data for the baseline year was used to establish baseline performance and for energy model calibration.
 - **Baseline performance:** Yearly utility use, GHG emissions and utility costs. For each utility, the baseline performance was derived from the metered utility use for the baseline year if available for that utility, or from the energy model described in Section 4 if metered data were unavailable or invalid for that utility. Table 13 summarizes the data source of the baseline performance for each utility.

Table 13: Baseline performance data source for each utility

Utility	Source
Electricity	Meter
Natural gas	Meter
Propane	Energy model

4. **Benchmarking analysis.** The yearly baseline energy use and GHG emissions of Shelley Herbert-Shea Memorial Arena was compared with those of similar facilities in Section 3.7. Data for similar facilities were obtained from the Government of Ontario's website, made available for the Broader Public Sector (BPS) through O. Reg. 25/23. The list below includes all municipalities considered for the benchmarking process. If this building is the only one presented, it indicates that similar buildings are not being reported to the database.
 - City of Greater Sudbury
 - City of North Bay
 - City of Temiskaming Shores
 - City of Timmins
 - Municipality of Temagami
 - Municipality of West Nipissing
 - Town of Iroquois Falls
 - Town of Kirkland Lake
 - Township of Armstrong

- Township of Black River-Matheson
 - Township of Brethour
 - Township of Casey
 - Township of Chamberlain
 - Township of Gauthier
 - Township of Harley
 - Township of Harris
 - Township of Hilliard
 - Township of Hudson
 - Township of James
 - Township of Kerns
 - Township of Larder Lake
 - Township of Matachewan
 - Township of McGarry
5. **Portfolio benchmarking analysis.** A portfolio benchmarking analysis was also performed, where Energy Star Portfolio Manager was used to benchmark the energy analysis of Shelley Herbert-Shea Memorial Arena.
6. **Utility use analysis discussion.** Results of the utility use analysis were studied and discussed in Section 3.9.

3.2 Utility analysis assumptions

Assumptions applied throughout the methodology are summarized as follows.

- GHG emissions factors were assumed as per Table 14.

Table 14: GHG emissions factor assumptions

Utility	Unit	Value	Source
Electricity	[tCO ₂ e/kWh]	0.0000239	Environment and Climate Change Canada Data Catalogue, Electricity Grid Intensities-1
Natural gas	[tCO ₂ e/m ³]	0.0019324	National Inventory Report, 1990-2023, Table 1-1, Table A61.1-1 and Table A61.1-3
Propane	[tCO ₂ e/L]	0.0015150	National Inventory Report, 1990-2023, Table A6.1-5

- Utility cost rates for the baseline year of 2023 were assumed as per Table 15. Electricity utility cost rates were assumed based on typical wholesale rates for the General Service Demand billing structure. Throughout this document, the Federal Carbon Charge ("FCC") was treated separately with respect to applicable fuels, rather than being blended into the utility cost rate for those fuels. As such, all other utility cost rates exclude the federal carbon charge. The Federal Carbon Charge was removed on April 1, 2025, as such, this document has been updated to have the FCC set to \$0/tCO₂e for 2025 and onward.

Table 15: Utility cost rate assumptions for the baseline year (2023)

Utility	Line item	Unit	Value
Electricity	Electricity consumption - Class B	[\$/kWh]	0.0200
Electricity	Global adjustment - Class B	[\$/kWh]	0.0735
Electricity	Regulatory	[\$/kWh]	0.0057
Electricity	Delivery	[\$/kW]	12.1217
Natural gas	Natural gas (blended)	[\$/m ³]	0.2600
GHG emissions	Federal carbon charge	[\$/tCO ₂ e]	50.0000
Propane	Propane	[\$/L]	0.6000

3.3 Electricity metered utility use

Hourly electricity use is plotted in Figure 187.

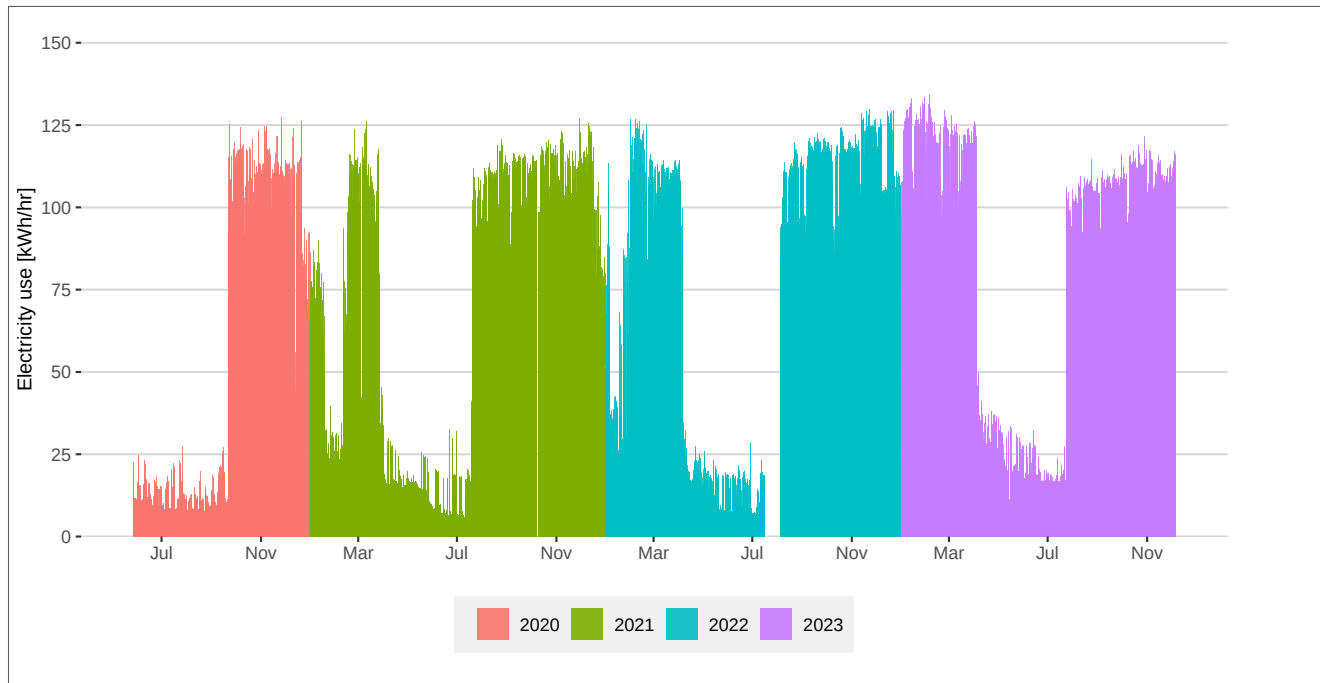


Figure 187: Hourly electricity use

The same hourly electricity use data is plotted in Figure 188, which highlights how electricity use is influenced by year, season, day of week and hour of day. The vertical axis on Figure 188 may be rescaled relative to in Figure 187 for greater resolution.

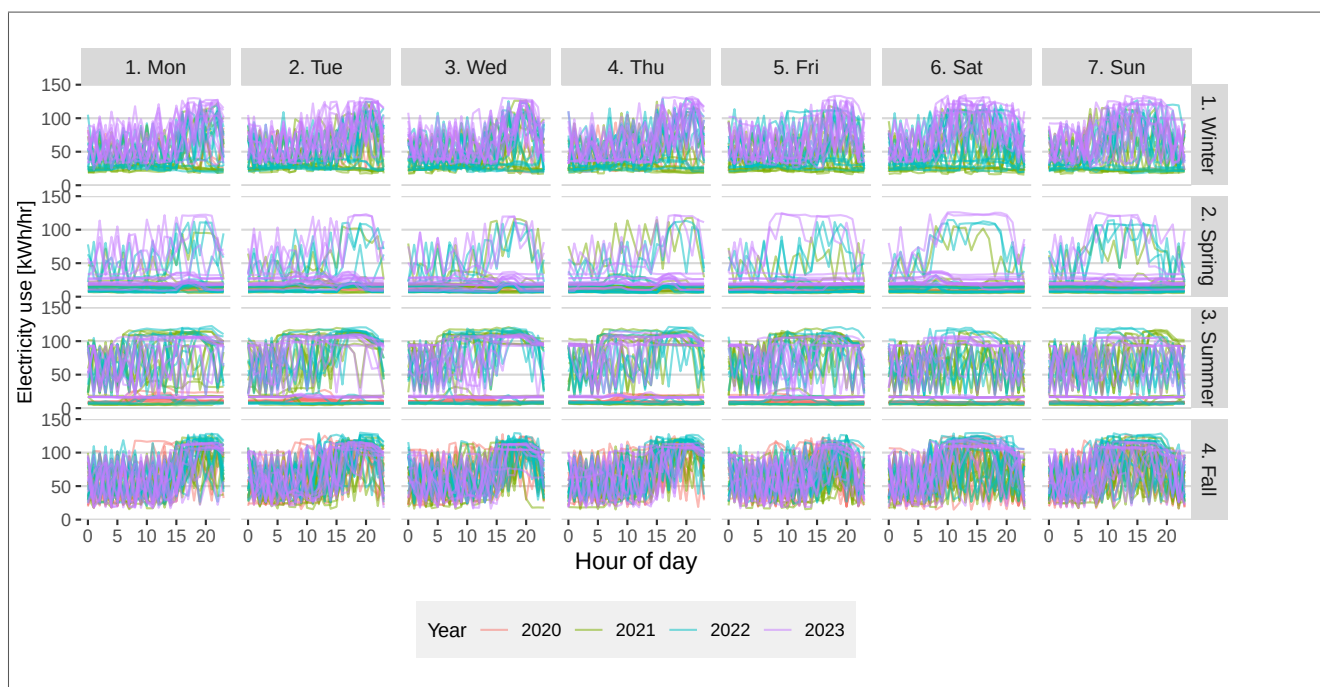


Figure 188: Hourly electricity use hairball plot

Monthly electricity use is plotted in Figure 189.

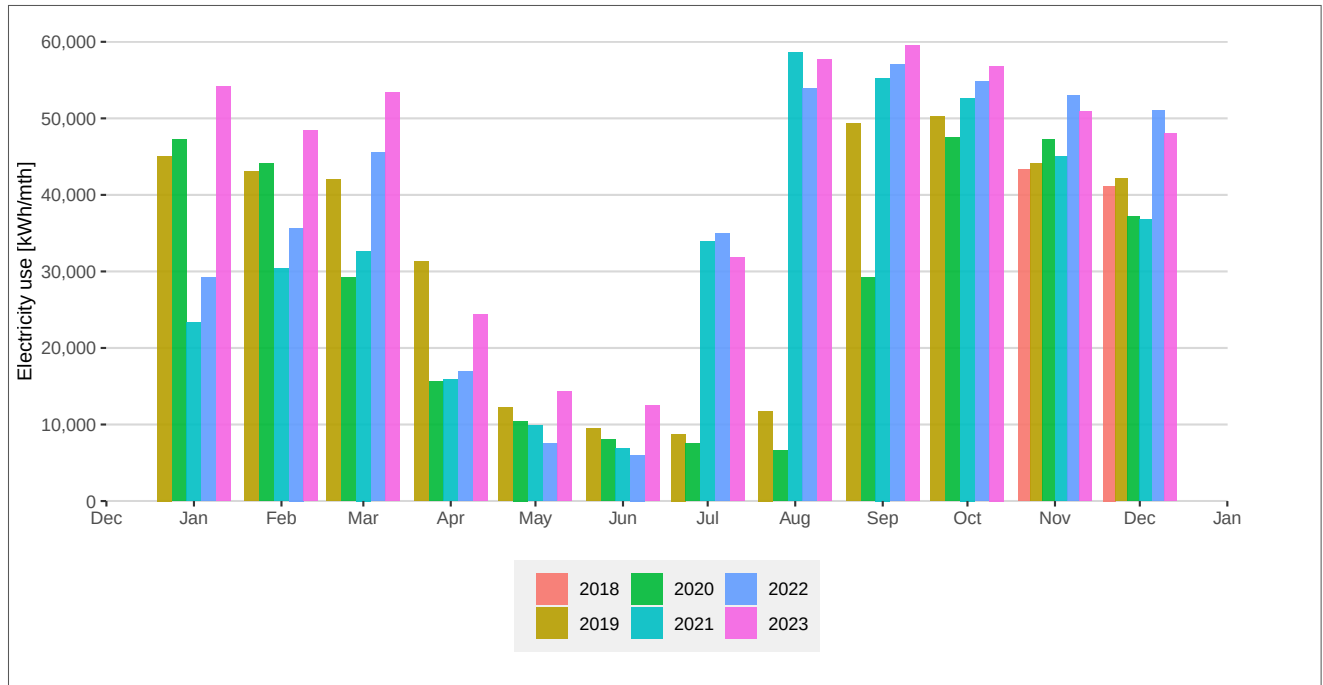


Figure 189: Monthly electricity use

3.4 Natural gas metered utility use

Monthly natural gas use is plotted in Figure 190.

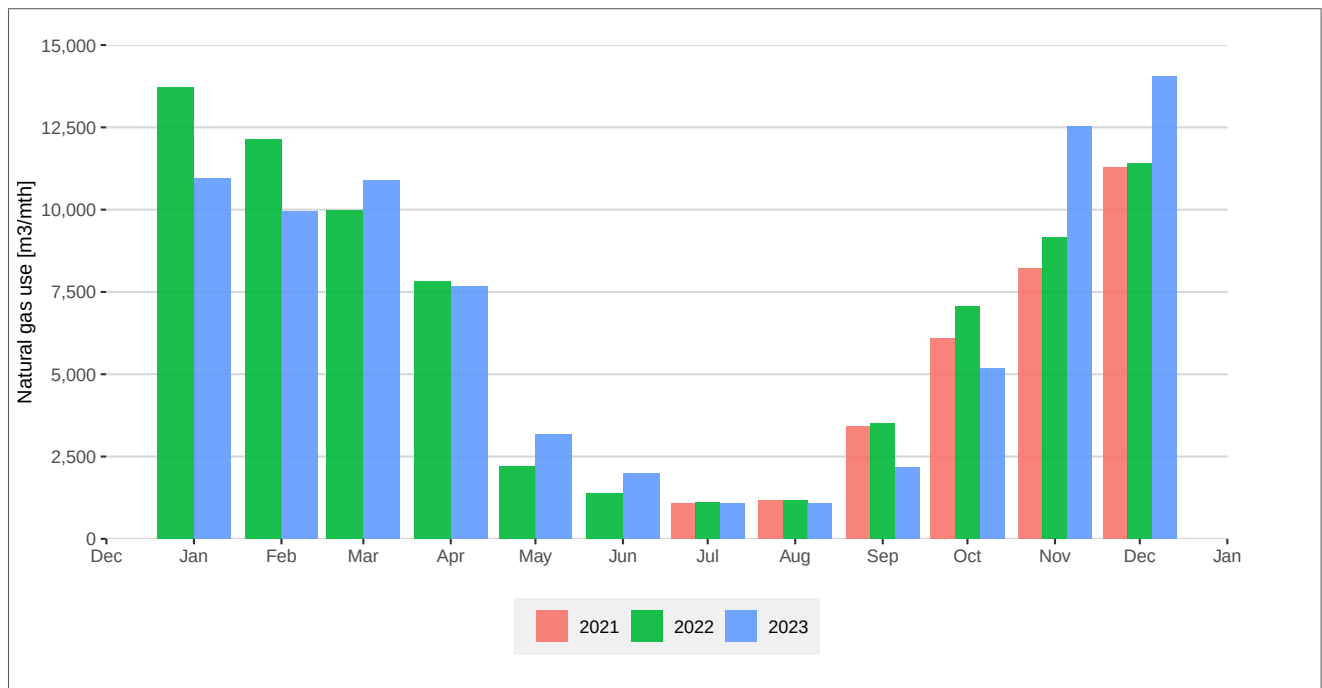


Figure 190: Monthly natural gas use

3.5 Propane metered utility use

Monthly propane use is plotted in Figure 191.

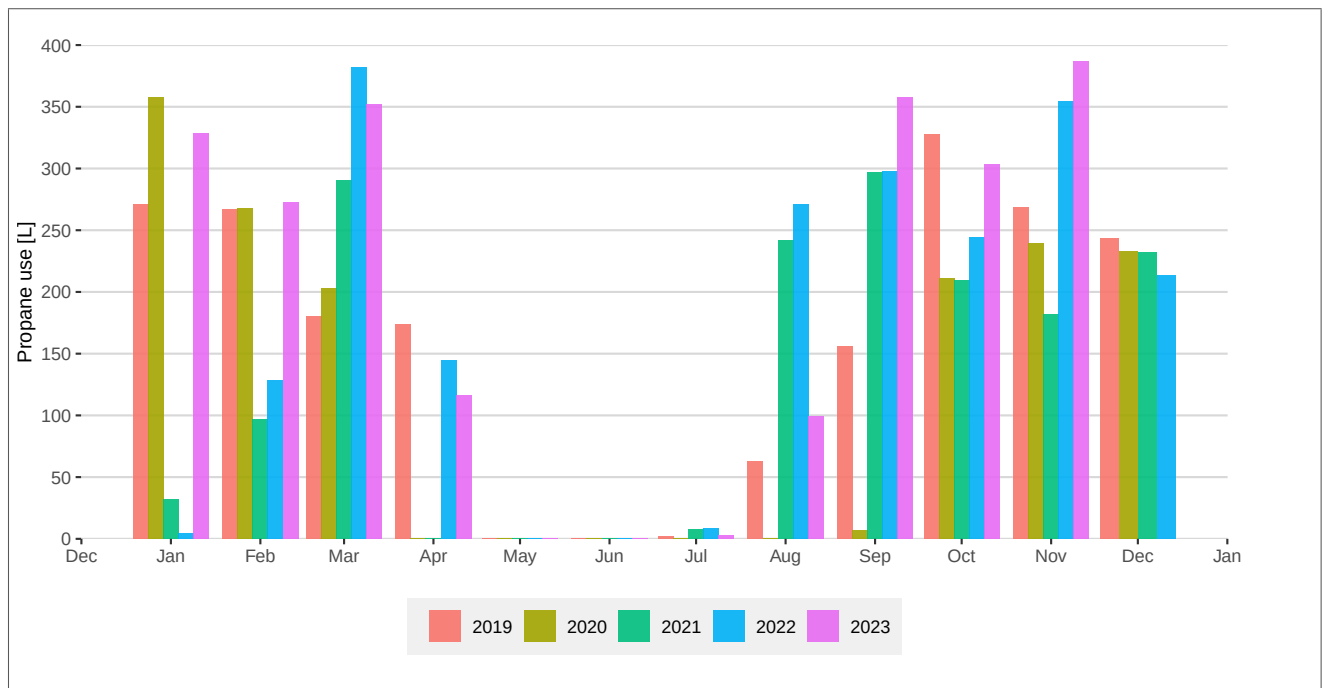


Figure 191: Monthly propane use

3.6 Utility use baseline

Baseline year

The baseline year for Shelley Herbert-Shea Memorial Arena, which is used to establish the baseline performance through the metered utility use data from that year, is as follows.

- **Baseline year:** 2023.

Baseline performance

Baseline utility use performance for the baseline year of 2023 is summarized in Table 16.

Table 16: Baseline utility use performance

Category	Utility	Unit	Value
Utility use	Electricity use	[kWh/yr]	511,953
	Natural gas use	[m3/yr]	82,661
	Propane use	[L/yr]	2,489
	Carbon offset use	[tCO2e/yr]	0
Equivalent energy use	Electricity energy	[kWh/yr]	511,953
	Natural gas energy	[kWh/yr]	872,625
	Total energy	[kWh/yr]	1,402,069
GHG emissions	Electricity GHGs	[tCO2e/yr]	12
	Natural gas GHGs	[tCO2e/yr]	160
	Carbon offsets GHGs	[tCO2e/yr]	0
	Total GHGs	[tCO2e/yr]	176
Utility cost	Electricity utility cost	[\$/yr]	66,048
	Natural gas utility cost	[\$/yr]	21,492
	Carbon offsets utility cost	[\$/yr]	0
	Federal carbon charge	[\$/yr]	8,175
	Total utility cost	[\$/yr]	97,208

3.7 Benchmarking analysis

Benchmarking analysis results are presented in the following figures.

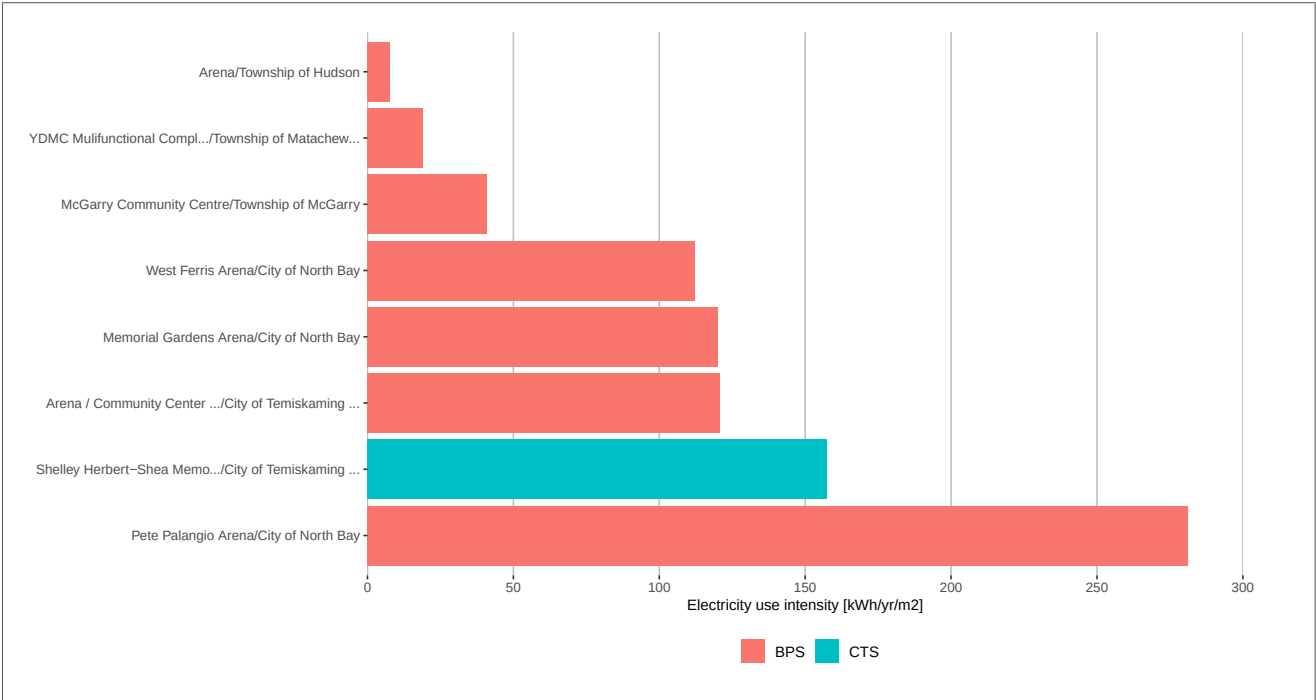


Figure 192: Electricity use intensity benchmarking analysis comparison

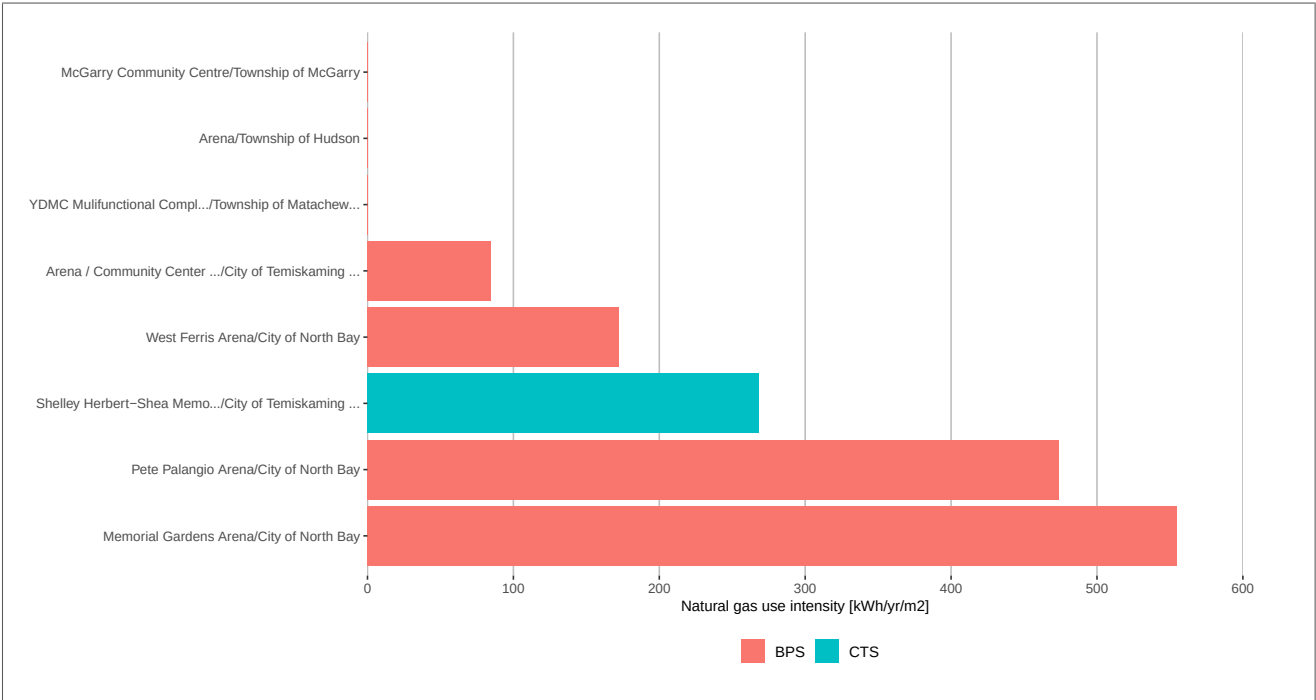


Figure 193: Natural gas use intensity benchmarking analysis comparison

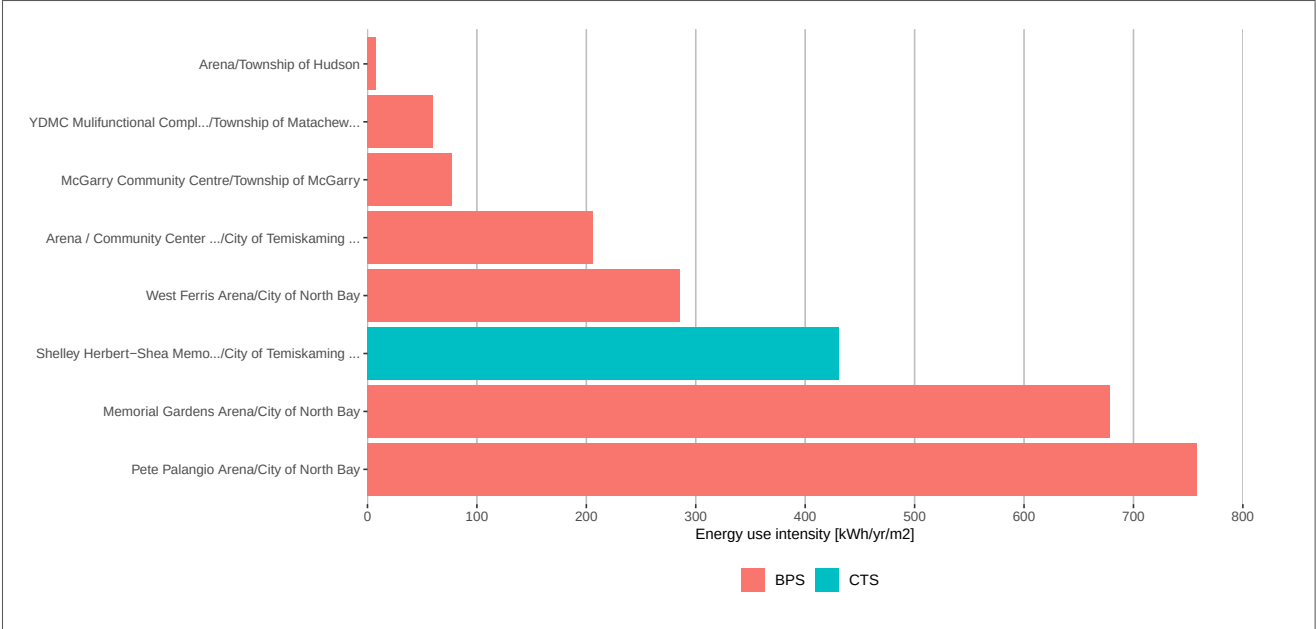


Figure 194: Total energy use intensity benchmarking analysis comparison

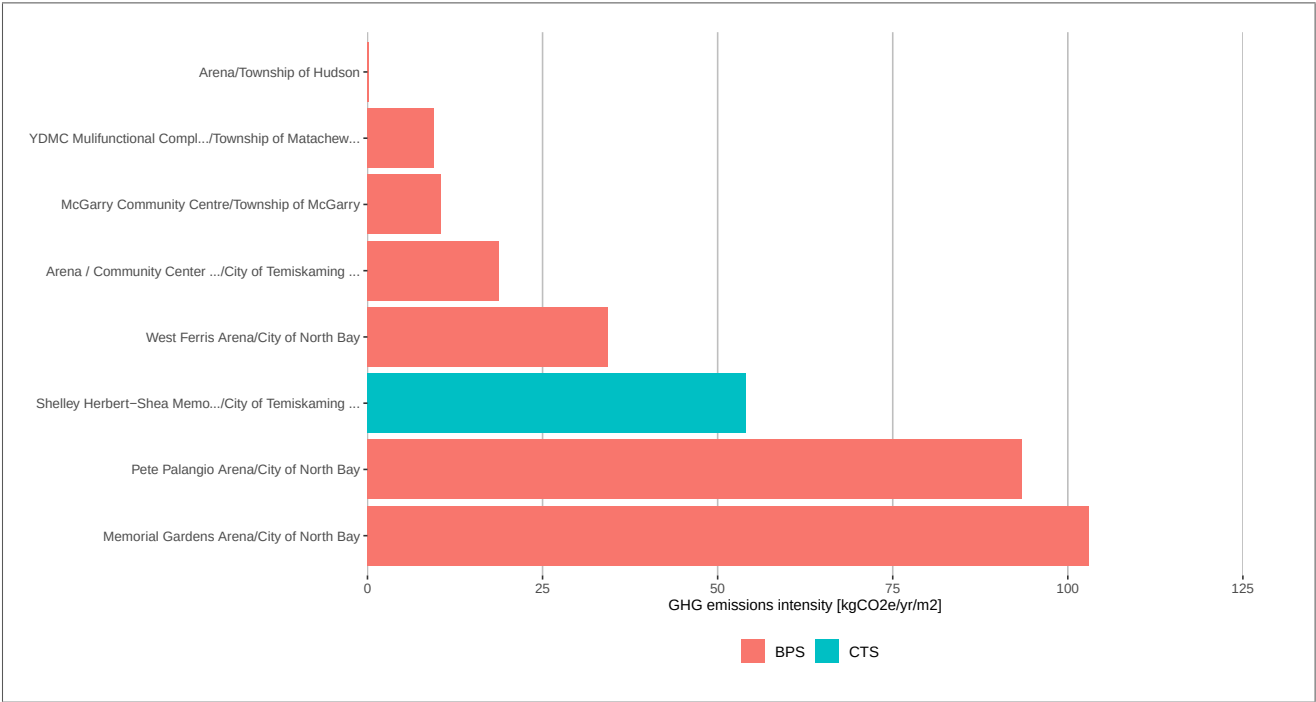


Figure 195: GHG emissions intensity benchmarking analysis comparison

3.8 ENERGY STAR Portfolio Manager benchmarking analysis

The scorecard is shown in Figure 196.

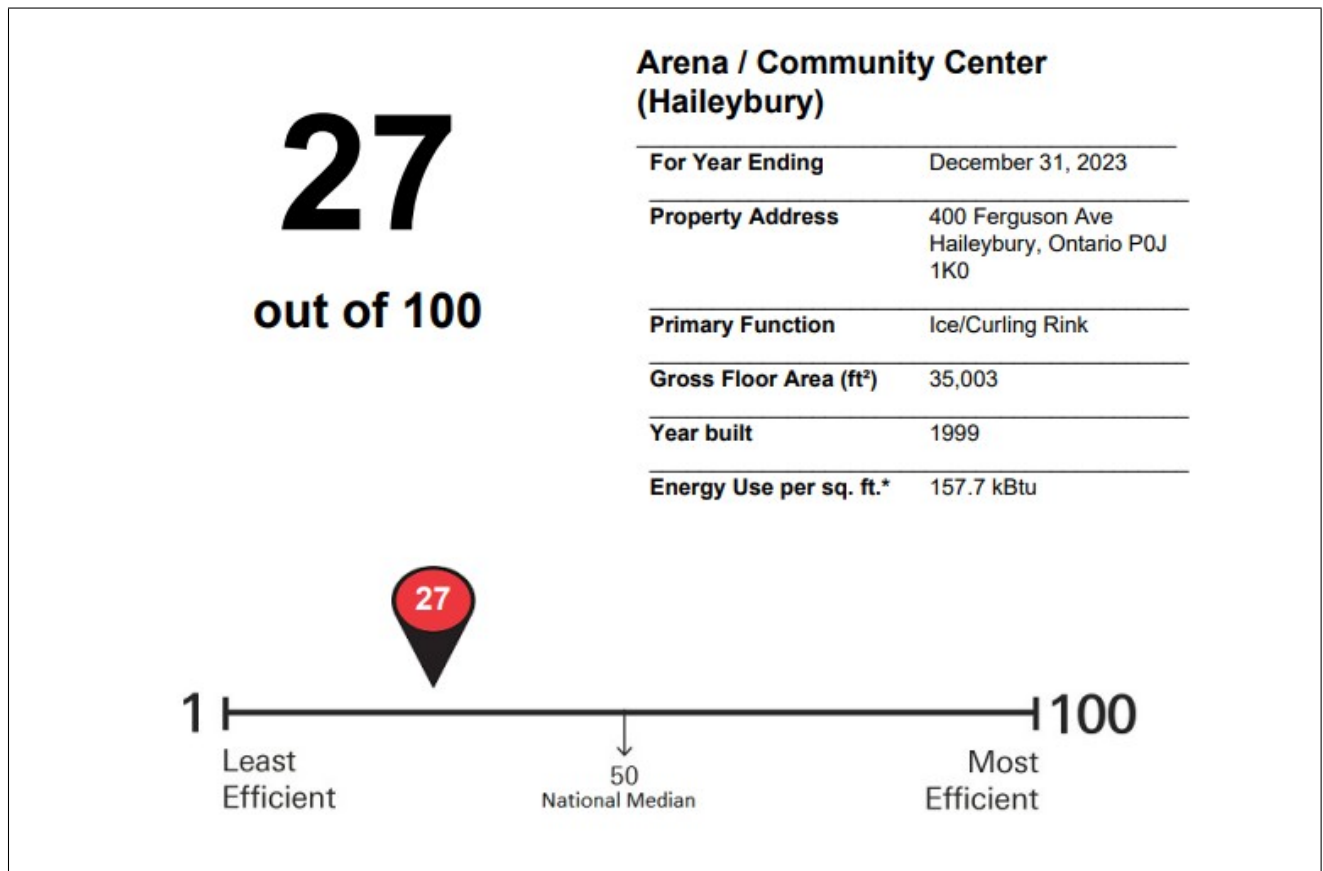


Figure 196: Energy Star energy performance scorecard.

3.9 Utility use analysis discussion

General

The following discussion seeks to explain utility use trends observed in the metered data, based on the understanding of the building systems and their operations presented in Section 2.

Electricity - Hourly

- Hourly electricity consumption typically peaks during the fall, winter, and spring, due to the refrigeration load of the ice plant.
- Hourly consumption is typically under 125 kWh and above 10 kWh. It appears that hourly consumption typically ranges from about 50-125 kWh when the ice is in, and 10-25 kWh otherwise.

Electricity - Monthly

- **2018:** The dataset provided started in November 2018 and did not allow for a full year of comparison.
- **2019:** Consumption is relatively constant from January to March and September to December, and lower from April to August. This suggests that the ice was removed in late April, and replaced in late August or early September.
- **2020:** Consumption is similar to that of other years, but the consumption from March to September is lower than in other years. This is likely the result of a change in operations due to the impact of the COVID-19 pandemic.
- **2021:** Consumption from January to March is lower than the seasonal average, which may be due to reduced operations from the COVID-19 pandemic.
- **2022:** Consumption in January was lower than the seasonal average.
- **2023:** There is slightly higher electricity use in the summer months when the ice rink is out, but otherwise the profile follows the seasonal average.

Natural gas

- Natural gas consumption has maintained a consistent profile year over year. It is highest during the heating season and very low during the cooling season.
- In this facility, natural gas is used for space heating, water heating, and to operate two gas stoves.
- Natural gas consumption in the summer is likely due to domestic hot water heating and to stove use.
- Of the 55 data points available for monthly natural gas consumption, only 25 were actual readings, not estimates. This observation can lead to calibration issues, as the model may not pass ASHRAE Guideline 14.

Propane

- Propane use is relatively consistent year over year. Propane is typically used from August to April, which is consistent with the operation of the ice plant.
- Propane is used to operate the ice resurfacer.

4 ENERGY MODEL DEVELOPMENT

4.1 Energy model development methodology

The utility use profile was developed from an hourly analysis, spanning one year, of the following energy systems. The analysis reflects the existing conditions of the facility as documented in Section 2.

The energy model was created in eQUEST v3.65, build 7175, using the DOE2.3 engine. The inputs were established to match the existing conditions as closely as possible. The following sources were used as background information to inform energy model inputs:

- Observations from site survey and conversations with facility staff.
- Schedules and setpoints from the BAS. As-built drawings provided by the City of Temiskaming Shores.
- References from the Ontario Building Code (OBC) SB-12, ASHRAE90.1, and NECB where the above data was not available.

1. **Hourly utility use profiles.** An hourly utility use profile for each utility was developed according to the following methodology. Results were presented in Section 4.2.

- (a) *Utilities and end uses.* Hourly utility use profiles developed through this analysis were assigned to both utilities and end uses. The utilities and end uses that were modelled are summarized in Table 17.

Table 17: Utility and end use summary and definitions

Utility	End use	Definition of end use
Electricity	Cool: Ice refig	Cooling energy use from ice refrigeration compressor motors.
	Cooling	Cooling energy use.
	Equipment	Equipment energy use.
	Exterior lights	Exterior lighting energy use.
	Fans	Fan motor energy use.
	Heat rejection	Energy use by heat rejection equipment (e.g. cooling towers).
	Lights	Lighting energy use.
	Other	Metered use less modelled use.
	Pumps	Pump motor energy use.
	Space heat	Space heating energy use.
Natural gas	DHW heat	Domestic hot water heating energy use.
	DHW: Ice resurfacing	Domestic hot water heating energy use for ice resurfacing water.
	Equipment	Equipment energy use.
	Space heat	Space heating energy use.
Propane	Ice resurfacer	Fuel used by ice resurfacer.

- (b) *Weather data.* Hourly weather data was obtained from the Earlton-Cimate weather station, ID 712130S.
- (c) *Facility spaces.* Facility spaces were grouped according to activities in the spaces and HVAC systems serving them. The thermal characteristics of the exterior building envelope components for each space were assumed based on findings documented in Section 2.7. Thermal loads within each space were calculated based on assumed space temperature and humidity setpoints, hourly weather data, and activities in the space that affect thermal conditions (e.g. lighting or equipment that generates heat).
- (d) *Primary systems.* Primary systems are defined as systems whose utility use can be predicted independent from other systems; examples include lighting, equipment (e.g. office and process equipment), pumps, etc. The hourly utility demand of primary systems was modelled based on assumed time-of-day operating schedules, peak power input and average loads relative to the peak power input. Peak power input was estimated from findings documented throughout Section 2, including lighting power or power density, nameplate horsepower of motors, etc.

- (e) *HVAC systems.* HVAC system energy use was modelled based on hourly weather data and space condition setpoints defined for the various spaces. The analysis also accounted for system-specific ventilation controls and activities and primary systems that have thermal influences on spaces (e.g. occupancy, lighting, equipment, processes that add heat to spaces). The analysis quantified hourly energy use of fans, heating (e.g. sensible, humidification, reheat) and cooling (e.g. sensible, dehumidification).
 - (f) *Generators.* The utility use and generation of on-site systems that generate energy or utilities was modelled based on the assumed capacities and operations of those systems according to findings documented in Section 2; examples include solar PV, CHP, etc. Utilities generated on site were treated as negative utility consumption relative to utilities consumed on site so that the consumption, generation and the aggregate use of utilities could be tracked accordingly.
 - (g) *Other.* For each utility having valid metered utility use data available for the baseline year, the Other end use was modelled from the top down to reconcile results of the above utility-consuming systems that were modelled from the bottom up with metered utility use data for the baseline year. This end use was called Other.
2. **Monthly utility use profiles.** A monthly utility use profile for each utility was developed by grouping and summing up the hourly utility use profiles by end use and by month. Results were presented in Section 4.3.
 3. **Calibration analysis.** After explicitly modeling the above systems, the model was calibrated for each of the following utilities (utilities for which valid metered data for the baseline year was available) through the Other end use, which was calculated as the difference of metered and modeled utility use. The above modeling steps were iterated as required to achieve reasonable calibration.
 - Electricity
 - Natural gas
 4. **End use analysis.** An end use analysis of each utility was completed. Since the hourly utility use profiles already track the hourly utility use by each end use, the end use analysis involved summarizing data from the hourly utility use profiles to obtain yearly utility use by each end use. Results were presented in Section 4.5.

4.2 Hourly utility use profiles

The hourly utility use profiles are presented graphically in this Section 4.2 in a format called a stacked bar plot. For each hour of the year, the utility use for all end uses active during that hour is presented in a single bar pertaining to that hour. The end uses are identified by colour, and all end uses are “stacked” on top of each other within each hour-specific bar such that the total height of each bar represents the total utility use of all end uses combined in that hour.

Electricity

The hourly electricity utility use profile by end use made by the energy model is plotted in Figure 197. See Table 17 for end use definitions.

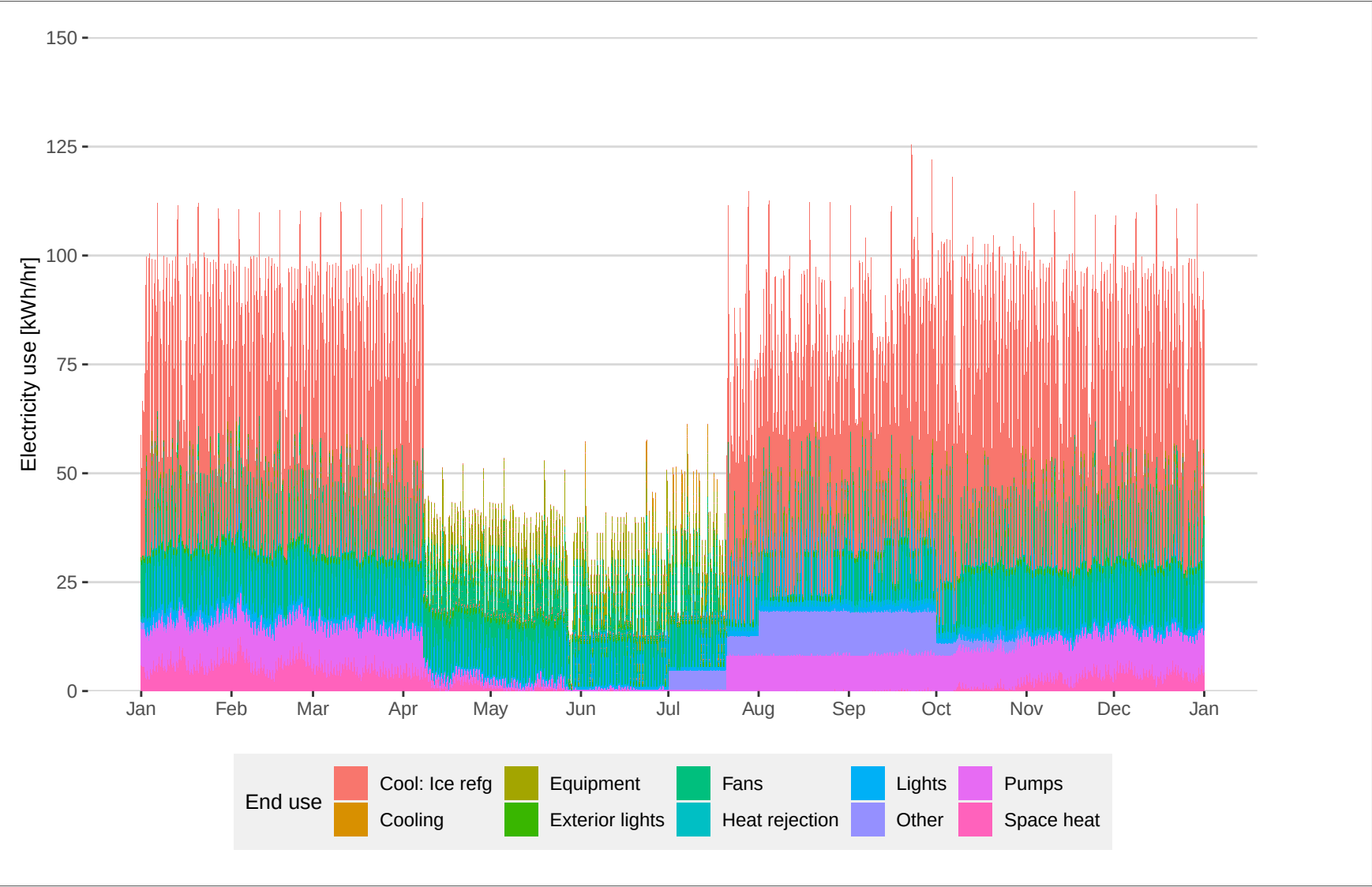


Figure 197: Hourly electricity utility use by end use (made by calibrated energy model)

Natural gas

The hourly natural gas utility use profile by end use made by the energy model is plotted in Figure 198. See Table 17 for end use definitions.

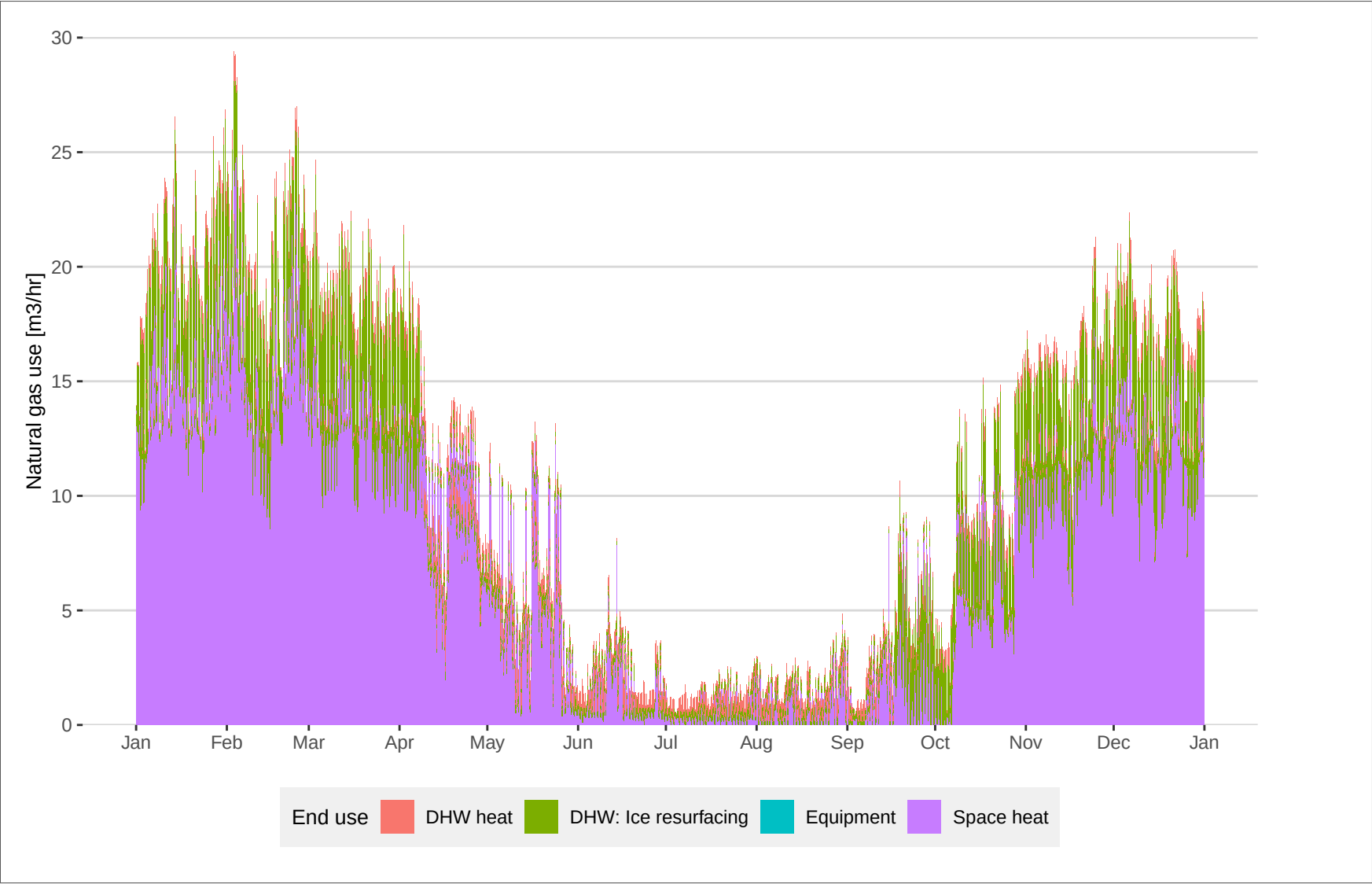


Figure 198: Hourly natural gas utility use by end use (made by calibrated energy model)

4.3 Monthly utility use profiles

Monthly utility use profiles for each modelled utility are presented in Figure 199.

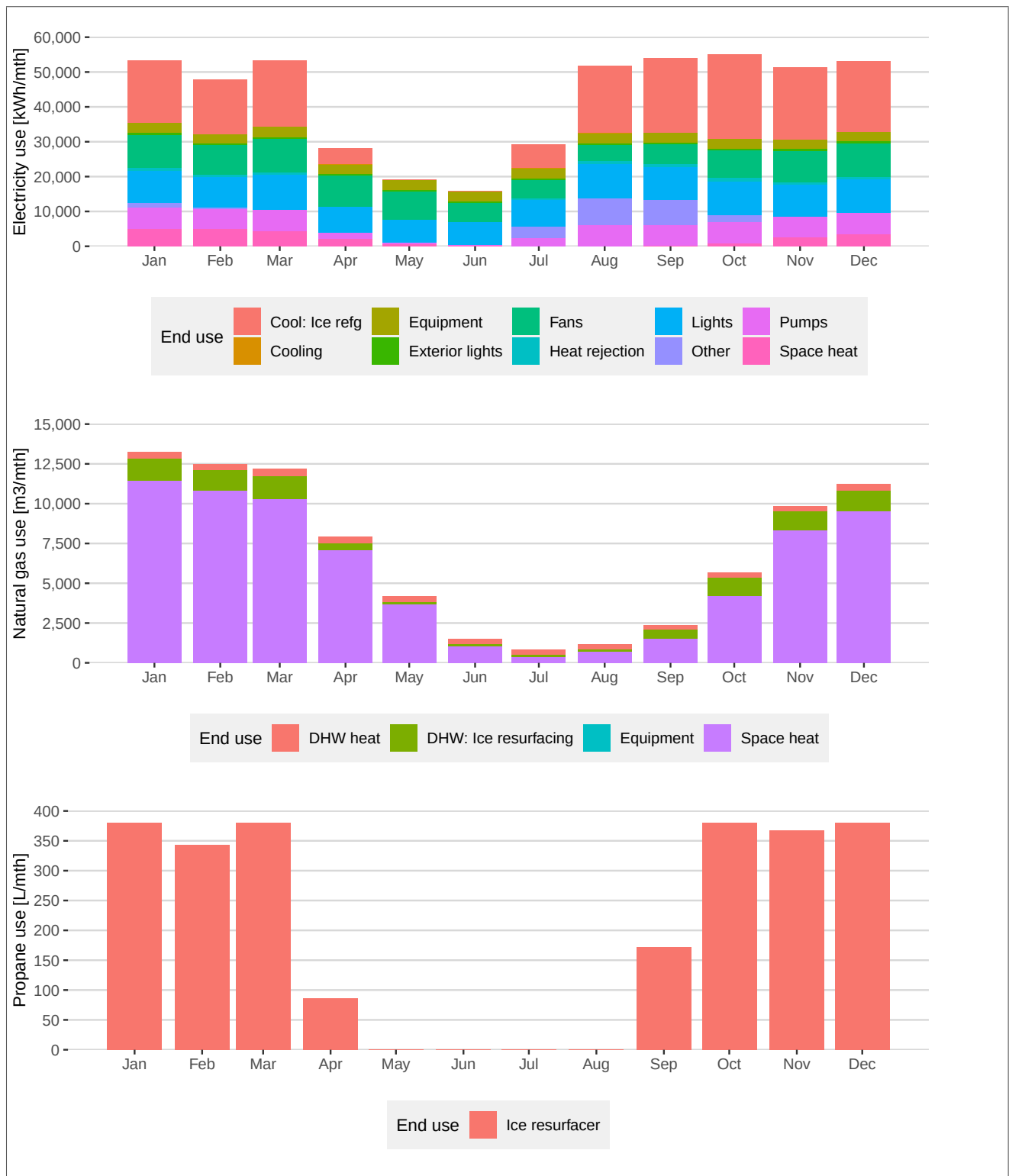


Figure 199: Monthly utility use profiles for each modelled utility

4.4 Calibration analysis

Electricity

Figure 200 compares the metered utility use with the modelled use to check how well the model is calibrated.

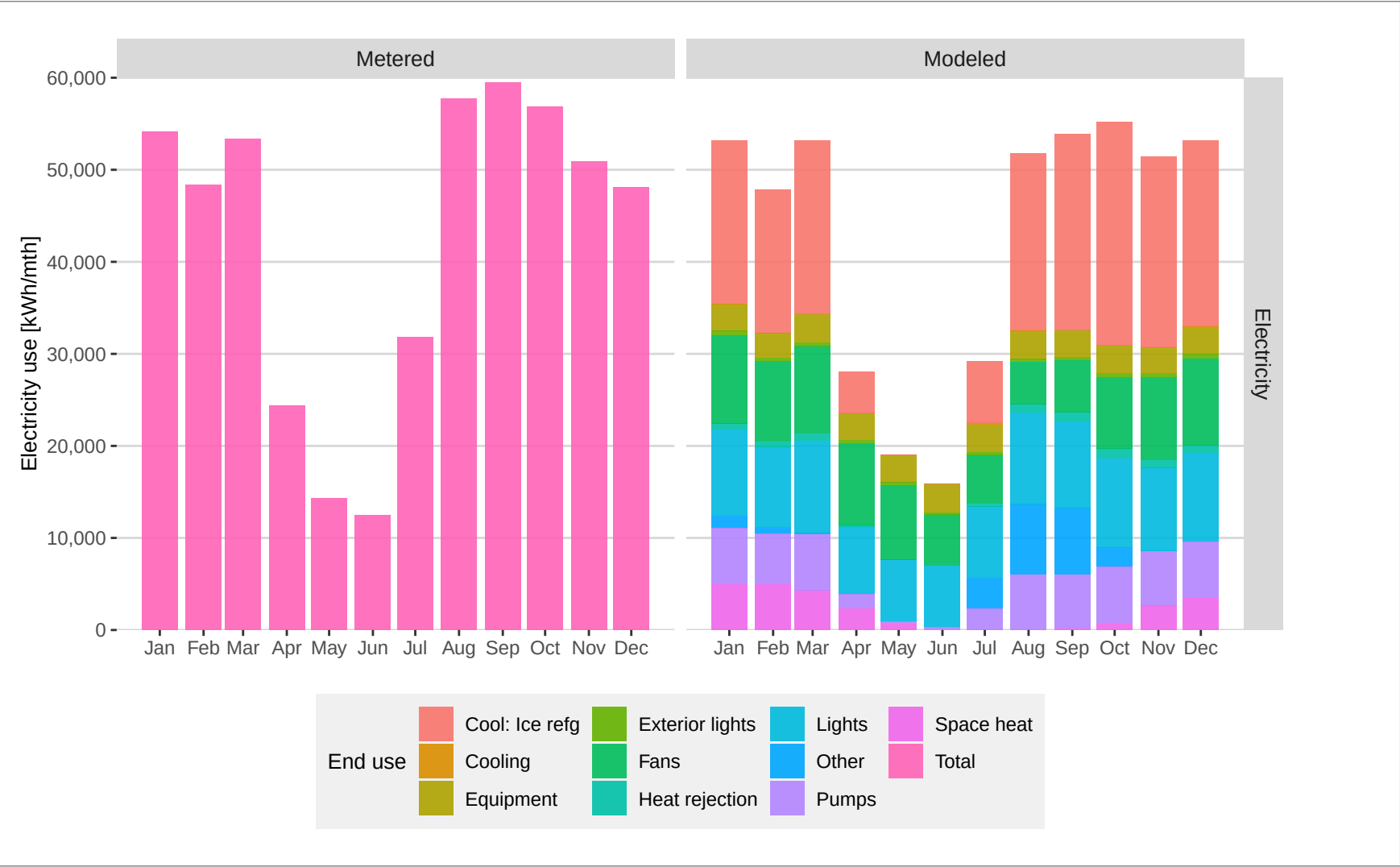


Figure 200: Electricity calibration analysis (metered vs modelled utility use)

Natural gas

Figure 201 compares the metered utility use with the modelled use to check how well the model is calibrated.

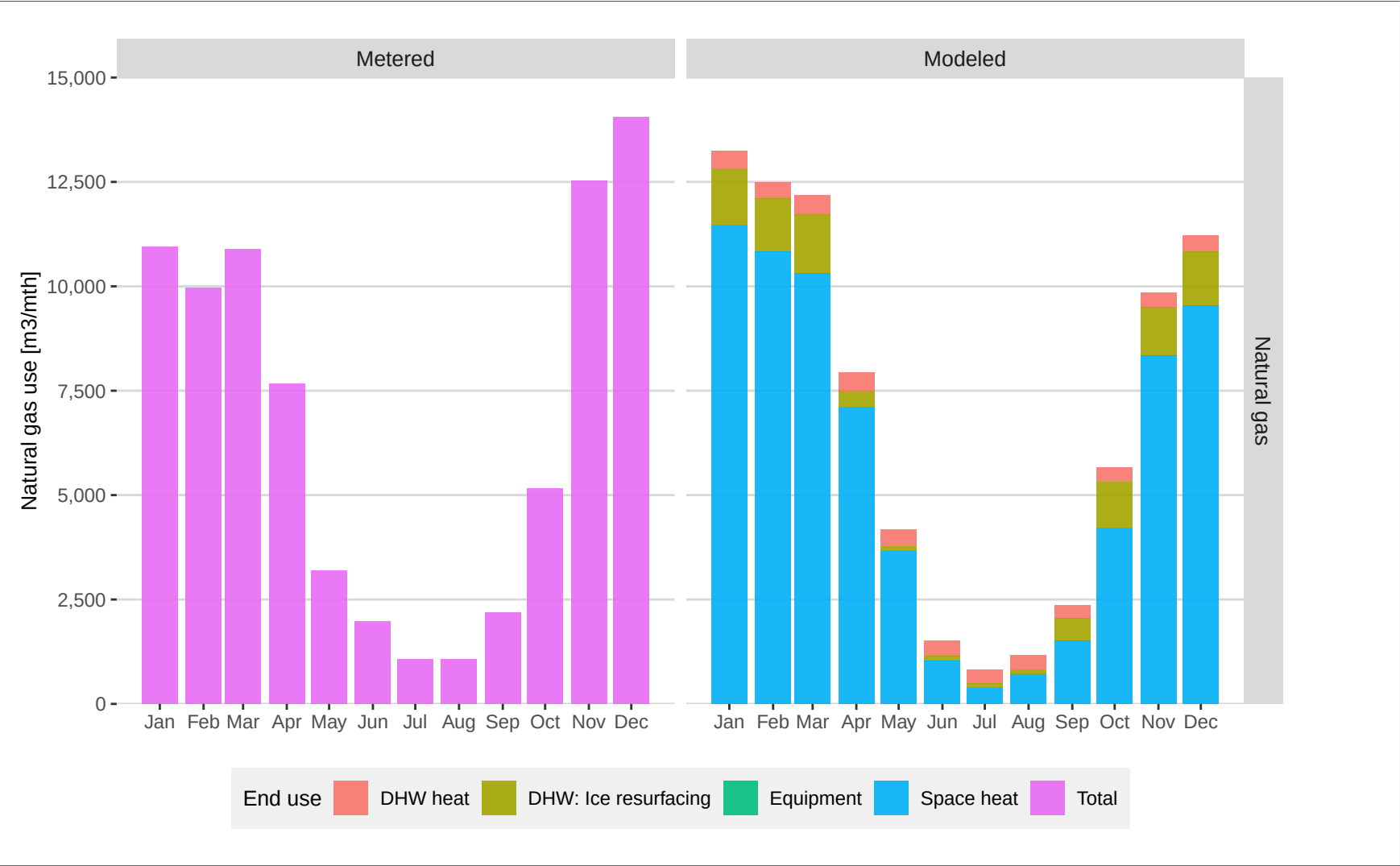


Figure 201: Natural gas calibration analysis (metered vs modelled utility use)

Statistical calibration analysis

ASHRAE Guideline 14 suggests maximum allowable values for the mean bias error, and the root mean bias error, which are defined as follows with respect to energy model calibration.

- **Mean bias error (MBE).** The average monthly error between modelled and metered utility use as a percentage of the mean monthly metered utility use. This metric indicates the ability of the model to accurately predict yearly utility use, despite month-to-month errors, by capturing the direction of all month-to-month errors.
- **Root mean square error (RMSE).** The square root of the sum of all squared monthly errors as a percentage of the mean monthly metered utility use. This metric indicates the ability of the model to accurately predict month-specific utility use.

Statistical calibration analysis results were calculated and are summarized in Table 18.

Table 18: Statistical calibration analysis summary

Utility	Description	Unit	ASHRAE 14	Model	Pass/Fail
Electricity	Mean bias error	[%]	< +/- 5	-0.0	Pass
	Root mean square error	[%]	< 15	8.7	Pass
Natural gas	Mean bias error	[%]	< +/- 5	-2.6	Pass
	Root mean square error	[%]	< 15	24.6	Fail

It should be noted that the root mean square error test suggested by ASHRAE Guideline 14 places undue emphasis on months that have relatively little utility use (e.g. natural gas or steam use in the summer). This is because the root mean square error test is calculated based on relative errors between monthly metered and modelled utility use. Because of this, a small absolute error between metered and modelled utility use for a certain month may also be a large relative error, causing a significant increase in the root mean square error. Practically, though, the ability of the energy model to accurately quantify utility use overall has little dependence on its ability to quantify utility use in months with relatively little metered use, because overall utility use is more heavily influenced by those months with greater utility use. Therefore, it may not always be suitable for the model to pass the root mean square error test, provided that it reasonably captures utility use in the months of greater use.

A discussion of the energy model calibration analysis is as follows.

- Figures 200 and 201 both demonstrate a strong agreement between monthly trends observed in the metered utility use data and the monthly utility use predicted by the calibrated energy model.
- Electricity use was successfully calibrated according to the standards of ASHRAE Guideline 14. Note that the mean bias error is zero for electricity and natural gas because the Other end-use ensures that the yearly modelled utility use matches the yearly metered utility use. This process also maintains consistency between the baseline utility use derived from the metered utility data and all measure and scenario analyses.
- Natural gas consumption fails to follow Guideline 14 on the root mean square error. Some notable issues are that consumption is higher in the model from January through March. There is also a discrepancy in the summer months. Another note is that only 4 of 12 natural gas readings are actual readings, and some of these readings encompass more than one month. This issue makes it difficult to calibrate the model, especially against estimated data that the LDC typically underestimates.
- The successful energy model calibration is largely due to the methodology used in developing the calibrated energy model. Under this methodology, the major systems affecting utility use were studied in detail (see Section 2), including their operations, so that these systems could be explicitly modelled one-to-one, precisely reflecting the unique operations associated with each system. Examples of such major systems include all air handling systems (MUA1, RTU1, RTU2, F1, and DH1) and the ice plant. The methodology also

integrates the Other end-use category, which reflects the exact difference between metered and modelled utility use in a top-down calculation after all systems have been modelled from the bottom-up.

- Therefore, there can be confidence that the utility use impacts quantified in the various measure and scenario analyses under this report are reasonable.

Electricity

- Figure 200 indicates strong agreement between modelled and metered data.
- The peak and trough hourly consumption align with the metered interval data.
- Based on metered electricity data, it is assumed that the ice-making process is started in mid-July.

Natural gas

- Figure 201 indicates good agreement between modelled and metered data.
- The annual amount of natural gas consumption in the model is very close to the annual amount of the metered data. However, there are variances within several months. That being said, there are several estimated readings for this particular dataset.

4.5 End use analysis

Electricity

The yearly electricity end use breakdown calculated by the energy model is plotted in Figure 202. See Table 17 for end use definitions.

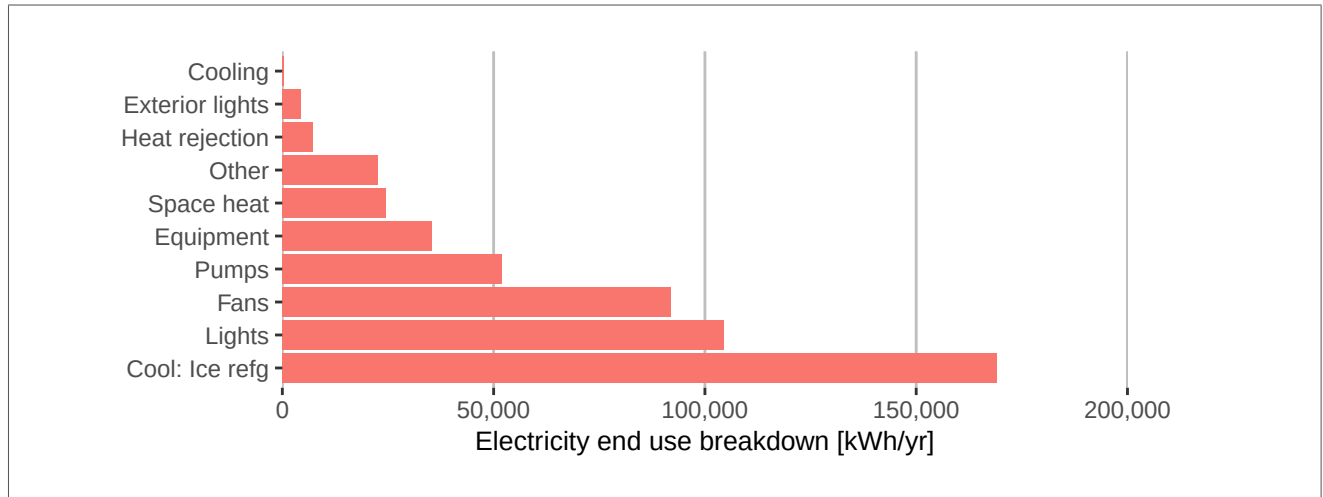


Figure 202: Electricity end use breakdown (calculated by calibrated energy model)

Natural gas

The yearly natural gas end use breakdown calculated by the energy model is plotted in Figure 203. See Table 17 for end use definitions.

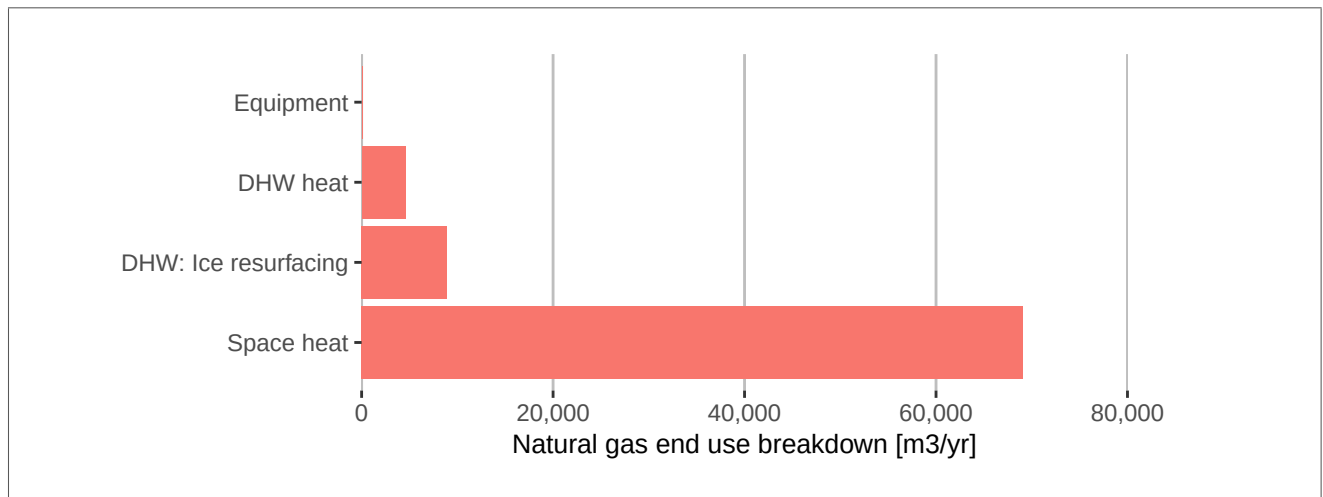


Figure 203: Natural gas end use breakdown (calculated by calibrated energy model)

5 MEASURE ANALYSIS

5.1 Measure analysis methodology

The measure analysis was completed according to the following methodology.

1. **Measure identification and triaging.** Measures that could be implemented to help achieve City of Temiskaming Shores's goals were identified based on the findings documented in Sections 2 and 3. Identified measures were triaged by labeling each one as either 'Analyzed' or 'Not analyzed'. The intent of triaging was to focus efforts on analyzing measures for which analysis was considered most valuable (typically for measures that are more complex or more impactful). Results are summarized in Section 5.3.
2. **Measure analysis.** For each 'Analyzed' measure, the analysis completed for that measure was summarized in a dedicated sub-section named after that measure (see Sections 5.4 through 5.23). In each sub-section, the following was documented.
 - *Measure description.* The relevant existing condition was summarized, an opportunity for improving the stated existing condition was described, and the intended utility-savings mechanism associated with the opportunity was described.
 - *Design description.* A conceptual design description was provided, including a written description of the proposed design concept and the associated project cost estimate.
 - *Utility analysis.* A utility analysis was completed using the energy model introduced in Section 4. Measure-specific assumptions applied in calculating the impacts on utility use were provided for each measure. For each measure, the expected GHG emissions, utility costs and financial incentives associated with implementing the measure were calculated based on utility use, using the assumptions outlined in Section 5.2. A life cycle cost analysis was completed, applying the assumptions summarized in Tables 15 and 21 according to the following methodology.
 - (a) The life cycle cost for each measure was calculated based on the assumed implementation year of 2026 for each measure. The life cycle cost for each measure was calculated as the sum of the following future financial cost expenditures, discounted back to present value using the discount rate from Table 21, over the evaluation period of present to 2050.
 - (b) Project costs: The future value of project costs was calculated based on the project cost estimate of each measure, inflated to future value associated with the assumed implementation year using the general inflation rate from Table 21. In the life cycle cost calculation, the project cost was amortized over the expected life of the measure such that the yearly present value is constant over every year of the expected life of the measure. This results in the net present value of the project cost being equal to what it would be if the owner was to pay for it via lump sum in the implementation year for that measure.
 - (c) Replacement costs: The future value of replacement costs was calculated assuming that a financial cost was incurred to replace equipment associated with each measure at the end of the expected life of that measure equal to 50% of the initial project cost, inflated to future value associated with the estimated time of replacement using the general inflation rate from Table 21. The same amortization approach as for project costs was used.
 - (d) Utility costs: The future value of yearly utility costs of the entire facility was accounted for in the life cycle cost calculation for each measure. The future value of yearly utility costs was calculated by applying the future utility cost rates from Table 19 to the utility use of the entire facility for that year as predicted by the calibrated energy model for each measure and scenario.
3. **Measure risk analysis.** A risk analysis of each individual measure was completed to test how the performance of that measure might be affected by changes to certain risk parameters. In this risk analysis, each of the risk parameters defined in Table 22 was tested under each risk case also defined in Table 22 for that risk parameter. For each risk case of each risk parameter, the expected performance of each measure was quantified, and the results were summarized using box and whisker plots indicating the range over

which performance might be expected to vary. Findings from the risk analysis were summarized in Section 5.24.

4. **Measure analysis summary.** Measure analysis results for all measures were summarized in table format in Section 5.25.

5.2 Measure analysis assumptions

Assumptions general to all measures are as follows.

- GHG emissions factor assumptions are summarized in Table 14, in Section 3.2.
- Utility cost rate assumptions applied to quantify yearly utility cost impacts relative to the baseline are summarized in Table 15, in Section 3.2. Utility cost rate future assumptions applied in the life cycle analysis for each measure are summarized in Table 19. Note that throughout this Pathway to Decarbonization Feasibility Study the Federal Carbon Charge is treated separately (if applicable) with respect to associated fuels (rather than being accounted for within the rates of the applicable fuels, the federal carbon charge line item is calculated separately based on the estimated yearly GHG emissions for that fuel). As such, all other utility cost rates exclude the federal carbon charge.

Table 19: Utility cost rate future assumptions

Year	Natural gas	Federal carbon charge	Propane	Carbon offsets	Class B HOEP	Class B GA	Class B regulatory	Class B Delivery
-	[\$/m3]	[\$/tCO2e]	[\$/L]	[\$/tCO2e]	[\$/kWh]	[\$/kWh]	[\$/kWh]	[\$/kW]
2023	0.2652	65	0.612	30	0.0204	0.075	0.0058	12.36
2024	0.2705	80	0.6242	30.6	0.0208	0.0765	0.0059	12.61
2025	0.2759	0	0.6367	31.21	0.0212	0.078	0.006	12.86
2026	0.2814	0	0.6494	31.84	0.0216	0.0796	0.0061	13.12
2027	0.287	0	0.6624	32.47	0.022	0.0812	0.0062	13.38
2028	0.2927	0	0.6756	33.12	0.0224	0.0828	0.0063	13.65
2029	0.2986	0	0.6891	33.78	0.0228	0.0845	0.0064	13.92
2030	0.3046	0	0.7029	34.46	0.0233	0.0862	0.0065	14.2
2031	0.3107	0	0.717	35.15	0.0238	0.0879	0.0066	14.49
2032	0.3169	0	0.7313	35.85	0.0243	0.0897	0.0067	14.78
2033	0.3232	0	0.7459	36.57	0.0248	0.0915	0.0068	15.07
2034	0.3297	0	0.7608	37.3	0.0253	0.0933	0.0069	15.37
2035	0.3363	0	0.776	38.05	0.0258	0.0952	0.007	15.68
2036	0.343	0	0.7915	38.81	0.0263	0.0971	0.0071	15.99
2037	0.3499	0	0.8073	39.58	0.0268	0.099	0.0072	16.31
2038	0.3569	0	0.8234	40.38	0.0273	0.101	0.0073	16.64
2039	0.364	0	0.8399	41.18	0.0278	0.103	0.0074	16.97
2040	0.3713	0	0.8567	42.01	0.0284	0.1051	0.0075	17.31
2041	0.3787	0	0.8738	42.85	0.029	0.1072	0.0077	17.66
2042	0.3863	0	0.8913	43.7	0.0296	0.1093	0.0079	18.01
2043	0.394	0	0.9091	44.58	0.0302	0.1115	0.0081	18.37
2044	0.4019	0	0.9273	45.47	0.0308	0.1137	0.0083	18.74
2045	0.4099	0	0.9458	46.38	0.0314	0.116	0.0085	19.11
2046	0.4181	0	0.9647	47.31	0.032	0.1183	0.0087	19.5
2047	0.4265	0	0.984	48.25	0.0326	0.1207	0.0089	19.89
2048	0.435	0	1.004	49.22	0.0333	0.1231	0.0091	20.28
2049	0.4437	0	1.024	50.2	0.034	0.1256	0.0093	20.69
2050	0.4526	0	1.044	51.21	0.0347	0.1281	0.0095	21.1

- Financial incentive assumptions are summarized in Table 20.

Table 20: Financial incentive assumptions

Incentive program	Incentive calculation rules
Enbridge custom	0.25 \$/m3/yr of natural gas reduction Up to a maximum of 50% of eligible project costs Up to a maximum of \$100,000
FCM CBR GHG reduction pathway grant	Up to 80% of project costs (grant + loan) Up to \$5 million (grant + loan) Up to 25% of funding can be grant

- Life cycle cost analysis assumptions are summarized in Table 21.

Table 21: Life cycle cost analysis assumptions

Description	Unit	Value
General cost inflation	[%]	2
Discount rate	[%]	5

- Risk analysis assumptions, including risk parameters and risk cases that were tested in the measure risk analysis are summarized in Table 22.

Table 22: Risk parameter and case definitions

Parameter	Description	Methodology	Case	X	Unit
Project cost	Project cost may differ from the estimated values.	The case project cost = x TIMES the initial project cost estimate.	Very low Low High Very high	0.75 0.9 1.1 1.25	[decimal]
Replacement cost	Replacement cost may differ from the estimated values.	The case replacement cost = x TIMES the initial replacement cost estimate.	Very low Low High Very high	0.75 0.9 1.1 1.25	[decimal]
Utility use change	Changes to utility use and thermal energy demand in a measure or scenario may differ from reality.	The case utility use profile is the baseline profile plus x TIMES the difference between the initial proposed profile and the baseline profile.	Very low Low High Very high	0.75 0.9 1.1 1.25	[decimal]
Electricity GHG factor	Future GHG factors for electricity may differ than those assumed.	For each year for which the GHG factor is projected, the case GHG factor for that year = the current year factor PLUS (x TIMES the difference between the initial value for that year, and the factor for the current year).	Very low Low High Very high	0.75 0.9 1.1 1.25	[decimal]
Incentive rates	Actual incentives may be different from estimated ones. While project cost and utility use affects incentive amounts, this risk parameter seeks to identify the risk in changes to the financial rates used in incentive amount calculations (e.g., if saveon energy provides incentives at 0.05 \$/kWh rather than 0.04 \$/kWh, etc).	For each financial rate used in incentive amount calculations, the case rate is x TIMES the initial rate.	Very low Low High Very high	0.75 0.9 1.1 1.25	[decimal]
Federal carbon charge	Future federal carbon charge rates may differ than those assumed.	The default federal carbon charge increases to 170 \$/tCO2e by 2030 and to 300 \$/tCO2e by 2050. The case federal carbon charge follows the default trend but limited to a maximum value of x.	Very low Low High Very high	0 100 240 300	[\$/tCO2e]
Utility cost inflation	Future utility cost rates may differ than what was assumed.	The case utility cost inflation rate for all utilities is x (as a decimal) compounded yearly.	Very low Low High Very high	0.01 0.015 0.025 0.03	[decimal]
General cost inflation	General cost inflation may differ from what was assumed. Note that general cost inflation is applied ONLY to project costs, replacement costs, and maintenance costs (future utility cost rates are handled separately).	The case general cost inflation rate is x.	Very low Low High Very high	0.01 0.015 0.025 0.03	[decimal]
Discount rate	It is worth testing the sensitivity of the discount rate on life cycle cost / net present value calculations.	The case discount rate is x.	Very low Low High Very high	0.05 0.06 0.08 0.09	[decimal]

- This building has not undergone a building condition assessment, and therefore, business as usual (BAU) measures were not available. WalterFedy utilized previous reports to gauge the potential costing of BAU renewal measures. These measures are provided for reference only and are not intended for use in budgetary

requirements. It's recommended that the City of Temiskaming Shores undertake a Building Condition Assessment of this building.

5.3 Measure identification

Results of the measure identification and triaging process are summarized in Table 23.

Table 23: Measure identification and triaging summary

Measure name	Triage for analysis
Baseline	
Carbon offsets 20	Analyzed.
Cold water flooding	Analyzed.
DHW heaters to ASHP	Analyzed.
Exterior LED lighting upgrade	Analyzed.
Ice resurfacer conversion	Analyzed.
Implement a laser ice leveler	Analyzed.
Interior LED lighting upgrade	Analyzed.
Low-flow handwashing faucet aerators	Analyzed.
Low-flow shower fixtures	Analyzed.
MUA conversion to ASHP with ERV	Analyzed.
Natural gas stove conversion to electric	Analyzed.
Radiant heaters to electric	Analyzed.
Refrigeration heat recovery and optimization	Analyzed.
Roof upgrade to high performance	Analyzed.
RTUs to ASHP with electric backup	Analyzed.
RTUs to ASHP with natural gas backup	Analyzed.
Solar PV rooftop	Analyzed.
Space heating boiler conversion to VRF and electric backup	Analyzed.
Wall upgrade to high performance	Analyzed.
Windows and doors to high performance	Analyzed.
Boiler renewal	Business as usual.
Compressor renewal	Business as usual.
DHW renewal	Business as usual.
Exterior lighting renewal	Business as usual.
Exterior walls renewal	Business as usual.
Ice resurfacer renewal	Business as usual.
Interior lighting renewal	Business as usual.
MUA renewal	Business as usual.
Natural gas stove renewal	Business as usual.
Radiant heaters renewal	Business as usual.
Roof renewal	Business as usual.
RTUs renewal	Business as usual.
Shower renewal	Business as usual.
Sinks renewal	Business as usual.
Windows and doors renewal	Business as usual.
BAS investigation	Not analyzed: Given the age of the BAS system, that the supplier no longer exists, and that staff have not used it for numerous years, it is next to impossible to examine this measure.
Arena dehumidification	Not analyzed: The arena recently replaced the dehumidifier and it is electric.
Solar PV canopy	Not analyzed: There is no parking lot at this facility.

5.4 Carbon offsets 20

Measure description

Existing condition

The facility is currently purchasing no carbon offsets.

Opportunity

After implementing other measures, purchase carbon offsets to offset 20% of the remaining GHG emissions.

Utility-savings mechanism

Energy use is not affected by purchasing carbon offsets. Yearly GHG emissions accounted against the facility will be reduced by the same quantity as those purchased for that year.

Design description

Net zero definition

The Canadian Green Building Council (CaGBC) defines net carbon emissions for a facility as in the following formula.

$$\text{Net emissions} = \text{Embodied carbon} + \text{Operational carbon} - \text{Avoided emissions}$$

The terms of this formula are defined as follows.

- **Embodied carbon.** GHG emissions associated with the construction, maintenance and final end-of-life disposal of the facility.
- **Operational carbon.** GHG emissions associated with the use of energy of the facility while in operation.
- **Avoided emissions.** GHG emissions avoided through activities such as exporting green power to local grids, or the purchase of carbon offsets.

Net Zero emissions as achieved when the Net emissions from this formula is zero or less.

This measure focuses on the on-going use of avoided emissions (as defined above) to offset operational carbon associated with ongoing energy use at the facility. Note that embodied carbon emissions tend to be a one-time event, in contrast to the on-going emissions associated with operations, which must also be accounted for through avoided emissions.

Renewable energy certificates

As defined above, emission avoidance activities recognized by the CaGBC definition of Net-Zero include exporting green power, or the purchase of carbon offsets. Green power exports include the exporting of on-site renewable energy, as well as the injection of renewable energy into local grids through off-site renewable energy generation facilities. The latter approach is typically accomplished through the purchase of Renewable Energy Certificates (RECs). RECs are utility-specific and are purchased by unit energy of the utility in question (e.g. kWh for electricity, or m³ for natural gas), and can only be used to offset GHG emissions associated with the specific utility in question. For example, electricity RECs can be purchased to offset up to 100% of electricity used by the building, but cannot be used to offset natural gas used by the building (and vice versa). RECs are typically considered best practise because they facilitate an immediate injection of renewable energy into grids. RECs can be purchased through REC providers such as Bullfrog Power.

Carbon offsets

The purchase of carbon offsets is the second approach for avoided emissions recognized by CaGBC. Carbon offsets are purchased per tonne of GHG emissions, and can be used to offset either direct (e.g. natural gas combustion on-site) or indirect (e.g. electricity use on-site, which is generated offsite) GHG emissions. Carbon offsets must be certified as stipulated within the CaGBCs Zero Carbon Building Standard, which is required to

uphold quality standards of the carbon offsets. Carbon offsets can be purchased through certified providers such as Less Emissions Inc.

Cost rates

Cost rates for RECs and carbon offsets are summarized as follows.

- Electricity REC cost rate (Bullfrog Power): 0.025 \$/kWh.
- Natural gas REC cost rate (Bullfrog Power): 0.186 \$/m3.
- Carbon offset cost rate (Less Emissions Inc.): 30 \$/mtCO2e.

Utility analysis

Utility analysis methodology

Energy use is not affected by purchasing carbon offsets. Yearly GHG emissions accounted against the facility will be reduced by the same quantity as those purchased for that year.

Baseline. It is assumed that no carbon offsets are purchased.

Proposed. Carbon offsets are assumed to be purchased in the quantity equal to 20% of remaining GHG emissions. Note that as an individual measure, the analysis indicates the impact of offsetting baseline GHG emissions with carbon offsets. When considered as part of the scenario analyses in Section 6, this measure will cause 20% of remaining GHG emissions to be offset.

Utility analysis results

Table 24: Carbon offsets 20 analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	511,953	0	0
	Natural gas use	[m3/yr]	82,661	82,661	0	0
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	35.1	-35.1	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	511,953	0	0
	Natural gas energy	[kWh/yr]	872,625	872,625	0	0
	Total energy	[kWh/yr]	1,402,069	1,402,069	0	0
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	12.2	0	0
	Natural gas GHGs	[tCO2e/yr]	160	160	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	-35.1	35.1	—
	Total GHGs	[tCO2e/yr]	176	141	35.1	20
Utility cost	Electricity utility cost	[\$/yr]	66,048	66,048	0	0
	Natural gas utility cost	[\$/yr]	21,492	21,492	0	0
	Carbon offsets utility cost	[\$/yr]	0	1,054	-1,054	—
	Federal carbon charge	[\$/yr]	8,175	8,175	0	0
	Total utility cost	[\$/yr]	97,208	98,262	-1,054	-1.1
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	—	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	—	—	—
	Life cycle cost	[\$]	2,080,290	2,099,518	—	—
	Net present value	[\$]	0	-19,228	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	—	—	—
	Simple payback period	[yr]	—	—	—	—

5.5 Cold water flooding

Measure description

Existing condition

Domestic hot water is currently used for ice resurfacing.

Opportunity

Implement a cold-water flooding strategy similar to "REALice" to reduce water heating and ice plant energy.

Utility-savings mechanism

Reduced domestic hot water heating use due to avoiding heating the ice resurfacing water. Reduced refrigeration energy use due to avoiding the load associated with cooling the hot water down.

Design description

Overview

Purchase and install a water de-aeration system similar to the REALice system to allow ice resurfacing to be completed using cold water. A single system is to be installed and piped to the ice resurfacer area to refill the machine when needed. Ice resurfacing procedures may require updates as staff deems necessary.

Review with operations staff before installation. Staff training and process adjustments are required for the success of this measure. Implementing this measure as a pilot project on recreational ice surfaces is also recommended before implementing ice pads used for competition.

Note that this measure is not believed to be feasible by operational staff, and thus this measure is omitted from scenario analysis.

Project cost estimate

Table 25: Project cost estimate (Cold water flooding)

Category	Line item	Unit	Value
Materials and labour	Equipment and Installation	[\$]	45,000
Contingency	Subtotal after Materials and labour	[\$]	45,000
	General Contingency (50%)	[\$]	22,500
Total	Total	[\$]	67,500

Utility analysis

Utility analysis methodology

Baseline: Ice resurfacing water temperature is assumed to be 60C (140F).

Proposed: The water temperature is applied at 15C (ambient). Energy impacts with both DHW heating and refrigeration plant are captured.

Utility analysis results

Table 26: Cold water flooding analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	490,387	21,566	4.2
	Natural gas use	[m3/yr]	82,661	75,638	7,022	8.5
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	490,387	21,566	4.2
	Natural gas energy	[kWh/yr]	872,625	798,493	74,132	8.5
	Total energy	[kWh/yr]	1,402,069	1,306,371	95,698	6.8
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	11.7	0.52	4.2
	Natural gas GHGs	[tCO2e/yr]	160	146	13.6	8.5
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	162	14.1	8.0
Utility cost	Electricity utility cost	[\$/yr]	66,048	63,276	2,772	4.2
	Natural gas utility cost	[\$/yr]	21,492	19,666	1,826	8.5
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	7,497	678	8.3
	Total utility cost	[\$/yr]	97,208	91,932	5,276	5.4
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	67,500	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	67,500	—	—
	Life cycle cost	[\$]	2,080,290	2,069,879	—	—
	Net present value	[\$]	0	10,411	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	4,792	—	—
	Simple payback period	[yr]	—	13	—	—

5.6 DHW heaters to ASHP

Measure description

Existing condition

DHW heating is served by gas-fired DHW heaters.

Opportunity

Replace the gas-fired DHW heaters with ASHP (air source heat pump) equivalents.

Utility-savings mechanism

This measure will convert the heat fuel from natural gas to electricity. This will result in an overall energy reduction due to the higher efficiency of the heat pump compared to that of the natural gas DHW tanks and a reduction in GHG intensity.

Design description

Design concept

It is recommended that each gas-fired hot water boiler, complete with storage tanks and the DHW heater, be replaced with a hybrid heat pump hot water heater that extracts heat from the space for hot water.

Both water heaters replacing the boilers shall be equivalent to an AO Smith model CAHP-120 and provided with the following features:

- Nominal capacity 119 gal (450L)
- First-hour rating hybrid 179 gal (677L)

The third hot water heater shall be an 80USG AO Smith Vortex hot water heater.

Electrical

The ASHP will add approximately 5 kW of power to the existing system, which will put the system at 158 kW, which is approximately 48% of the full load of the electrical capacity of the building.

Project cost estimate

Table 27: Project cost estimate (DHW heaters to ASHP)

Category	Line item	Unit	Value
Materials and labour	AO Smith CAHP-120 (Qty 2)	[\$]	30,000
	AO Smith Vortex	[\$]	5,000
	Installation	[\$]	15,000
	Electrical work	[\$]	12,000
Contingency	Subtotal after Materials and labour	[\$]	62,000
	General Contingency (50%)	[\$]	31,000
Total	Total	[\$]	93,000

Utility analysis

Utility analysis methodology

The following assumptions were applied to the energy model to estimate utility use impacts.

- **Baseline.** DHW heating is provided by gas-fired tanks at an efficiency of 80%.
- **Proposed.** DHW heating is provided by an ASHP at a COP of 3.5.

Utility analysis results

Table 28: DHW heaters to ASHP analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	538,197	-26,244	-5.1
	Natural gas use	[m3/yr]	82,661	69,164	13,497	16.3
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	538,197	-26,244	-5.1
	Natural gas energy	[kWh/yr]	872,625	730,143	142,482	16.3
	Total energy	[kWh/yr]	1,402,069	1,285,831	116,238	8.3
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	12.9	-0.63	-5.1
	Natural gas GHGs	[tCO2e/yr]	160	134	26.1	16.3
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	150	25.5	14.5
Utility cost	Electricity utility cost	[\$/yr]	66,048	69,112	-3,064	-4.6
	Natural gas utility cost	[\$/yr]	21,492	17,983	3,509	16.3
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	6,871	1,304	16.0
	Total utility cost	[\$/yr]	97,208	95,459	1,749	1.8
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	93,000	—	—
	Incentive amount	[\$]	0	3,374	—	—
	Incremental project cost	[\$]	0	89,626	—	—
	Life cycle cost	[\$]	2,080,290	2,189,952	—	—
	Net present value	[\$]	0	-109,662	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	3,521	—	—
	Simple payback period	[yr]	—	>20	—	—

5.7 Exterior LED lighting upgrade

Measure description

Existing condition

The building exterior lighting utilizes LED and metal halide lighting.

Opportunity

Replace all non-LED fixtures with LED equivalent fixtures.

Utility-savings mechanism

Reduced lighting energy use through more energy-efficient lamps. Given the fixtures are exterior to the building (i.e. unconditioned spaces), there are no effects on heating and cooling.

Design description

Overview

The lighting system shall be designed to meet the latest ASHRAE 90.1 energy codes, IESNA standards, the Shelley Herbert-Shea Memorial Arena standards and other applicable regulations and standards.

The existing site has gone through some recent LED upgrades. It will be proposed that all the remaining fluorescent fixtures will be replaced with new LED fixtures.

LED luminaires shall be provided with an expected service life of over 50,000 hours, dark-sky compliant, and be listed on the Energy Star Qualified Commercial Lighting List or the Design Lights Consortium List (DLC) for incentive eligibility from the IESOs Save on Energy Program.

With the extended lifespan associated with LED fixtures, the likelihood of a complete fixture failure is significantly less likely than previous fixture types. Rather, the user would witness a slow degradation of the lighting output of the fixtures. It would be recommended that an annual lighting review is conducted to measure the lighting levels after dusk or before dawn. At the 70% output level, the owner would expect a much quicker decline in the loss of lighting output in each fixture. As such, at the 70% lighting level, it would be recommended that the fixtures be replaced.

Type M fixtures should be replaced.

Project cost estimate

Table 29: Project cost estimate (Exterior LED lighting upgrade)

Category	Line item	Unit	Value
Materials and labour	Exterior LED lighting upgrade	[\$]	2,000
Contingency	Subtotal after Materials and labour	[\$]	2,000
	General Contingency (50%)	[\$]	1,000
Total	Total	[\$]	3,000

Utility analysis

Utility analysis methodology

The following assumptions were applied to the calibrated energy model to estimate utility use impacts.

- **Baseline:** Exterior lighting is assumed to consume 1 kW.
- **Proposed:** It is assumed that the exterior lighting is replaced with an LED equivalent which consumes 0.6 kW.

Utility analysis results

Table 30: Exterior LED lighting upgrade analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	510,208	1,745	0.34
	Natural gas use	[m3/yr]	82,661	82,661	0	0
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	510,208	1,745	0.34
	Natural gas energy	[kWh/yr]	872,625	872,625	0	0
	Total energy	[kWh/yr]	1,402,069	1,400,324	1,745	0.12
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	12.2	0.04	0.34
	Natural gas GHGs	[tCO2e/yr]	160	160	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	176	0.04	0.02
Utility cost	Electricity utility cost	[\$/yr]	66,048	65,875	173	0.26
	Natural gas utility cost	[\$/yr]	21,492	21,492	0	0
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	8,175	0	0
	Total utility cost	[\$/yr]	97,208	97,035	173	0.18
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	3,000	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	3,000	—	—
	Life cycle cost	[\$]	2,080,290	2,078,863	—	—
	Net present value	[\$]	0	1,427	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	71,942	—	—
	Simple payback period	[yr]	—	17	—	—

5.8 Ice resurfacer conversion

Measure description

Existing condition

One ice resurfacer is presently located at the Shelley Herbert-Shea Memorial Arena. The ice resurfacer is fired primarily by carbon-intensive propane. The ice resurfacer uses a manual ice levelling approach.

Opportunity

Replace the existing ice resurfacer with an electric ice resurfacer.

Utility-savings mechanism

The primary intent of this measure is to reduce GHG emissions by converting the fuel used for propelling the ice resurfacer from propane to electricity due to electricity having a lower GHG intensity than propane. Reduced propane use and increased electricity use would be expected as a result.

Design description

Overview

Currently, the ice rink is resurfaced through a propane-fired machine. The intent is to provide a fully electric ice resurfacer with a laser ice levelling system. It is proposed that one electric system be implemented.

Multiple manufacturers are offering electric ice-resurfacing equipment. For the schematic design, we have selected the Zamboni Model 552AC Lithium-Ion. Fully charged, this machine has the capacity for approximately 12 floods. This unit also allows for quick charging. For example, after a 10-minute flood, only 15 minutes are required to restore the charge. The unit has the capacity to serve two rinks on a busy day, based on experience at other facilities. A single pad building would allow the resurfacer to resurface the rink for 15 minutes (including buffer time for emptying the tank, or refilling), and have 45 minutes for recharging between uses.

Electrical

The ice resurfacer requires a Level 2 charger, which will add approximately 7.3 kW of power to the existing system. This will put the system at 160.3 kW, which is approximately 48% of the full load of the electrical capacity of the building.

Project cost estimate

Table 31: Project cost estimate (Ice resurfacer conversion)

Category	Line item	Unit	Value
Materials and labour	Ice Resurfacer Complete with Charger	[\$]	185,000
	Electrical for Charger installation	[\$]	5,000
Contingency	Subtotal after Materials and labour	[\$]	190,000
	General Contingency (50%)	[\$]	95,000
Total	Total	[\$]	285,000

Utility analysis

Utility analysis methodology

Baseline: Ice resurfacing is assumed to occur 16 times a day on each rink and utilizes only propane consumption. It is assumed that each resurfacing event results in 0.6 kilometres travelled by the ice resurfacer and has a fuel efficiency of 2.1 kbtuh/km of propane.

Proposed: The ice resurfacer is assumed to be energized by electricity, with a fuel efficiency of 0.5 kWh/km.

Utility analysis results

Table 32: Ice resurfacer conversion analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	526,569	-14,616	-2.9
	Natural gas use	[m3/yr]	82,661	82,661	0	0
	Propane use	[L/yr]	2,489	0	2,489	100
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	526,569	-14,616	-2.9
	Natural gas energy	[kWh/yr]	872,625	872,625	0	0
	Total energy	[kWh/yr]	1,402,069	1,399,194	2,875	0.21
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	12.6	-0.35	-2.9
	Natural gas GHGs	[tCO2e/yr]	160	160	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	172	3.4	1.9
Utility cost	Electricity utility cost	[\$/yr]	66,048	67,963	-1,915	-2.9
	Natural gas utility cost	[\$/yr]	21,492	21,492	0	0
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	7,986	189	2.3
	Total utility cost	[\$/yr]	97,208	97,442	-234	-0.24
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	285,000	—	—
	Incentive amount	[\$]	0	57,000	—	—
	Incremental project cost	[\$]	0	228,000	—	—
	Life cycle cost	[\$]	2,080,290	2,371,824	—	—
	Net present value	[\$]	0	-291,534	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	66,642	—	—
	Simple payback period	[yr]	—	—	—	—

5.9 Implement a laser ice leveler

Measure description

Existing condition

One ice resurfacer is presently located at the Shelley Herbert-Shea Memorial Arena. The ice resurfacer is fired primarily by carbon-intensive propane. The ice resurfacer uses a manual ice levelling approach.

Opportunity

Implement a laser ice levelling product to automate blade adjustment.

Utility-savings mechanism

Laser ice levelling could allow the refrigeration plant to operate at slightly higher brine temperatures due to optimizing the ice thickness, which would increase the COP of the ice plant.

Design description

Overview

Currently, the ice resurfacer manually controls the blade adjustment. Implementing a laser ice levelling system is recommended to optimize ice thickness and improve the energy efficiency of the ice plant.

Project cost estimate

Table 33: Project cost estimate (Implement a laser ice leveler)

Category	Line item	Unit	Value
Materials and labour	Laser Level System	[\$]	25,000
Contingency	Subtotal after Materials and labour	[\$]	25,000
	General Contingency (50%)	[\$]	12,500
Total	Total	[\$]	37,500

Utility analysis

Utility analysis methodology

The following assumptions were applied to the energy model to estimate utility use impacts.

- **Baseline.** Ice resurfacing is performed using a manual ice leveler. Ice plant COP is 3.1.
- **Proposed.** Resurfacing water use is assumed to be reduced by 20% based on case studies of similar facilities using this equipment. Ice plant COP is 3.16.

Utility analysis results

Table 34: Implement a laser ice leveler analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	508,609	3,344	0.65
	Natural gas use	[m3/yr]	82,661	80,834	1,826	2.2
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	508,609	3,344	0.65
	Natural gas energy	[kWh/yr]	872,625	853,345	19,280	2.2
	Total energy	[kWh/yr]	1,402,069	1,379,444	22,625	1.6
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	12.2	0.08	0.65
	Natural gas GHGs	[tCO2e/yr]	160	156	3.5	2.2
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	172	3.6	2.1
Utility cost	Electricity utility cost	[\$/yr]	66,048	65,632	416	0.63
	Natural gas utility cost	[\$/yr]	21,492	21,017	475	2.2
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	7,999	176	2.2
	Total utility cost	[\$/yr]	97,208	96,141	1,068	1.1
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	37,500	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	37,500	—	—
	Life cycle cost	[\$]	2,080,290	2,107,036	—	—
	Net present value	[\$]	0	-26,747	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	10,390	—	—
	Simple payback period	[yr]	—	>20	—	—

5.10 Interior LED lighting upgrade

Measure description

Existing condition

Some areas of the building currently operate with LED fixtures (e.g. rinks and some change rooms). The remaining areas of the building primarily utilize T8s or T12 lamps.

Opportunity

Replace remaining fixtures containing T12 and T8 lamps with new LED fixtures.

Utility-savings mechanism

Reduced interior lighting energy use with higher efficiency LED fixtures. However, heating energy use will increase to offset the reduction in internal heat gain from the fixtures, while cooling energy use will decrease.

Design description

Overview

The lighting system shall be designed to meet the latest ASHRAE 90.1 energy codes, IESNA standards, the Shelley Herbert-Shea Memorial Arena standards and other applicable regulations and standards.

The existing site has gone through some recent LED upgrades. It will be proposed that all the remaining fluorescent fixtures will be replaced with new LED fixtures.

LED luminaires shall be provided with an expected service life of over 50,000 hours and be listed on the Energy Star Qualified Commercial Lighting List or the Design Lights Consortium List (DLC) for incentive eligibility from the IESOs Save on Energy Program.

With the extended lifespan associated with LED fixtures, the likelihood of a complete fixture failure is significantly less likely than previous fixture types. Rather, the user would witness a slow degradation of the lighting output of the fixtures. It would be recommended that an annual lighting review is conducted to measure the lighting levels within each space of the facility. At the 70% output level, the owner would expect a much quicker decline in the loss of lighting output in each fixture. As such, at the 70% lighting level, it would be recommended that the fixtures within that room be replaced.

Type B1, C, C1, E, G, H, and I fixtures should be replaced.

Project cost estimate

Table 35: Project cost estimate (Interior LED lighting upgrade)

Category	Line item	Unit	Value
Materials and labour	Interior LED lighting upgrade	[\$]	18,000
Contingency	Subtotal after Materials and labour	[\$]	18,000
	General Contingency (50%)	[\$]	9,000
Total	Total	[\$]	27,000

Utility analysis

Utility analysis methodology

The following assumptions were applied to the calibrated energy model to estimate utility use impacts.

- **Baseline:** It is assumed that there is an average lpd of 0.9104 W/ft².
- **Proposed:** It is assumed that the average lpd is reduced to 0.5462 W/ft². Operation schedules are maintained.

Utility analysis results

Table 36: Interior LED lighting upgrade analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	468,193	43,760	8.5
	Natural gas use	[m3/yr]	82,661	85,340	-2,680	-3.2
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	468,193	43,760	8.5
	Natural gas energy	[kWh/yr]	872,625	900,915	-28,290	-3.2
	Total energy	[kWh/yr]	1,402,069	1,386,599	15,470	1.1
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	11.2	1.0	8.5
	Natural gas GHGs	[tCO2e/yr]	160	165	-5.2	-3.2
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	180	-4.1	-2.4
Utility cost	Electricity utility cost	[\$/yr]	66,048	59,440	6,608	10.0
	Natural gas utility cost	[\$/yr]	21,492	22,189	-697	-3.2
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	8,434	-259	-3.2
	Total utility cost	[\$/yr]	97,208	91,556	5,652	5.8
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	27,000	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	27,000	—	—
	Life cycle cost	[\$]	2,080,290	2,007,321	—	—
	Net present value	[\$]	0	72,969	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	-6,534	—	—
	Simple payback period	[yr]	—	4.8	—	—

5.11 Low-flow handwashing faucet aerators

Measure description

Existing condition

Handwashing faucets were mostly manually controlled, and aerators were rated at 2.2 gpm.

Opportunity

Install low flow faucets aerators on handwashing faucets throughout the facility.

Utility-savings mechanism

Reduced water use and reduced natural gas required for DHW heating.

Design description

Overview

Remove existing handwashing faucet aerators and replace them with low-flow aerators. The proposed flow rate for the new aerators would be 0.5 to 1 gallons per minute (gpm), depending on user preferences.

Project cost estimate

Project cost parameters

The following table outlines the parameters that project costs were assumed to depend on, and the assumed value of each parameter.

Table 37: Project cost parameters (Low-flow handwashing faucet aerators)

Line item	Unit	Value
Aerators quantity to be replaced	[aerator]	14

Project cost estimate

The project cost estimate is summarized in the following table.

Table 38: Project cost estimate (Low-flow handwashing faucet aerators)

Category	Line item	Unit	Value
Materials and labour	New aerator materials	[\$]	700
	New aerator installation	[\$]	2,800
Contingency	Subtotal after Materials and labour	[\$]	3,500
	General Contingency (50%)	[\$]	1,800
Total	Total	[\$]	5,300

Utility analysis

Utility analysis methodology

The following assumptions were applied to the energy model to estimate utility use impacts.

- **Baseline.** Faucet flow rate of 2.2 GPM. It is assumed that washroom faucets account for 40% of DHW used at the facility (not including ice resurfacing DHW).
- **Proposed.** Faucet flow rate of 0.5 GPM.

Utility analysis results

Table 39: Low-flow handwashing faucet aerators analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	511,953	0	0
	Natural gas use	[m3/yr]	82,661	81,316	1,344	1.6
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	511,953	0	0
	Natural gas energy	[kWh/yr]	872,625	858,434	14,191	1.6
	Total energy	[kWh/yr]	1,402,069	1,387,878	14,191	1.0
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	12.2	0	0
	Natural gas GHGs	[tCO2e/yr]	160	157	2.6	1.6
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	173	2.6	1.5
Utility cost	Electricity utility cost	[\$/yr]	66,048	66,048	0	0
	Natural gas utility cost	[\$/yr]	21,492	21,142	350	1.6
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	8,045	130	1.6
	Total utility cost	[\$/yr]	97,208	96,729	479	0.49
Financial	Assumed life	[yrs]	15	7	—	—
	Project cost	[\$]	0	5,300	—	—
	Incentive amount	[\$]	0	336	—	—
	Incremental project cost	[\$]	0	4,964	—	—
	Life cycle cost	[\$]	2,080,290	2,083,229	—	—
	Net present value	[\$]	0	-2,939	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	1,911	—	—
	Simple payback period	[yr]	—	10	—	—

5.12 Low-flow shower fixtures

Measure description

Existing condition

There are approximately 16 showers in changerooms at the facility that are manually controlled. Sampled showerheads had capacities ranging from 1.25 gpm to 2 gpm.

Opportunity

Install low-flow shower fixtures to replace existing fixtures.

Utility-savings mechanism

Reduce DHW heating energy use through reduced use of heated water.

Design description

Overview

This measure investigates lower-flow fixtures serving the showers throughout the building. Lower water flow at these fixtures reduces hot water usage, resulting in energy savings and potential capital reductions in the heat pump sizing for the domestic hot water heating heat pumps.

Sizing and Design

The building currently consists of approximately 16 shower heads throughout the facility.

Project cost estimate

Table 40: Project cost estimate (Low-flow shower fixtures)

Category	Line item	Unit	Value
Materials and labour	Supply (300 \$/fixture; showerhead only)	[\$]	4,800
	Installation (200 \$/fixture; showerhead only)	[\$]	3,200
Contingency	Subtotal after Materials and labour	[\$]	8,000
	General Contingency (50%)	[\$]	4,000
Total	Total	[\$]	12,000

Utility analysis

Utility analysis methodology

The following assumptions were applied to the energy model to estimate utility use impacts.

- **Baseline.** The showerheads have a flow rate of 1.5 GPM. It is assumed that showers account for 50% of DHW used at the facility (not including ice resurfacing DHW).
- **Proposed.** The showerheads have a flow rate of 1 GPM.

Utility analysis results

Table 41: Low-flow shower fixtures analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	511,953	0	0
	Natural gas use	[m3/yr]	82,661	81,936	725	0.88
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	511,953	0	0
	Natural gas energy	[kWh/yr]	872,625	864,973	7,652	0.88
	Total energy	[kWh/yr]	1,402,069	1,394,417	7,652	0.55
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	12.2	0	0
	Natural gas GHGs	[tCO2e/yr]	160	158	1.4	0.88
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	174	1.4	0.80
Utility cost	Electricity utility cost	[\$/yr]	66,048	66,048	0	0
	Natural gas utility cost	[\$/yr]	21,492	21,303	188	0.88
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	8,105	70.0	0.86
	Total utility cost	[\$/yr]	97,208	96,950	259	0.27
Financial	Assumed life	[yrs]	15	7	—	—
	Project cost	[\$]	0	12,000	—	—
	Incentive amount	[\$]	0	181	—	—
	Incremental project cost	[\$]	0	11,819	—	—
	Life cycle cost	[\$]	2,080,290	2,098,720	—	—
	Net present value	[\$]	0	-18,430	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	8,438	—	—
	Simple payback period	[yr]	—	>20	—	—

5.13 MUA conversion to ASHP with ERV

Measure description

Existing condition

MUA1, serving the changerooms, is a make-up air unit complete with natural gas burners. There are exhaust fans in the changerooms as well, but they do not appear to be interlocked with MUA1. No cooling is on this unit, given the ice rink is not used during the cooling season.

Opportunity

Replace the MUA and use an air-source heat pump for heating and cooling source with natural gas backup. Add an ERV component to recover energy from exhaust air. Add electric supplementary heat to support the removal of the hydronic baseboards.

Utility-savings mechanism

The primary intent of this measure is to reduce GHG emissions by converting the fuel used for heating from natural gas to electricity because electricity has a lower GHG intensity than natural gas. Reduced natural gas use and increased electricity use would be expected.

Design description

Proposed scope

Provide a new energy recovery ventilator at the roof level adjacent to the existing MUA serving the changerooms. The unit shall be ducted to the existing exhaust fan locations and draw from the changerooms. Tempered fresh air will be supplied to through a new ASHP MUA. A structural engineer shall review weights and any other structural considerations.

The Basis of design for the units shall be:

- ERV - Aldes PE30[e] - 2500 CFM
- MUA - Envent built-up AHU with 15T LG Condensor and 25 kW electric resistance heat

Electrical

The ASHP with the ERV will add approximately 54 kW of power to the existing system, which will put the system at 207 kW, which is approximately 62% of the full load of the electrical capacity of the building.

Project cost estimate

Table 42: Project cost estimate (MUA conversion to ASHP with ERV)

Category	Line item	Unit	Value
Construction	ERV Supply	[\$]	20,000
	MUA supply	[\$]	80,000
	Installation	[\$]	120,000
	Structural assessment	[\$]	2,000
	Electrical contingency	[\$]	28,000
	General requirements (25%)	[\$]	62,500
Contingency	Subtotal after Construction	[\$]	312,500
	Design Contingency (25%)	[\$]	78,100
	Construction Contingency (10%)	[\$]	31,200
Design, Contractors, PM	Subtotal after Contingency	[\$]	421,800
	Engineering Design and Field Review (10%)	[\$]	42,200
	Contractor Fee (7%)	[\$]	29,500
Total	Total	[\$]	493,500

Utility analysis

Utility analysis methodology

The following assumptions were applied to the calibrated energy model to estimate utility use impacts.

- **Baseline:** The MUA provides space heating through natural gas-fired burners with no heat recovery. The existing heating efficiency is 79%.
- **Proposed:** The MUA provides space heating through air-source heat pumps. The proposed average heating COP is 3. Backup heating is provided from the existing gas-fired furnaces when the outdoor air temperature is below -15 C. In addition, it is assumed that the ERV recovers heat from the exhaust with an effectiveness of 60%.

Utility analysis results

Table 43: MUA conversion to ASHP with ERV analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	559,009	-47,056	-9.2
	Natural gas use	[m3/yr]	82,661	69,798	12,863	15.6
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	559,009	-47,056	-9.2
	Natural gas energy	[kWh/yr]	872,625	736,837	135,789	15.6
	Total energy	[kWh/yr]	1,402,069	1,313,337	88,732	6.3
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	13.4	-1.1	-9.2
	Natural gas GHGs	[tCO2e/yr]	160	135	24.9	15.6
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	152	23.7	13.5
Utility cost	Electricity utility cost	[\$/yr]	66,048	71,490	-5,442	-8.2
	Natural gas utility cost	[\$/yr]	21,492	18,147	3,344	15.6
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	6,932	1,243	15.2
	Total utility cost	[\$/yr]	97,208	98,063	-855	-0.88
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	493,500	—	—
	Incentive amount	[\$]	0	98,700	—	—
	Incremental project cost	[\$]	0	394,800	—	—
	Life cycle cost	[\$]	2,080,290	2,557,752	—	—
	Net present value	[\$]	0	-477,462	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	16,637	—	—
	Simple payback period	[yr]	—	—	—	—

5.14 Natural gas stove conversion to electric

Measure description

Existing condition

The facility has two natural gas-fired stoves in the facility. Staff have indicated that they are rarely used.

Opportunity

Consider removing or replacing the natural gas-fired stoves with an electric equivalent.

Utility-savings mechanism

The primary intent of this measure is to reduce GHG emissions by converting the fuel used for cooking from natural gas to electricity because electricity has a lower GHG intensity than natural gas. Reduced natural gas use and increased electricity use would be expected.

Design description

Overview

Replace the existing natural gas stoves with energy-star-rated electric stoves. This measure assumes a new 240V circuit will be required.

Project cost estimate

Table 44: Project cost estimate (Natural gas stove conversion to electric)

Category	Line item	Unit	Value
Materials and labour	2 x Electric Range - Supply and Delivery	[\$]	3,000
	Electrical	[\$]	5,000
Contingency	Subtotal after Materials and labour	[\$]	8,000
	General Contingency (50%)	[\$]	4,000
Total	Total	[\$]	12,000

Utility analysis

Utility analysis methodology

The following assumptions were applied to the calibrated energy model to estimate utility use impacts.

- **Baseline.** Stoves at this facility are gas-fired.
- **Proposed.** Stoves are converted to electrical models. There is no change in stove operation.

Utility analysis results

Table 45: Natural gas stove conversion to electric analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	512,787	-834	-0.16
	Natural gas use	[m3/yr]	82,661	82,580	80.6	0.10
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	512,787	-834	-0.16
	Natural gas energy	[kWh/yr]	872,625	871,774	851	0.10
	Total energy	[kWh/yr]	1,402,069	1,402,052	17	0.00
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	12.3	-0.02	-0.16
	Natural gas GHGs	[tCO2e/yr]	160	160	0.16	0.10
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	176	0.14	0.08
Utility cost	Electricity utility cost	[\$/yr]	66,048	66,131	-82.8	-0.13
	Natural gas utility cost	[\$/yr]	21,492	21,471	21.0	0.10
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	8,167	7.8	0.10
	Total utility cost	[\$/yr]	97,208	97,262	-54	-0.06
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	12,000	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	12,000	—	—
	Life cycle cost	[\$]	2,080,290	2,096,246	—	—
	Net present value	[\$]	0	-15,956	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	88,335	—	—
	Simple payback period	[yr]	—	—	—	—

5.15 Radiant heaters to electric

Measure description

Existing condition

The rink spectator area is heated by gas-fired radiant heaters.

Opportunity

Replace the gas-fired heaters with electric resistance equivalents.

Utility-savings mechanism

This measure will convert the heat fuel from natural gas to electricity. This will result in an overall energy reduction due to the higher efficiency of the electric resistance heat compared to that of the natural gas, as well as a reduction in GHG intensity.

Design description

Overview

Remove the ceiling-hung, gas-fired infrared tube heaters currently serving the arena spectators and provide electric replacements. To match the existing service area of the gas-fired units, six ceiling-hung 4.5 kW electric units will be required and located accordingly. The new unit controls are to be implemented with a combination of occupancy/motion detection and manual enable.

Electrical

The radiant heaters will add approximately 27 kW of power to the existing system, which will put the system at 180 kW, which is approximately 51% of the full load of the electrical capacity of the building.

Project cost estimate

Table 46: Project cost estimate (Radiant heaters to electric)

Category	Line item	Unit	Value
Construction	Supply and install	[\$]	36,000
	Electrical	[\$]	10,000
	General requirements (25%)	[\$]	11,500
Contingency	Subtotal after Construction	[\$]	57,500
	Design Contingency (25%)	[\$]	14,400
	Construction Contingency (10%)	[\$]	5,800
Design, Contractors, PM	Subtotal after Contingency	[\$]	77,700
	Engineering Design and Field Review (10%)	[\$]	7,800
	Contractor Fee (7%)	[\$]	5,400
Total	Total	[\$]	90,900

Utility analysis

Utility analysis methodology

The following assumptions were applied to the energy model to estimate utility use impacts.

- **Baseline.** Heat is provided by gas-fired radiant heaters at an efficiency of 50%.
- **Proposed.** Heat is provided by electric resistance radiant heaters at an efficiency of 100%.

Utility analysis results

Table 47: Radiant heaters to electric analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	521,248	-9,295	-1.8
	Natural gas use	[m3/yr]	82,661	80,620	2,041	2.5
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	521,248	-9,295	-1.8
	Natural gas energy	[kWh/yr]	872,625	851,083	21,542	2.5
	Total energy	[kWh/yr]	1,402,069	1,389,822	12,247	0.87
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	12.5	-0.22	-1.8
	Natural gas GHGs	[tCO2e/yr]	160	156	3.9	2.5
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	172	3.7	2.1
Utility cost	Electricity utility cost	[\$/yr]	66,048	67,198	-1,150	-1.7
	Natural gas utility cost	[\$/yr]	21,492	20,961	531	2.5
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	7,978	197	2.4
	Total utility cost	[\$/yr]	97,208	97,630	-422	-0.43
Financial	Assumed life	[yrs]	15	10	—	—
	Project cost	[\$]	0	90,900	—	—
	Incentive amount	[\$]	0	18,180	—	—
	Incremental project cost	[\$]	0	72,720	—	—
	Life cycle cost	[\$]	2,080,290	2,210,683	—	—
	Net present value	[\$]	0	-130,393	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	19,543	—	—
	Simple payback period	[yr]	—	—	—	—

5.16 Refrigeration heat recovery and optimization

Measure description

Existing condition

There is opportunity to improve the efficiency of the refrigeration system and recover heat.

Opportunity

Replace the compressors with higher efficiency models and install a desuperheater to provide preheating to the DHW system.

Utility-savings mechanism

The primary intent of this measure is to reduce the amount of waste heat by re-directing it to be used with DHW. This approach will result in lower natural gas relating to DHW and lower electricity consumption due to less heat rejection. Pumps end use will increase to allow for circulation between the desuperheater and DHW. Furthermore, replacing the reciprocating compressors will result in a higher ice plant COP, reducing electricity consumption.

Design description

Overview

Install a new desuperheater on the existing ice plant to reject heat to a domestic hot water pre-heat tank. The pre-heat tank will provide hot water for the ice resurfacer, and domestic hot water uses. Note that the cost below has been provided based on a high-level budget estimate of a complete turn-key install for a desuperheater.

Upgrade existing compressors to high efficiency model. Retrofit to account for modification to piping.

Project cost estimate

Table 48: Project cost estimate (Refrigeration heat recovery and optimization)

Category	Line item	Unit	Value
Construction	Compressor upgrade (x2)	[\$]	180,000
	Equipment and Installation	[\$]	120,000
	Electrical upgrades (miscellaneous power connections)	[\$]	5,000
	General requirements (25%)	[\$]	76,200
Contingency	Subtotal after Construction	[\$]	381,200
	Design Contingency (25%)	[\$]	95,300
	Construction Contingency (10%)	[\$]	38,100
Design, Contractors, PM	Subtotal after Contingency	[\$]	514,600
	Engineering Design and Field Review (10%)	[\$]	51,500
	Contractor Fee (7%)	[\$]	36,000
Total	Total	[\$]	602,100

Utility analysis

Utility analysis methodology

The following assumptions were applied to the calibrated energy model to estimate utility use impacts.

- **Baseline:** No heat recovery from the refrigeration plant. Compressors provide cooling to the cold brine at a COP of 3.1.
- **Proposed:** It is assumed that the desuperheater can recover heat to serve as preheat for the DHW plant. Compressors provide cooling to the cold brine at a COP of 3.3.

Utility analysis results

Table 49: Refrigeration heat recovery and optimization analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	501,548	10,405	2.0
	Natural gas use	[m3/yr]	82,661	81,467	1,194	1.4
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	501,548	10,405	2.0
	Natural gas energy	[kWh/yr]	872,625	860,023	12,602	1.4
	Total energy	[kWh/yr]	1,402,069	1,379,063	23,006	1.6
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	12.0	0.25	2.0
	Natural gas GHGs	[tCO2e/yr]	160	157	2.3	1.4
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	173	2.6	1.5
Utility cost	Electricity utility cost	[\$/yr]	66,048	64,753	1,295	2.0
	Natural gas utility cost	[\$/yr]	21,492	21,181	310	1.4
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	8,060	115	1.4
	Total utility cost	[\$/yr]	97,208	95,488	1,721	1.8
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	602,100	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	602,100	—	—
	Life cycle cost	[\$]	2,080,290	2,673,257	—	—
	Net present value	[\$]	0	-592,967	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	235,625	—	—
	Simple payback period	[yr]	—	>20	—	—

5.17 Roof upgrade to high performance

Measure description

Existing condition

No architectural drawings were available for Shelley Herbert-Shea Memorial Arena. Site observations revealed an exterior layer of modified bitumen membrane.

Opportunity

Upgrade upon the end of useful life or as required to meet scenario criteria.

Utility-savings mechanism

Reduced heating energy use through improved thermal performance of the roof.

Design description

Overview

The existing sloped roof is finished with a modified bitumen membrane, which, as mentioned earlier, we assume was installed in 2020. It appears that no new insulation was added at that time, leading to a thermal performance likely below R10 - about one-quarter of the recommended level.

The roof structure consists of steel and wood bow trusses, which seem to have some insulation (though this has not been confirmed) and liner fabric between them. As a result, there is likely significant thermal bridging around the perimeter of the arena, diminishing the performance of both the walls and the roof. The smaller flat-roof sections likely rest on a steel or wooden deck supported by the block walls, again with minimal insulation. Based on photographs, the flat roofs appear to be in poor condition.

We recommend removing all existing modified bitumen membranes, insulation, sheathing, and vapour barriers. It is advisable to install at least 8-9 inches of rigid insulation on top of a new layer of sheathing supported by the existing structure, along with a new air barrier and a new PVC or TPO roof membrane as a replacement for the current membrane. This upgrade should enhance the performance of the roof to around R40-R45, meeting the current code minimum requirement, which specifies that roofs with all insulation above the deck must achieve at least R40.

The joints between the walls and the roof should be inspected to ensure there is no air leakage or thermal bridging. Sealants and/or spray foam should be applied where leaks are found, as these can significantly affect thermal performance. The parapet and membrane flashing will need to be reworked around the parapets and eaves to accommodate the additional insulation thickness on the roof. Additionally, the steel structure inside the arena should be painted to prevent deterioration from rust, and the membrane liner should be removed at this time to check for air and thermal leaks at the wall-to-roof junction.

Project cost estimate

Table 50: Project cost estimate (Roof upgrade to high performance)

Category	Line item	Unit	Value
Construction	Roof replacement	[\$]	1,491,000
	General requirements (25%)	[\$]	372,800
Contingency	Subtotal after Construction	[\$]	1,863,800
	Design Contingency (25%)	[\$]	466,000
	Construction Contingency (10%)	[\$]	186,400
Design, Contractors, PM	Subtotal after Contingency	[\$]	2,516,200
	Engineering Design and Field Review (10%)	[\$]	251,600
	Contractor Fee (7%)	[\$]	176,100
Total	Total	[\$]	2,943,900

Utility analysis

Utility analysis methodology

The following assumptions were applied to the calibrated energy model to estimate utility use impacts.

- **Baseline.** An average roof U-value of 0.010 BTU/hr.ft².F (R10) was assumed.
- **Proposed.** An average roof U-value of 0.025 BTU/hr.ft².F (R40) was assumed.

Utility analysis results

Table 51: Roof upgrade to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	504,908	7,044	1.4
	Natural gas use	[m ³ /yr]	82,661	75,683	6,978	8.4
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO ₂ e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	504,908	7,044	1.4
	Natural gas energy	[kWh/yr]	872,625	798,963	73,662	8.4
	Total energy	[kWh/yr]	1,402,069	1,321,362	80,707	5.8
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	12.2	12.1	0.17	1.4
	Natural gas GHGs	[tCO ₂ e/yr]	160	146	13.5	8.4
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	0	0	—
	Total GHGs	[tCO ₂ e/yr]	176	162	13.7	7.8
Utility cost	Electricity utility cost	[\$/yr]	66,048	65,270	778	1.2
	Natural gas utility cost	[\$/yr]	21,492	19,678	1,814	8.4
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	7,501	674	8.2
	Total utility cost	[\$/yr]	97,208	93,942	3,266	3.4
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	2,943,900	—	—
	Incentive amount	[\$]	0	588,780	—	—
	Incremental project cost	[\$]	0	2,355,120	—	—
	Life cycle cost	[\$]	2,080,290	4,516,229	—	—
	Net present value	[\$]	0	-2,435,939	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	172,513	—	—
	Simple payback period	[yr]	—	>20	—	—

5.18 RTUs to ASHP with electric backup

Measure description

Existing condition

Three RTUs (one defunct) are located on the roof above the banquet hall, which provides natural gas-fired heating and DX cooling to the banquet hall.

Opportunity

Replace the RTUs and use air-source heat pumps as the heating and cooling source with electric backup.

Utility-savings mechanism

The primary intent of this measure is to reduce GHG emissions by converting the fuel used for heating from natural gas to electricity because electricity has a lower GHG intensity than natural gas. Reduced natural gas use and increased electricity use would be expected.

Design description

This measure replaces each of the two gas-fired rooftop units (RTUs) with an air-source heat pump (ASHP) option. The available heating output from an air-source heat pump decreases as the outdoor air temperature decreases. Each unit will be equipped with a 40 kW electric resistance backup heating section to supplement heat pump operation.

Both RTUs shall be equivalent to an 8-Ton Daikin model DPS and provided with the following features:

- Variable speed supply modulated according to the heating load - 3200 cfm assumed
- Full OA economizer for free cooling
- ASHP for heating and cooling (sized for 8 tons of cooling)
- Standard programmable thermostat control

During the detailed design phase:

- Consider upgrading controls if a BAS system is implemented,
- The amount of additional heating required number can be refined, and
- Any unavailable airflow values can be found using an air-balancing procedure.

Electrical

- The ASHP with the electric backup will add approximately 104 kW of power to the existing system, which will put the system at 257 kW, which is approximately 77% of the full load of the electrical capacity of the building.

Project cost estimate

Table 52: Project cost estimate (RTUs to ASHP with electric backup)

Category	Line item	Unit	Value
Construction	Equipment	[\$]	182,000
	Installation	[\$]	12,000
	Electrical work	[\$]	72,000
	General requirements (25%)	[\$]	66,500
Contingency	Subtotal after Construction	[\$]	332,500
	Design Contingency (25%)	[\$]	83,100
	Construction Contingency (10%)	[\$]	33,200
Design, Contractors, PM	Subtotal after Contingency	[\$]	448,800
	Engineering Design and Field Review (10%)	[\$]	44,900
	Contractor Fee (7%)	[\$]	31,400
Total	Total	[\$]	525,100

Utility analysis

Utility analysis methodology

The following assumptions were applied to the calibrated energy model to estimate utility use impacts.

- **Baseline:** The RTUs provide space heating and cooling through natural gas-fired burners and DX, respectively. The existing heating efficiency and cooling COP are 80% and 4, respectively.
- **Proposed:** The RTUs provide space heating and cooling through air-source heat pumps. The proposed average heating and cooling COPs are 3 and 4.1 (14 EER), respectively. Backup heating is provided through electric resistance when the outdoor air temperature is below -15 C.

Utility analysis results

Table 53: RTUs to ASHP with electric backup analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	577,479	-65,526	-12.8
	Natural gas use	[m3/yr]	82,661	66,701	15,959	19.3
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	577,479	-65,526	-12.8
	Natural gas energy	[kWh/yr]	872,625	704,147	168,478	19.3
	Total energy	[kWh/yr]	1,402,069	1,299,117	102,952	7.3
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	13.8	-1.6	-12.8
	Natural gas GHGs	[tCO2e/yr]	160	129	30.8	19.3
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	146	29.3	16.7
Utility cost	Electricity utility cost	[\$/yr]	66,048	73,696	-7,648	-11.6
	Natural gas utility cost	[\$/yr]	21,492	17,342	4,149	19.3
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	6,633	1,542	18.9
	Total utility cost	[\$/yr]	97,208	99,164	-1,956	-2.0
Financial	Assumed life	[yrs]	15	18	—	—
	Project cost	[\$]	0	525,100	—	—
	Incentive amount	[\$]	0	105,020	—	—
	Incremental project cost	[\$]	0	420,080	—	—
	Life cycle cost	[\$]	2,080,290	2,640,751	—	—
	Net present value	[\$]	0	-560,461	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	14,350	—	—
	Simple payback period	[yr]	—	—	—	—

5.19 RTUs to ASHP with natural gas backup

Measure description

Existing condition

Three RTUs (one defunct) are located on the roof above the banquet hall, which provides natural gas-fired heating and DX cooling to the banquet hall.

Opportunity

Replace the RTUs and use air-source heat pumps as the heating and cooling source with natural gas backup.

Utility-savings mechanism

The primary intent of this measure is to reduce GHG emissions by converting the fuel used for heating from natural gas to electricity because electricity has a lower GHG intensity than natural gas. Reduced natural gas use and increased electricity use would be expected.

Design description

This measure replaces each of the two gas-fired rooftop units (RTUs) with an air-source heat pump (ASHP) option. The available heating output from an air-source heat pump decreases as the outdoor air temperature decreases. Each unit will be equipped with a 200,000BTU input NG backup heating section to supplement heat pump operation.

Both RTUs shall be equivalent to an 8-Ton Daikin model DPS and provided with the following features:

- Variable speed supply modulated according to the heating load - 3200 cfm assumed
- Full OA economizer for free cooling
- ASHP for heating and cooling (sized for 8 tons of cooling)
- Standard programmable thermostat control

During the detailed design phase:

- Consider upgrading controls if a BAS system is implemented,
- The amount of additional heating required number can be refined, and
- Any unavailable airflow values can be found using an air-balancing procedure.

Electrical

The ASHP with the gas backup will add approximately 24 kW of power to the existing system, which will put the system at 177 kW, which is approximately 53% of the full load of the electrical capacity of the building.

Project cost estimate

Table 54: Project cost estimate (RTUs to ASHP with natural gas backup)

Category	Line item	Unit	Value
Construction	Equipment	[\$]	182,000
	Installation	[\$]	12,000
	Electrical work	[\$]	10,000
	General requirements (25%)	[\$]	51,000
Contingency	Subtotal after Construction	[\$]	255,000
	Design Contingency (25%)	[\$]	63,800
	Construction Contingency (10%)	[\$]	25,500
Design, Contractors, PM	Subtotal after Contingency	[\$]	344,300
	Engineering Design and Field Review (10%)	[\$]	34,400
	Contractor Fee (7%)	[\$]	24,100
Total	Total	[\$]	402,800

Utility analysis

Utility analysis methodology

The following assumptions were applied to the calibrated energy model to estimate utility use impacts.

- **Baseline:** The RTUs provide space heating and cooling through natural gas-fired burners and DX, respectively. The existing heating efficiency and cooling COP are 80% and 4, respectively.
- **Proposed:** The RTUs provide space heating and cooling through air-source heat pumps. The proposed average heating and cooling COPs are 3 and 4.1 (14 EER), respectively. Backup heating is provided from the existing gas-fired furnaces when the outdoor air temperature is below -15 C.

Utility analysis results

Table 55: RTUs to ASHP with natural gas backup analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	556,776	-44,824	-8.8
	Natural gas use	[m3/yr]	82,661	69,512	13,149	15.9
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	556,776	-44,824	-8.8
	Natural gas energy	[kWh/yr]	872,625	733,814	138,811	15.9
	Total energy	[kWh/yr]	1,402,069	1,308,082	93,987	6.7
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	13.3	-1.1	-8.8
	Natural gas GHGs	[tCO2e/yr]	160	134	25.4	15.9
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	151	24.3	13.8
Utility cost	Electricity utility cost	[\$/yr]	66,048	71,183	-5,135	-7.8
	Natural gas utility cost	[\$/yr]	21,492	18,073	3,419	15.9
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	6,905	1,270	15.5
	Total utility cost	[\$/yr]	97,208	97,653	-445	-0.46
Financial	Assumed life	[yrs]	15	18	—	—
	Project cost	[\$]	0	402,800	—	—
	Incentive amount	[\$]	0	80,560	—	—
	Incremental project cost	[\$]	0	322,240	—	—
	Life cycle cost	[\$]	2,080,290	2,491,657	—	—
	Net present value	[\$]	0	-411,367	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	13,241	—	—
	Simple payback period	[yr]	—	—	—	—

5.20 Solar PV rooftop

Measure description

Existing condition

There is no solar PV system at this facility.

Opportunity

Install a solar PV system on the roof where feasible. A net-metering agreement is recommended so that the reduced GHG emissions associated with the electricity generated by the system can be retained by the City of Temiskaming Shores or exported to the grid if on-site electricity consumption is fulfilled.

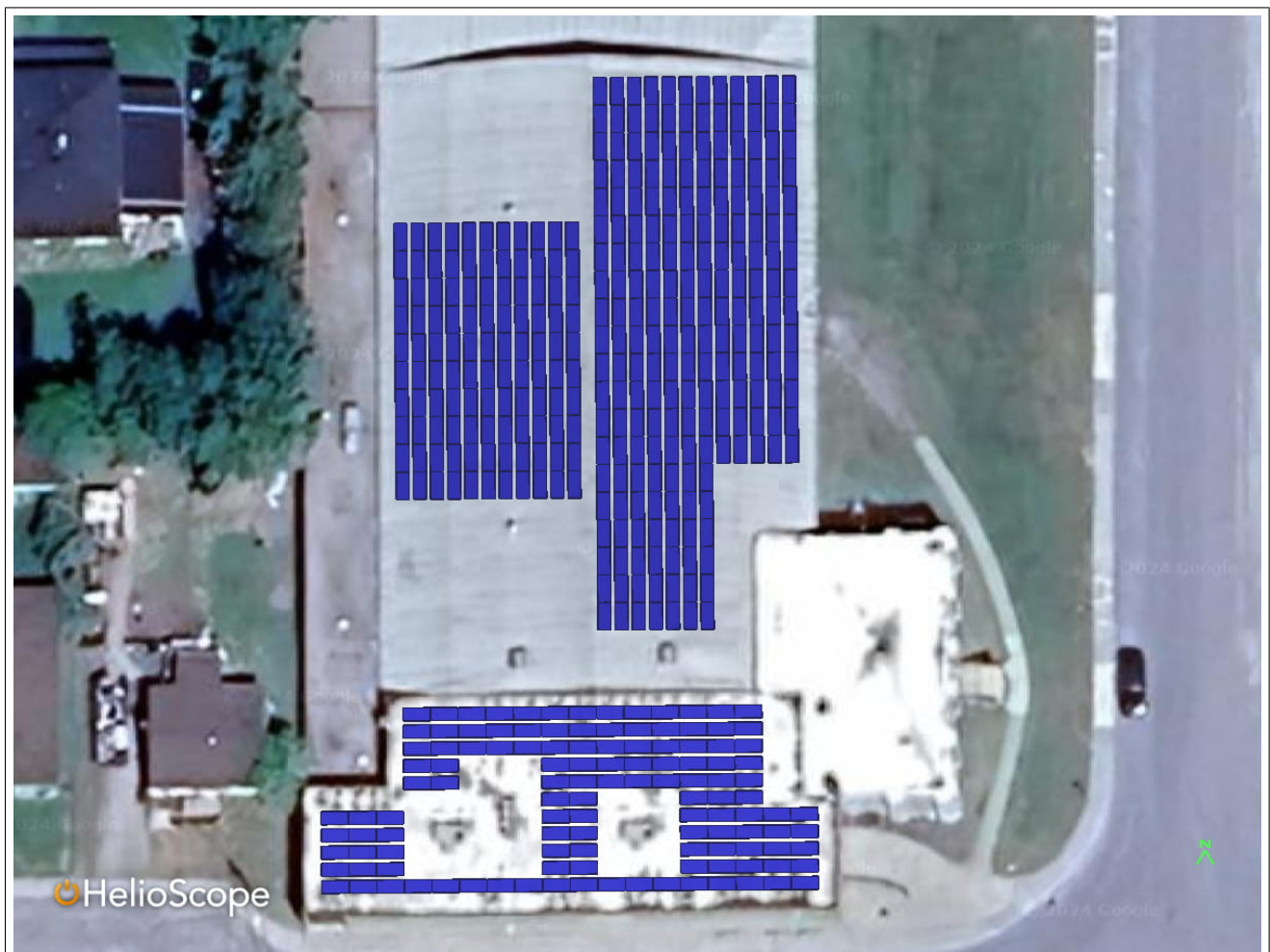
Utility-savings mechanism

The solar PV system will reduce the electricity use from the grid, GHG emissions, and utility costs.

Design description

Helioscope overview

Helioscope was used to determine a preliminary design concept for the proposed solar PV system. The Helioscope model is depicted in the following image.



Based on the results from the Helioscope model, the proposed solar PV system was assumed to have the following output capacity.

- Total system output capacity (DC) = 188 kW.

Proposed scope

Supply and install a rooftop solar PV electricity generation system, including the following.

- Solar PV modules.
- Racking system for mounting the solar panels onto.
- DC to AC inverters.
- Wiring, disconnects, meters, panels and transformers. The AC output from inverters is to be wired into a dedicated solar PV electrical panel before being connected to the main switchboard via a new breaker.
- Connection impact assessment, and other requirements to satisfy the utility provider for executing a Net Metering agreement.
- Installation of the above.

Electrical

With the existing system, the panel is not rated high enough to accommodate the additional 188 kW of the solar. The main panel will need to have the bus upgraded to 600A 600V or a new 600A 600V panel installed.

Project cost estimate

Table 56: Project cost estimate (Solar PV rooftop)

Category	Line item	Unit	Value
Materials and labour	Solar PV electricity system installed (assuming 188 kW at 2000 \$/kW) Electrical	[\$]	376,000
		[\$]	75,000
Contingency	Subtotal after Materials and labour	[\$]	451,000
	General Contingency (20%)	[\$]	90,200
	Design Contingency (10%)	[\$]	45,100
Total	Total	[\$]	586,300

Utility analysis

Utility analysis methodology

The following assumptions were applied to the calibrated energy model to estimate utility use impacts.

- **Baseline.** There is no solar PV present at this site.
- **Proposed.** The proposed solar PV electricity generation system described above was assumed to be implemented. Helioscope was used to model the hourly electricity output from the solar PV system. All electricity generated by the system was assumed to be used on-site, directly reducing grid electricity consumption, GHG emissions and utility costs.

Utility analysis results

Table 57: Solar PV rooftop analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	326,193	185,760	36.3
	Natural gas use	[m3/yr]	82,661	82,661	0	0
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	326,193	185,760	36.3
	Natural gas energy	[kWh/yr]	872,625	872,625	0	0
	Total energy	[kWh/yr]	1,402,069	1,216,309	185,760	13.2
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	7.8	4.4	36.3
	Natural gas GHGs	[tCO2e/yr]	160	160	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	171	4.4	2.5
Utility cost	Electricity utility cost	[\$/yr]	66,048	45,900	20,148	30.5
	Natural gas utility cost	[\$/yr]	21,492	21,492	0	0
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	8,175	0	0
	Total utility cost	[\$/yr]	97,208	77,060	20,148	20.7
Financial	Assumed life	[yrs]	15	30	—	—
	Project cost	[\$]	0	586,300	—	—
	Incentive amount	[\$]	0	117,260	—	—
	Incremental project cost	[\$]	0	469,040	—	—
	Life cycle cost	[\$]	2,080,290	1,976,100	—	—
	Net present value	[\$]	0	104,190	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	105,648	—	—
	Simple payback period	[yr]	—	>20	—	—

5.21 Space heating boiler conversion to VRF and electric backup

Measure description

Existing condition

One non-condensing boiler provides hot water to radiators throughout the building. This boiler used to be a coal boiler and was retrofitted to use natural gas.

Opportunity

Remove the existing boiler and radiators. Change the HVAC type serving the original building to zone VRF coupled with electric-resistant baseboards below windows and beside doors. For the west changerooms, supplementary electric heat in the MUA will replace the hydronic baseboard heaters.

Utility-savings mechanism

The primary intent of this measure is to reduce GHG emissions by converting the fuel used for heating from natural gas to electricity because electricity has a lower GHG intensity than natural gas. Reduced natural gas use and increased electricity use would be expected.

Design description

Proposed scope

Provide a new VRF system to supplement the hydronic heating system. All zones with a hydronic heating system will have a wall-hung condensing unit sized between 0.5T and 2T based on the space served. The existing hydronic system will operate as a backup.

Replace the existing boiler and radiators with electric resistance radiators located below windows and in vestibule spaces.

- A 10T LG Condensing unit will serve both floors of the South wing.
- A 12T LG Condensing unit will serve the 2nd-floor Hall, first-floor main lobby and concession areas.
- Electric baseboard heaters will serve smaller spaces.
- The storage spaces currently served by unit heaters will be converted to electric unit heaters.

Electrical

The ASHP with the electric backup will add approximately 53 kW of power to the existing system, which will put the system at 206 kW, which is approximately 62% of the full load of the electrical capacity of the building.

Project cost estimate

Table 58: Project cost estimate (Space heating boiler conversion to VRF and electric backup)

Category	Line item	Unit	Value
Construction	LG VRF Supply and Install	[\$]	132,000
	Electric baseboards and Unit heaters	[\$]	25,600
	Electrical contingency	[\$]	18,000
	General requirements (25%)	[\$]	43,900
Contingency	Subtotal after Construction	[\$]	219,500
	Design Contingency (25%)	[\$]	54,900
	Construction Contingency (10%)	[\$]	22,000
Design, Contractors, PM	Subtotal after Contingency	[\$]	296,400
	Engineering Design and Field Review (10%)	[\$]	29,600
	Contractor Fee (7%)	[\$]	20,700
Total	Total	[\$]	346,700

Utility analysis

Utility analysis methodology

The following assumptions were applied to the energy model to estimate utility use impacts.

- **Baseline.** B1 has a thermal efficiency of 75%.
- **Proposed.** The VRF system was assumed to get primary heating from air-source VRF heat pumps with an average heating COP of 3. Backup heating is provided through electric resistance when the outdoor air temperature is below -15 C.

Utility analysis results

Table 59: Space heating boiler conversion to VRF and electric backup analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	653,097	-141,144	-27.6
	Natural gas use	[m3/yr]	82,661	57,400	25,261	30.6
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	653,097	-141,144	-27.6
	Natural gas energy	[kWh/yr]	872,625	605,954	266,671	30.6
	Total energy	[kWh/yr]	1,402,069	1,276,542	125,527	9.0
GHG emissions	Electricity GHGs	[tCO2e/yr]	12.2	15.6	-3.4	-27.6
	Natural gas GHGs	[tCO2e/yr]	160	111	48.8	30.6
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	176	130	45.4	25.9
Utility cost	Electricity utility cost	[\$/yr]	66,048	82,416	-16,368	-24.8
	Natural gas utility cost	[\$/yr]	21,492	14,924	6,568	30.6
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	5,734	2,441	29.9
	Total utility cost	[\$/yr]	97,208	104,568	-7,360	-7.6
Financial	Assumed life	[yrs]	15	30	—	—
	Project cost	[\$]	0	346,700	—	—
	Incentive amount	[\$]	0	69,340	—	—
	Incremental project cost	[\$]	0	277,360	—	—
	Life cycle cost	[\$]	2,080,290	2,550,340	—	—
	Net present value	[\$]	0	-470,051	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	6,104	—	—
	Simple payback period	[yr]	—	—	—	—

5.22 Wall upgrade to high performance

Measure description

Existing condition

No architectural drawings were available for Shelley Herbert-Shea Memorial Arena. Site observations revealed two different types of exterior layers: metal siding or concrete block.

Opportunity

Upgrade upon the end of useful life or as required to meet scenario criteria.

Utility-savings mechanism

Reduced heating energy use through improved thermal performance of exterior walls.

Design description

Overview

The performance of the existing wall is currently unknown. However, we assume that the original arena was constructed with concrete blocks and lacks insulation on the interior. There are steel columns around the perimeter that support steel and wood bow trusses. At some point, corrugated steel siding was added to the exterior walls, and we assume there is at least 1 inch of rigid insulation beneath the steel.

The thermal performance of these walls is likely less than R10, which is significantly below the current building code requirement of R20. To improve this performance, we recommend applying an EIFS (Exterior Insulation and Finish System) to the face of the existing block. This system could provide almost R30 of insulation if it is applied directly to the block and includes an air barrier that can connect to the new roof barrier.

For this installation, the existing corrugated steel siding would need to be removed, and the EIFS system would be applied directly to the original arena walls. Similarly, for the historic building, we recommend removing the steel siding and adding an EIFS system to what we believe is the original historic masonry. The EIFS can be finished with a masonry veneer if desired; however, an assessment of the structural capacity is necessary to determine if the masonry can support the extra weight.

Typically, adding an additional 150 mm of EIFS with an acrylic stucco finish to existing brick or block does not pose structural issues regarding the brick ties. Alternatively, semi-rigid batt insulation could be applied to the masonry, with thermally broken clips supporting a new layer of steel panels on the exterior. This approach would significantly increase the weight on the existing cladding, so an assessment of its structural capacity is necessary. Furthermore, this option is expected to be more expensive than the EIFS system.

If the decision is made not to add insulation to the exterior walls, we recommend using thermal imaging and blower door testing to identify any significant points of air leakage or thermal bridging that may be compromising the performance of the walls and roof. These issues can often be addressed locally using sealants and spray foam.

Project cost estimate

Table 60: Project cost estimate (Wall upgrade to high performance)

Category	Line item	Unit	Value
Construction	Add EIFS system to existing exterior wall	[\$]	1,682,000
	General requirements (25%)	[\$]	420,500
Contingency	Subtotal after Construction	[\$]	2,102,500
	Design Contingency (25%)	[\$]	525,600
	Construction Contingency (10%)	[\$]	210,200
Design, Contractors, PM	Subtotal after Contingency	[\$]	2,838,300
	Engineering Design and Field Review (10%)	[\$]	283,800
	Contractor Fee (7%)	[\$]	198,700
Total	Total	[\$]	3,320,800

Utility analysis

Utility analysis methodology

The following assumptions were applied to the calibrated energy model to estimate utility use impacts.

- **Baseline.** An average wall U-value of 0.010 BTU/hr.ft².F (R10) was assumed.
- **Proposed.** An average wall U-value of 0.0333 BTU/hr.ft².F (R30) was assumed. Infiltration flow was assumed to be reduced by 10% in total relative to the Baseline for affected spaces.

Utility analysis results

Table 61: Wall upgrade to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	500,603	11,350	2.2
	Natural gas use	[m ³ /yr]	82,661	72,261	10,400	12.6
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO ₂ e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	500,603	11,350	2.2
	Natural gas energy	[kWh/yr]	872,625	762,835	109,790	12.6
	Total energy	[kWh/yr]	1,402,069	1,280,929	121,140	8.6
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	12.2	12.0	0.27	2.2
	Natural gas GHGs	[tCO ₂ e/yr]	160	140	20.1	12.6
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	0	0	—
	Total GHGs	[tCO ₂ e/yr]	176	155	20.4	11.6
Utility cost	Electricity utility cost	[\$/yr]	66,048	64,543	1,505	2.3
	Natural gas utility cost	[\$/yr]	21,492	18,788	2,704	12.6
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	7,170	1,005	12.3
	Total utility cost	[\$/yr]	97,208	91,994	5,214	5.4
Financial	Assumed life	[yrs]	15	75	—	—
	Project cost	[\$]	0	3,320,800	—	—
	Incentive amount	[\$]	0	664,160	—	—
	Incremental project cost	[\$]	0	2,656,640	—	—
	Life cycle cost	[\$]	2,080,290	2,860,681	—	—
	Net present value	[\$]	0	-780,391	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	130,434	—	—
	Simple payback period	[yr]	—	>20	—	—

5.23 Windows and doors to high performance

Measure description

Existing condition

Windows consist mainly of double-pane windows that appeared to be in good condition. As for doors, there are swing doors with glazing, hollow metal, and one overhead door.

Opportunity

Upgrade upon the end of useful life or as required to meet scenario criteria.

Utility-savings mechanism

Reduced heating energy use through improved thermal performance of windows and doors.

Design description

Windows

We recommend replacing all windows with Passive House Certified Triple-glazed, thermally broken windows. These could be framed in aluminum, vinyl or fibreglass. This approach will improve the thermal performance of the windows from about R2 or R3 to at least R7 or R8.

Doors

Doors are a significant source of heat loss and air infiltration. To minimize their impact, we recommend the following measures:

- **Hollow Metal Doors:** Replace existing hollow metal doors with insulated doors in thermally broken frames.
- **Glazed Entry Doors:** Should be triple-glazed and thermally broken as part of the window system improvements.
- **Overhead Doors:** Replace the existing overhead doors with high-performance sectional insulated roll-up doors that use systems with polyurethane cores and a full perimeter seal.

Project cost estimate

Table 62: Project cost estimate (Windows and doors to high performance)

Category	Line item	Unit	Value
Construction	Window and door replacement	[\$]	99,000
	General requirements (25%)	[\$]	24,800
Contingency	Subtotal after Construction	[\$]	123,800
	Design Contingency (25%)	[\$]	31,000
	Construction Contingency (10%)	[\$]	12,400
Design, Contractors, PM	Subtotal after Contingency	[\$]	167,200
	Engineering Design and Field Review (10%)	[\$]	16,700
	Contractor Fee (7%)	[\$]	11,700
Total	Total	[\$]	195,600

Utility analysis

Utility analysis methodology

The following assumptions were applied to the calibrated energy model to estimate utility use impacts.

- **Baseline.** The average U-value of all windows and doors was assumed to be 0.667 BTU/hr.ft².F.

- **Proposed.** The average U-value of all windows and doors was assumed to be 0.125 BTU/hr.ft².F (R8). Infiltration flow was assumed to be reduced by 10% in total relative to the Baseline for affected spaces.

Utility analysis results

Table 63: Windows and doors to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	511,953	510,389	1,564	0.31
	Natural gas use	[m ³ /yr]	82,661	80,907	1,754	2.1
	Propane use	[L/yr]	2,489	2,489	0	0
	Carbon offset use	[tCO ₂ e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	511,953	510,389	1,564	0.31
	Natural gas energy	[kWh/yr]	872,625	854,111	18,514	2.1
	Total energy	[kWh/yr]	1,402,069	1,381,991	20,078	1.4
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	12.2	12.2	0.04	0.31
	Natural gas GHGs	[tCO ₂ e/yr]	160	156	3.4	2.1
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	0	0	—
	Total GHGs	[tCO ₂ e/yr]	176	172	3.4	1.9
Utility cost	Electricity utility cost	[\$/yr]	66,048	65,835	213	0.32
	Natural gas utility cost	[\$/yr]	21,492	21,036	456	2.1
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	8,175	8,006	169	2.1
	Total utility cost	[\$/yr]	97,208	96,370	838	0.86
Financial	Assumed life	[yrs]	15	40	—	—
	Project cost	[\$]	0	195,600	—	—
	Incentive amount	[\$]	0	39,120	—	—
	Incremental project cost	[\$]	0	156,480	—	—
	Life cycle cost	[\$]	2,080,290	2,162,742	—	—
	Net present value	[\$]	0	-82,452	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	45,671	—	—
	Simple payback period	[yr]	—	>20	—	—

5.24 Measure risk analysis

Utility use sensitivity

Figure 204 indicates how sensitive cumulative electricity and natural gas use are to variations in each risk parameter.

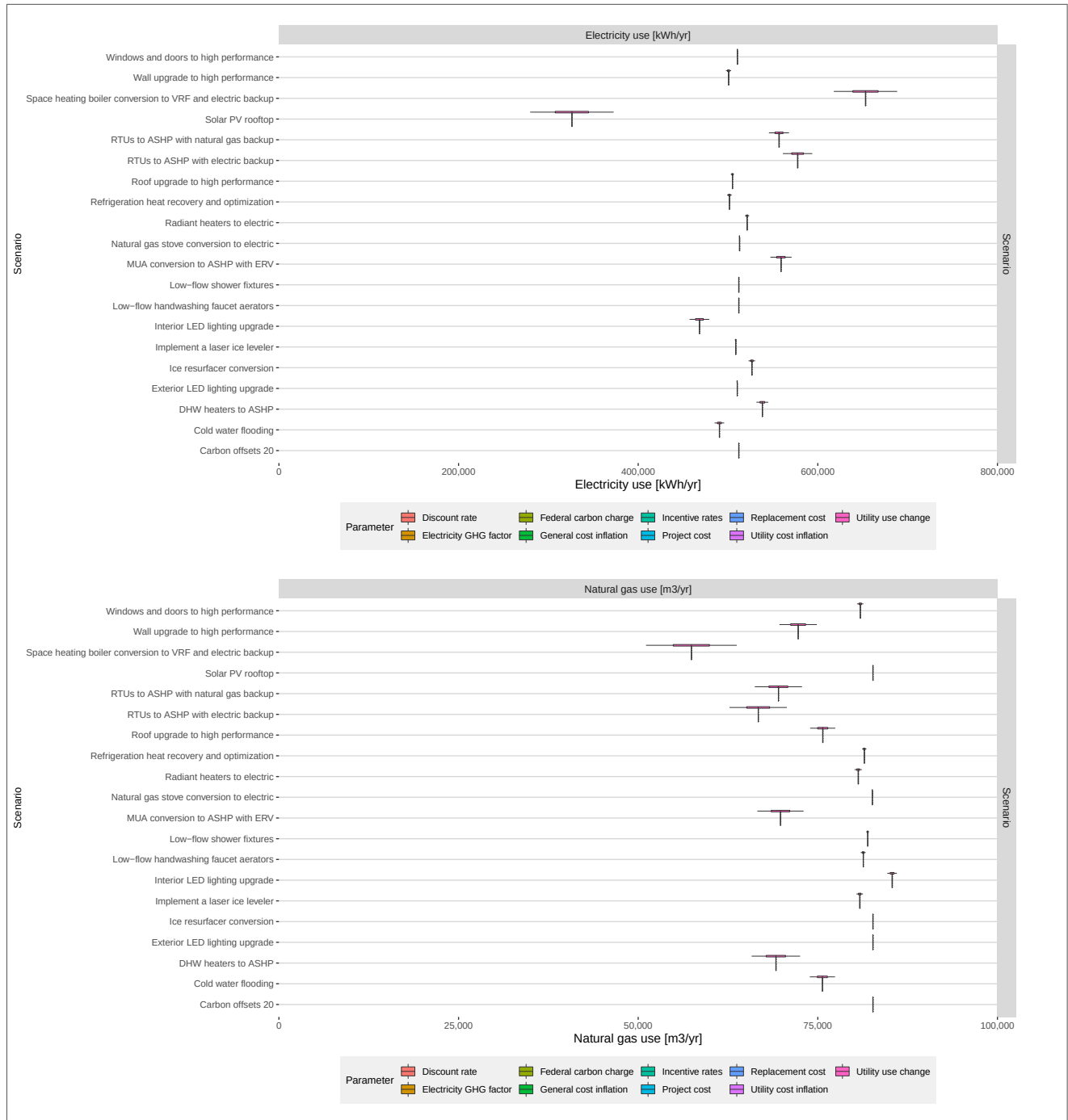


Figure 204: Utility cumulative use sensitivity analysis

GHG emissions and life cycle cost sensitivity

Figure 205 indicates how sensitive cumulative GHG emissions and life cycle costs are to variations in each risk parameter.

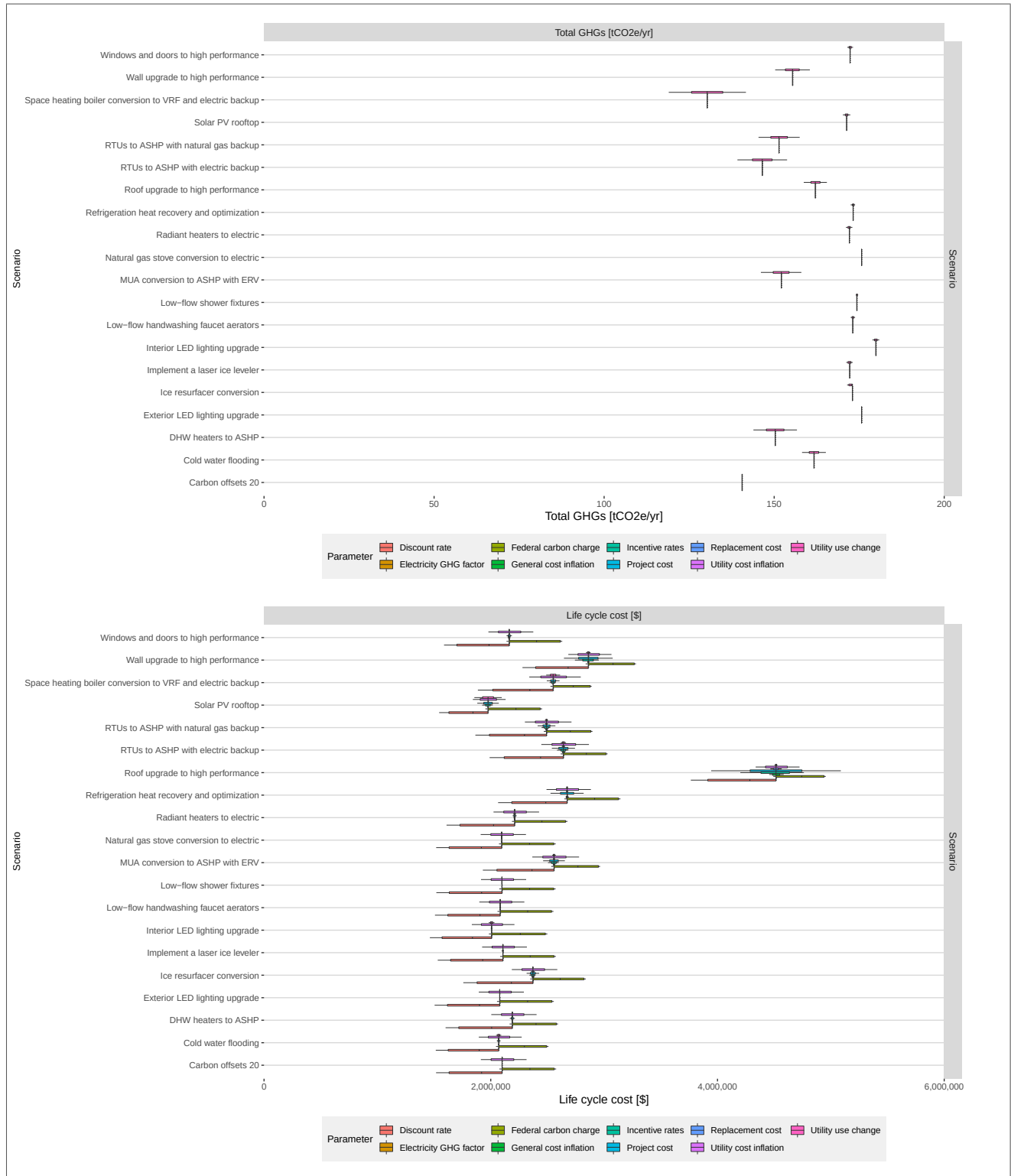


Figure 205: GHG cumulative emissions and life cycle cost sensitivity analysis

5.25 Measure analysis summary

For each analyzed measure, the analysis results are summarized in Table 64.

Table 64: Measure analysis summary

Measure ID	Utility use						Equivalent energy use		GHG emissions		Utility cost		Financial							
Measure name	Electricity use reduction	Electricity use reduction	Natural gas use reduction	Natural gas use reduction	Propane use reduction	Propane use reduction	Total energy reduction	Total energy reduction	Total GHG reduction	Total GHG reduction	Utility cost reduction	Utility cost reduction	Assumed life	Project cost	Incentive amount	Incremental project cost	Life cycle cost	Net present value	Project cost per GHG	Simple payback period
-	[kWh/yr]	[%]	[m3/yr]	[%]	[L/yr]	[%]	[kWh/yr]	[%]	[tCO2e/yr]	[%]	[\$/yr]	[%]	[yrs]	[\$]	[\$]	[\$]	[\$]	[\$]	[\$/tCO2e]	[yr]
Baseline	511,953	100.0	82,661	100.0	2,489	100.0	1,402,069	100.0	176	100.0	97,208	100.0	15	0	0	0	2,080,290	0	-	-
Carbon offsets 20	0	0.0	0	0.0	0	0.0	0	0.0	35	20.0	-1,054	-1.1	20	-	0	-	2,099,518	-19,228	-	-
Cold water flooding	21,566	4.2	7,022	8.5	0	0.0	95,698	6.8	14	8.0	5,276	5.4	15	67,500	0	67,500	2,069,879	10,411	4,792	13
DHW heaters to ASHP	-26,244	-5.1	13,497	16.3	0	0.0	116,238	8.3	25	14.5	1,749	1.8	15	93,000	3,374	89,626	2,189,952	-109,662	3,521	51
Exterior LED lighting upgrade	1,745	0.3	0	0.0	0	0.0	1,745	0.1	0	0.0	173	0.2	20	3,000	0	3,000	2,078,863	1,427	71,942	17
Ice resurfacer conversion	-14,616	-2.9	0	0.0	2,489	100.0	2,875	0.2	3	1.9	-234	-0.2	15	285,000	57,000	228,000	2,371,824	-291,534	66,642	-976
Implement a laser ice leveler	3,344	0.7	1,826	2.2	0	0.0	22,625	1.6	4	2.1	1,060	1.1	15	37,500	0	37,500	2,107,036	-26,747	10,390	35
Interior LED lighting upgrade	43,760	8.5	-2,680	-3.2	0	0.0	15,470	1.1	-4	-2.4	5,652	5.8	20	27,000	0	27,000	2,007,321	72,969	-6,534	5
Low-flow handwashing faucet aerators	0	0.0	1,344	1.6	0	0.0	14,191	1.0	3	1.5	479	0.5	7	5,300	336	4,964	2,083,229	-2,939	1,911	10
Low-flow shower fixtures	0	0.0	725	0.9	0	0.0	7,652	0.5	1	0.8	259	0.3	7	12,000	181	11,819	2,098,720	-18,430	8,438	46
MUA conversion to ASHP with ERV	-47,056	-9.2	12,863	15.6	0	0.0	88,732	6.3	24	13.5	-855	-0.9	20	493,500	98,700	394,800	2,557,752	-477,462	16,637	-462
Natural gas stove conversion to electric	-834	-0.2	81	0.1	0	0.0	17	0.0	0	0.1	-54	-0.1	15	12,000	0	12,000	2,096,246	-15,956	88,335	-222
Natural heaters to electric	-9,295	-1.8	2,041	2.5	0	0.0	12,247	0.9	4	2.1	-422	-0.4	10	90,900	18,180	72,720	2,210,683	-130,393	19,543	-172
Refrigeration heat recovery and optimization	10,405	2.0	1,194	1.4	0	0.0	23,006	1.6	3	1.5	1,721	1.8	20	602,100	0	602,100	2,673,257	-592,967	235,625	350
Roof upgrade to high performance	7,044	1.4	6,978	8.4	0	0.0	80,707	5.8	14	7.8	3,266	3.4	20	2,943,900	588,780	2,355,120	4,516,229	-2,435,939	172,513	721
RTUs to ASHP with electric backup	-65,526	-12.8	15,959	19.3	0	0.0	102,952	7.3	29	16.7	-1,956	-2.0	18	525,100	105,020	420,080	2,640,751	-560,461	14,350	-215
RTUs to ASHP with natural gas backup	-44,824	-8.8	13,149	15.9	0	0.0	93,987	6.7	24	13.8	-445	-0.5	18	402,800	80,560	322,240	2,491,657	-411,367	13,241	-723
Solar PV rooftop	185,760	36.3	0	0.0	0	0.0	185,760	13.2	4	2.5	20,148	20.7	30	586,300	117,260	469,040	1,976,100	104,190	105,647	23
Space heating boiler conversion to VRF and electric backup	-141,144	-27.6	25,261	30.6	0	0.0	125,527	9.0	45	25.9	-7,360	-7.6	30	346,700	69,340	277,360	2,550,340	-470,051	6,104	-38
Wall upgrade to high performance	11,350	2.2	10,400	12.6	0	0.0	121,140	8.6	20	11.6	5,214	5.4	75	3,320,800	664,160	2,656,640	2,860,681	-780,391	130,434	510
Windows and doors to high performance	1,564	0.3	1,754	2.1	0	0.0	20,078	1.4	3	1.9	838	0.9	40	195,600	39,120	156,480	2,162,742	-82,452	46,671	187
Total project cost	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boiler renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	30	35,000	0	35,000	2,108,623	-28,333	-	-
Compressor renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	120,000	0	120,000	2,205,022	-124,732	-	-
DHW renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	24,000	0	24,000	2,108,635	-28,345	-	-
Exterior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	2,000	0	2,000	2,082,369	-2,079	-	-
Exterior walls renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	75	17,000	0	17,000	2,085,795	-5,505	-	-
Ice resurfacer renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	120,000	0	120,000	2,222,017	-141,727	-	-
Interior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	76,000	0	76,000	2,159,287	-78,997	-	-
MUA renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	55,000	0	55,000	2,139,884	-59,594	-	-
Natural gas stove renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	5,000	0	5,000	2,086,195	-5,905	-	-
Radiant heaters renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	32,000	0	32,000	2,114,963	-34,673	-	-
Roof renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	1,091,000	0	1,091,000	3,214,311	-1,134,022	-	-
RTUs renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	72,000	0	72,000	2,158,304	-78,014	-	-
Shower renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7	8,000	0	8,000	2,095,031	-14,741	-	-
Sinks renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10	26,000	0	26,000	2,118,534	-38,244	-	-
Windows and doors renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	45,000	0	45,000	2,107,611	-27,321	-	-
BAU measure totals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
														-	1,728,000	-	-	-	-	-

6 SCENARIO ANALYSIS

6.1 Cluster scenario analysis methodology

A scenario analysis was completed to estimate the costs and benefits expected from implementing various combinations (i.e. scenarios) of the measures that were individually analyzed in Section 5. Whereas in Section 5, each measure was individually analyzed as though implemented by itself, in Section 6, scenarios of multiple measures being implemented together were analyzed, and the interactive effects between measures within each scenario were accounted for. The scenario analysis was completed according to the following methodology.

1. **Cluster scenario objectives.** All scenarios that were analyzed and their objectives were defined as summarized in Table 65.
2. **Cluster scenario composition.** Each scenario was composed by iteratively assigning measures to that scenario to achieve the objectives of that scenario as closely as possible. Results are presented in Section 6.3.
3. **Cluster scenario performance analysis.** Each scenario was analyzed using the energy model to estimate the overall performance that implementing all measures in that scenario would have on utility use, equivalent energy use, GHG emissions, utility costs and several financial performance metrics. Results are presented in Section 6.4.
4. **Cluster scenario analysis discussion.** Results of the scenario analysis were discussed in Section 6.4.

6.2 Cluster scenario objectives

The cluster scenarios that were analyzed and their objectives are summarized in Table 65.

Table 65: Scenario objectives

Scenario	Objectives
Control optimization	To estimate the impact of all control optimization measures combined.
Envelope upgrades	To estimate the impact of all envelope upgrade measures combined.
Load minimization	To estimate the impact of all controls optimization, envelope upgrades, and other measures intended to reduce the thermal and electrical load of the facility, which would ideally reduce the capacity requirements of new equipment.
Comprehensive cluster	To understand the limit of GHG reductions possible by implementing all measures that have the greatest reduction on GHG emissions.

6.3 Cluster scenario composition

In the scenario composition exercise, individual measures were assigned to each scenario in an iterative process to achieve the objectives of that scenario as closely as possible. Figure 206 and Table 66 present the results of this exercise, indicating which measures were assigned to which scenario.

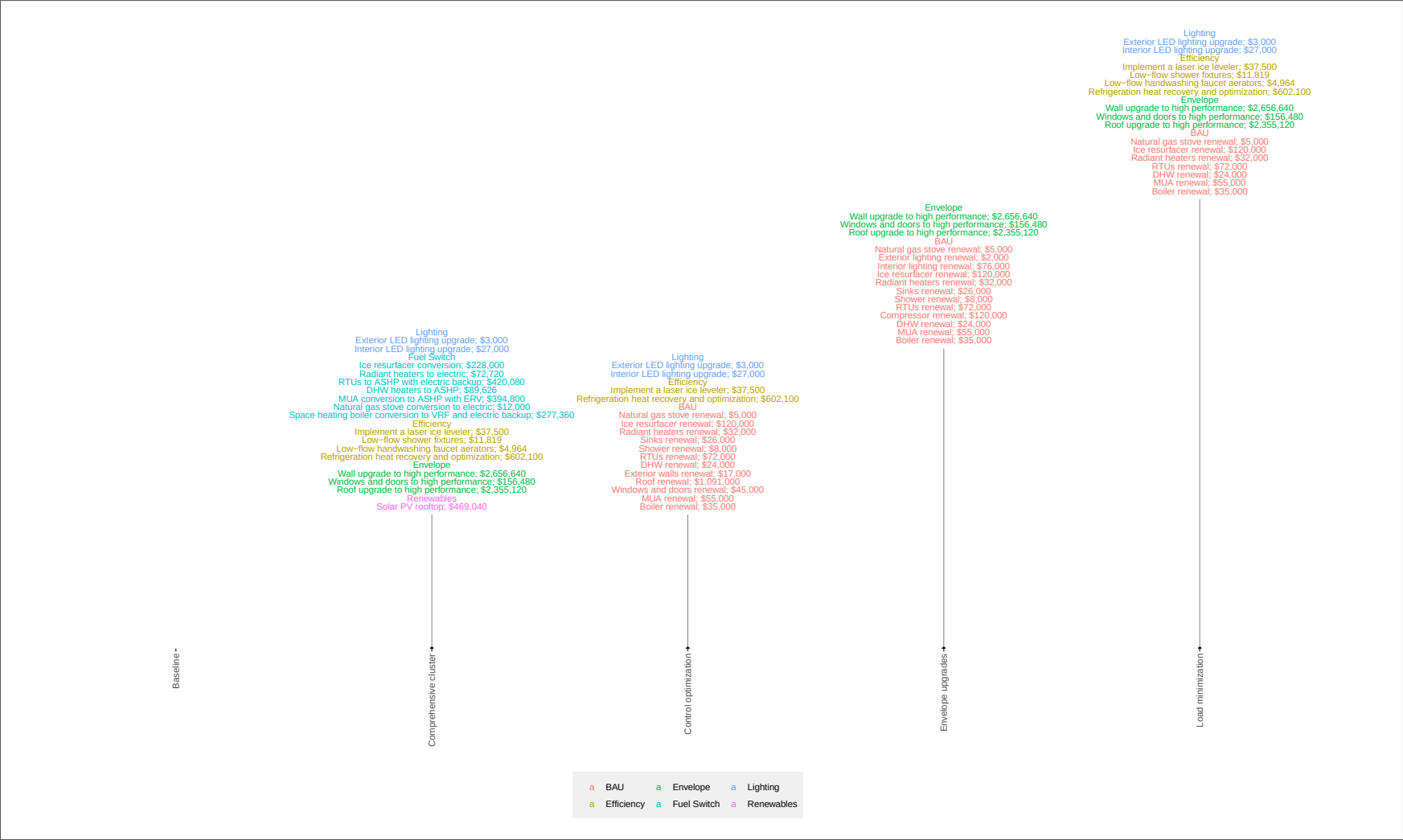


Figure 206: Scenario composition

Table 66: Cluster composition

Measure	Control optimization	Envelope upgrades	Load minimization	Comprehensive cluster
Carbon offsets 20	✗	✗	✗	✗
Cold water flooding	✗	✗	✗	✗
DHW heaters to ASHP	✗	✗	✗	✓
Exterior LED lighting upgrade	✓	✗	✓	✓
Ice resurfacer conversion	✗	✗	✗	✓
Implement a laser ice leveler	✓	✗	✓	✓
Interior LED lighting upgrade	✓	✗	✓	✓
Low-flow handwashing faucet aerators	✗	✗	✓	✓
Low-flow shower fixtures	✗	✗	✓	✓
MUA conversion to ASHP with ERV	✗	✗	✗	✓
Natural gas stove conversion to electric	✗	✗	✗	✓
Radiant heaters to electric	✗	✗	✗	✓
Refrigeration heat recovery and optimization	✓	✗	✓	✓
Roof upgrade to high performance	✗	✓	✓	✓
RTUs to ASHP with electric backup	✗	✗	✗	✓
RTUs to ASHP with natural gas backup	✗	✗	✗	✗
Solar PV rooftop	✗	✗	✗	✓
Space heating boiler conversion to VRF and electric backup	✗	✗	✗	✓
Wall upgrade to high performance	✗	✓	✓	✓
Windows and doors to high performance	✗	✓	✓	✓
Boiler renewal	✓	✓	✓	✗
Compressor renewal	✗	✓	✗	✗
DHW renewal	✓	✓	✓	✗
Exterior lighting renewal	✗	✓	✗	✗
Exterior walls renewal	✓	✗	✗	✗
Ice resurfacer renewal	✓	✓	✓	✗
Interior lighting renewal	✗	✓	✗	✗
MUA renewal	✓	✓	✓	✗
Natural gas stove renewal	✓	✓	✓	✗
Radiant heaters renewal	✓	✓	✓	✗
Roof renewal	✓	✗	✗	✗
RTUs renewal	✓	✓	✓	✗
Shower renewal	✓	✓	✗	✗
Sinks renewal	✓	✓	✗	✗
Windows and doors renewal	✓	✗	✗	✗

6.4 Cluster scenario performance analysis

The scenario performance analysis was completed by using the energy model (see Section 4) to determine the expected performance of implementing all measures in each scenario. Results are presented throughout Section

6.4.

Cluster scenario performance analysis summary

Results of the scenario analysis are summarized in Table 67, which indicates all individual measures that were considered to be implemented under each scenario, the measure-specific impacts that each measure was estimated to have if implemented by itself, and the combined impacts that implementing all measures in each scenario is expected to have, accounting for the interactive effects between measures within each scenario.

Table 67: Scenario analysis summary

Measure ID	Scenario	Measure name	Utility use						Equivalent energy use		GHG emissions		Utility cost		Financial							
			Electricity use reduction	Electricity use reduction	Natural gas use reduction	Natural gas use reduction	Propane use reduction	Propane use reduction	Total energy reduction	Total energy reduction	Total GHG reduction	Total GHG reduction	Utility cost reduction	Utility cost reduction	Assumed life	Project cost	Incentive amount	Incremental project cost	Life cycle cost	Net present value	Project cost per GHG reduction	Simple payback period
-	-	-	[kWh/yr]	[%]	[m3/yr]	[%]	[L/yr]	[%]	[kWh/yr]	[%]	[tCO2e/yr]	[%]	[\$/yr]	[%]	[yr]	[\$]	[\$]	[\$]	[\$]	[\$]	[\$/tCO2e]	[yr]
Comprehensive cluster	Combined		14,562	2.8	71,956	87.0	2,489	100.0	791,669	56.5	143	81.5	28,189	29.0	-	9,579,700	1,761,452	7,818,248	7,560,900	-5,480,610	54,611	277
Comprehensive cluster	Exterior LED lighting upgrade		1,745	0.3	0	0.0	0	0.0	1,745	0.1	0	0.0	173	0.2	20	3,000	0	3,000	2,078,863	1,427	71,942	17
Comprehensive cluster	Interior LED lighting upgrade		43,760	8.5	-2,680	-3.2	0	0.0	15,470	1.1	-4	-2.4	5,652	5.8	20	27,000	0	27,000	2,007,321	72,969	-6,534	5
Comprehensive cluster	Ice resurfacer conversion		-14,616	-2.9	0	0.0	2,489	100.0	2,875	0.2	3	1.9	-234	-0.2	15	285,000	57,000	228,000	2,371,824	-291,534	66,642	-976
Comprehensive cluster	Radiant heaters to electric		-9,295	-1.8	2,041	2.5	0	0.0	12,247	0.9	4	2.1	-422	-0.4	10	90,900	18,180	72,720	2,210,683	-130,393	19,543	-172
Comprehensive cluster	Implement a laser ice leveler		3,344	0.7	1,826	2.2	0	0.0	22,625	1.6	4	2.1	1,068	1.1	15	37,500	0	37,500	2,107,036	-26,747	10,390	35
Comprehensive cluster	Low-flow shower fixtures		0	0.0	725	0.9	0	0.0	7,652	0.5	1	0.8	259	0.3	7	12,000	181	11,819	2,098,720	-18,430	8,438	46
Comprehensive cluster	Low-flow handwashing faucet aerators		0	0.0	1,344	1.6	0	0.0	14,191	1.0	3	1.5	479	0.5	7	5,300	336	4,964	2,083,229	-2,939	1,911	10
Comprehensive cluster	RTUs to ASHP with electric backup		-65,526	-12.8	15,959	19.3	0	0.0	102,952	7.3	29	16.7	-1,956	-1.8	18	525,100	105,020	420,080	2,640,751	-560,641	14,350	-215
Comprehensive cluster	Refrigeration heat recovery and optimization		10,405	2.0	1,194	1.4	0	0.0	23,006	1.6	3	1.5	1,721	1.8	20	602,100	0	602,100	2,673,257	-592,967	235,625	350
Comprehensive cluster	DHW heaters to ASHP		-26,244	-5.1	13,497	16.3	0	0.0	116,238	8.3	25	14.5	1,749	1.8	15	93,000	3,374	89,626	2,189,952	-109,662	3,521	51
Comprehensive cluster	Wall upgrade to high performance		11,350	2.2	10,400	12.6	0	0.0	121,140	8.6	20	11.6	5,214	5.4	75	3,320,800	664,160	2,656,640	2,860,681	-780,391	130,434	510
Comprehensive cluster	Windows and doors to high performance		1,564	0.3	1,754	2.1	0	0.0	20,078	1.4	3	1.9	838	0.9	40	195,600	39,120	156,480	2,162,742	-82,452	45,671	187
Comprehensive cluster	Roof upgrade to high performance		7,044	1.4	6,978	8.4	0	0.0	80,707	5.8	14	7.8	3,266	3.4	20	2,943,900	588,780	2,355,120	4,516,229	-2,435,939	172,513	721
Comprehensive cluster	MUA conversion to ASHP with ERV		-47,056	-9.2	12,863	15.6	0	0.0	88,732	6.3	24	13.5	-855	-0.9	20	493,500	98,700	394,800	2,557,752	-477,662	16,637	-462
Comprehensive cluster	Natural gas stove conversion to electric		-834	-0.2	81	0.1	0	0.0	17	0.0	0	0.1	-54	-0.1	15	12,000	0	12,000	2,096,246	-15,956	88,335	-222
Comprehensive cluster	Space heating boiler conversion to VRF and electric backup		-141,144	-27.6	25,261	30.6	0	0.0	125,527	9.0	45	25.9	-7,360	-7.6	30	346,700	69,340	277,360	2,550,340	-470,051	6,104	-38
Comprehensive cluster	Solar PV rooftop		185,760	36.3	0	0.0	0	0.0	185,760	13.2	4	2.5	20,148	20.7	30	586,300	117,260	469,040	1,976,100	104,190	105,647	23
Control optimization	Combined		55,696	10.9	318	0.4	0	0.0	59,953	4.2	2	1.1	8,167	8.4	-	2,199,400	0	2,199,400	4,141,491	-2,061,201	1,130,565	269
Control optimization	Exterior LED lighting upgrade		1,745	0.3	0	0.0	0	0.0	1,745	0.1	0	0.0	173	0.2	20	3,000	0	3,000	2,078,863	1,427	71,942	17
Control optimization	Interior LED lighting upgrade		43,760	8.5	-2,680	-3.2	0	0.0	15,470	1.1	-4	-2.4	5,652	5.8	20	27,000	0	27,000	2,007,321	72,969	-6,534	5
Control optimization	Implement a laser ice leveler		3,344	0.7	1,826	2.2	0	0.0	22,625	1.6	4	2.1	1,068	1.1	15	37,500	0	37,500	2,107,036	-26,747	10,390	35
Control optimization	Refrigeration heat recovery and optimization		10,405	2.0	1,194	1.4	0	0.0	23,006	1.6	3	1.5	1,721	1.8	20	602,100	0	602,100	2,673,257	-592,967	235,625	350
Control optimization	Natural gas stove renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	5,000	0	5,000	2,086,195	-5,905	-	-
Control optimization	Ice resurfacer renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	120,000	0	120,000	2,222,017	-141,727	-	-
Control optimization	Radiant heaters renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	32,000	0	32,000	2,114,963	-34,673	-	-
Control optimization	Sinks renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10	26,000	0	26,000	2,118,534	-38,244	-	-
Control optimization	Shower renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7	8,000	0	8,000	2,095,031	-14,741	-	-
Control optimization	RTUs renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	72,000	0	72,000	2,158,304	-78,014	-	-
Control optimization	DHW renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	24,000	0	24,000	2,108,635	-28,345	-	-
Control optimization	Exterior walls renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	75	17,000	0	17,000	2,085,795	-5,505	-	-
Control optimization	Roof renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	1,091,000	0	1,091,000	3,214,311	-1,134,022	-	-
Control optimization	Windows and doors renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	45,000	0	45,000	2,107,611	-27,321	-	-
Control optimization	MUA renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	55,000	0	55,000	2,139,884	-59,594	-	-
Control optimization	Boiler renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	30	35,000	0	35,000	2,108,623	-28,333	-	-
Envelope upgrades	Combined		18,418	3.6	18,720	22.6	0	0.0	216,035	15.4	37	20.8	8,928	9.2	-	7,035,300	1,292,060	5,743,240	5,825,385	-3,745,095	156,864	643
Envelope upgrades	Wall upgrade to high performance		11,350	2.2	10,400	12.6	0	0.0	121,140	8.6	20	11.6	5,214	5.4	75	3,320,800	664,160	2,656,640	2,860,681	-780,391	130,434	510
Envelope upgrades	Windows and doors to high performance		1,564	0.3	1,754	2.1	0	0.0	20,078	1.4	3	1.9	838	0.9	40	195,600	39,120	156,480	2,162,742	-82,452	45,671	187
Envelope upgrades	Roof upgrade to high performance		7,044	1.4	6,978	8.4	0	0.0	80,707	5.8	14	7.8	3,266	3.4	20	2,943,900	588,780	2,355,120	4,516,229	-2,435,939	172,513	721
Envelope upgrades	Natural gas stove renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	5,000	0	5,000	2,086,195	-5,905	-	-
Envelope upgrades	Exterior lighting renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	2,000	0	2,000	2,082,369	-2,079	-	-
Envelope upgrades	Interior lighting renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	76,000	0	76,000	2,159,287	-78,997	-	-
Envelope upgrades	Ice resurfacer renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	120,000	0	120,000	2,222,017	-141,727	-	-
Envelope upgrades	Radiant heaters renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	32,000	0	32,000	2,114,963	-34,673	-	-
Envelope upgrades	Sinks renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10	26,000	0	26,000	2,118,534	-38,244	-	-
Envelope upgrades	Shower renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7	8,000	0	8,000	2,095,031	-14,741	-	-
Envelope upgrades	RTUs renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	72,000	0	72,000	2,158,304	-78,014	-	-
Envelope upgrades	Compressor renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	120,000	0	120,000	2,205,022	-124,732	-	-
Envelope upgrades	DHW renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	24,000	0	24,000	2,108,635	-28,345	-	-
Envelope upgrades	MUA renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	55,000	0	55,000	2,139,884	-59,594	-	-
Envelope upgrades	Boiler renewal		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	30	35,000	0	35,000	2,108,623	-28,333	-	-
Load minimization	Combined		73,565	14.4	19,841	24.0	0	0.0	283,017	20.2	40	22.8	17,494	18.0	-	7,490,200	1,292,577	6,197,623	6,138,779	-4,058,489	154,564	354
Load minimization	Exterior LED lighting upgrade		1,745	0.3	0	0.0	0	0.0	1,745	0.1	0	0.0	173	0.2	20	3,000	0	3,000	2,078,863	1,427	71,942	17
Load minimization	Interior LED lighting upgrade		43,760	8.5	-2,680	-3.2	0	0.0	15,470	1.1	-4	-2.4	5,652	5.8	20	27,000	0	27,000	2,007,321	72,969	-6,534	5
Load minimization	Implement a laser ice leveler		3,344	0.7	1,826	2.2	0	0.0	22,625	1.6	4	2.1	1,068	1.1	15	37,500	0	37,500	2,107,036	-26, -		

Utility use comparison

The following figures compare the total expected yearly utility use by end use between each scenario.

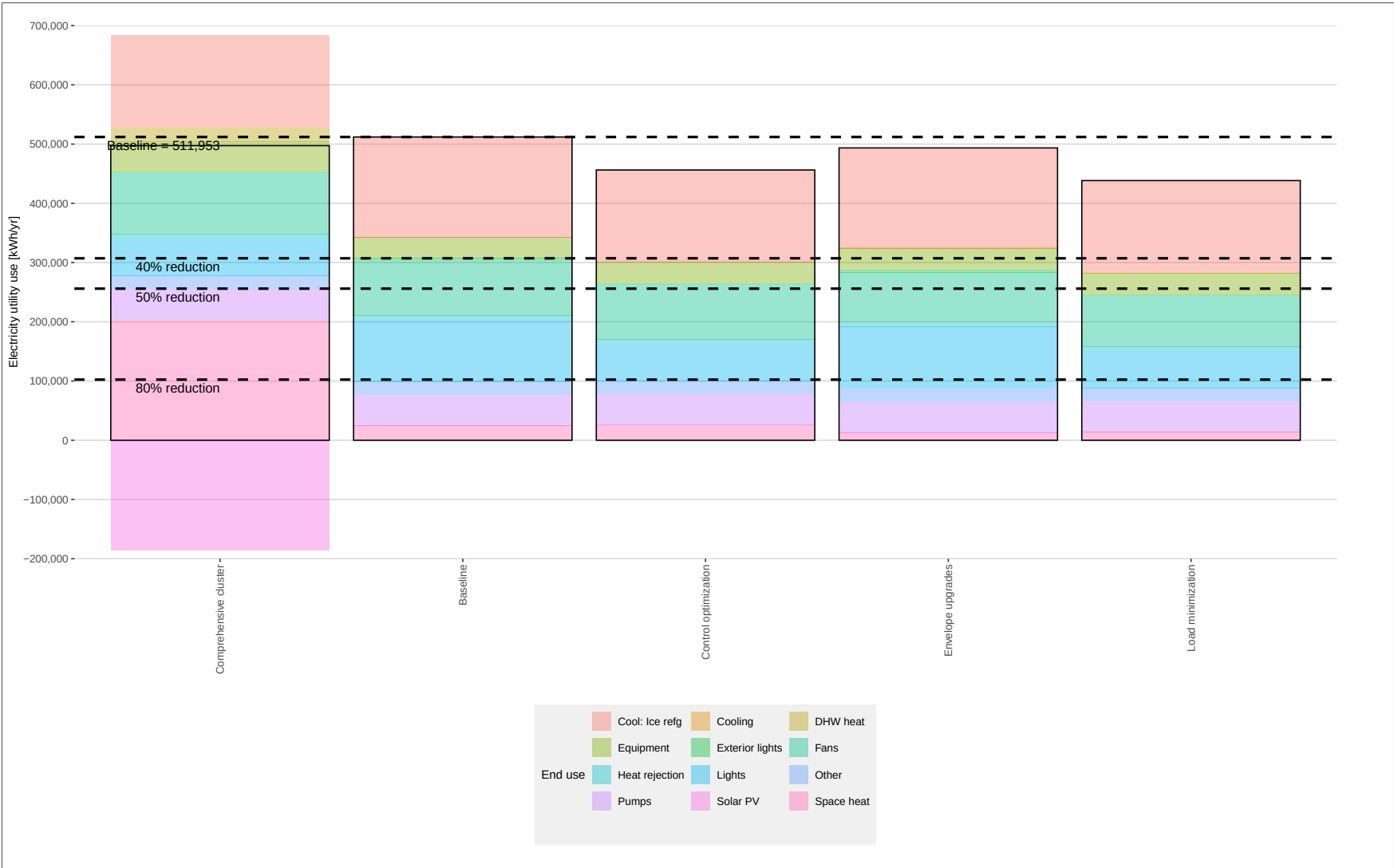


Figure 207: Electricity utility use expected yearly for each scenario by end use

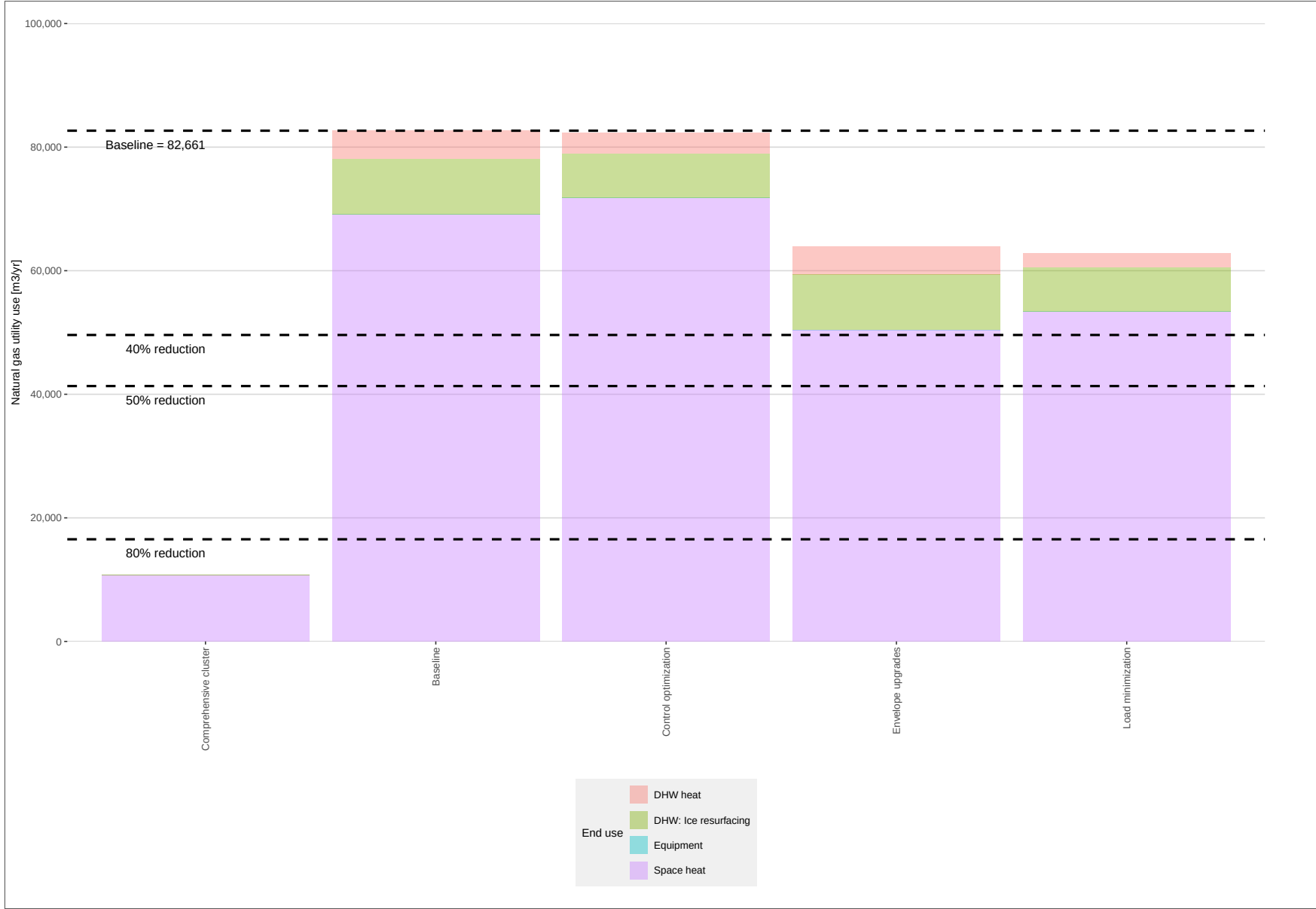


Figure 208: Natural gas utility use expected yearly for each scenario by end use

Energy, GHG and utility cost comparison

The following figures compare the total expected yearly equivalent energy use, GHG emissions and utility costs between each scenario.

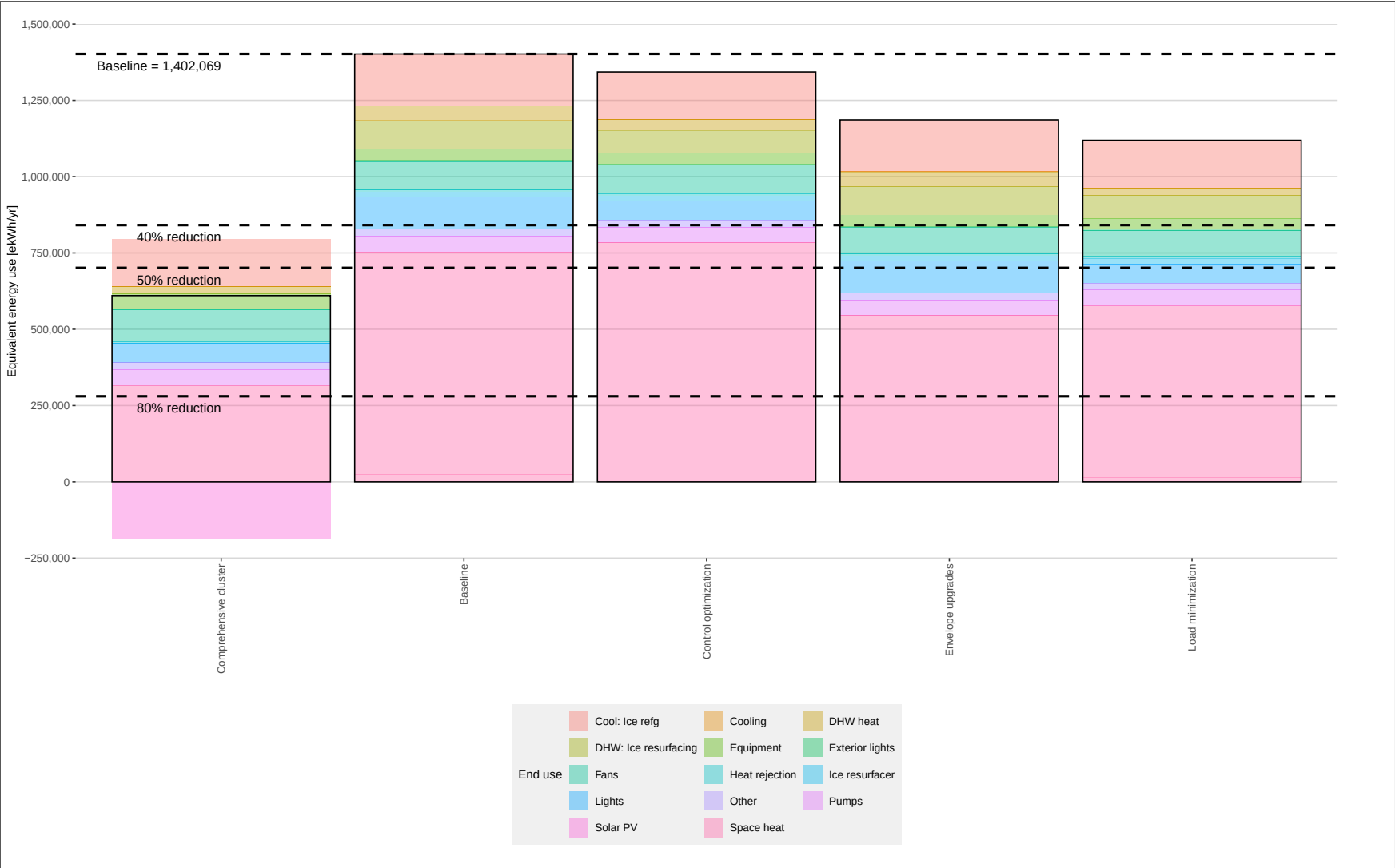


Figure 209: Equivalent energy use expected yearly for each scenario by end use

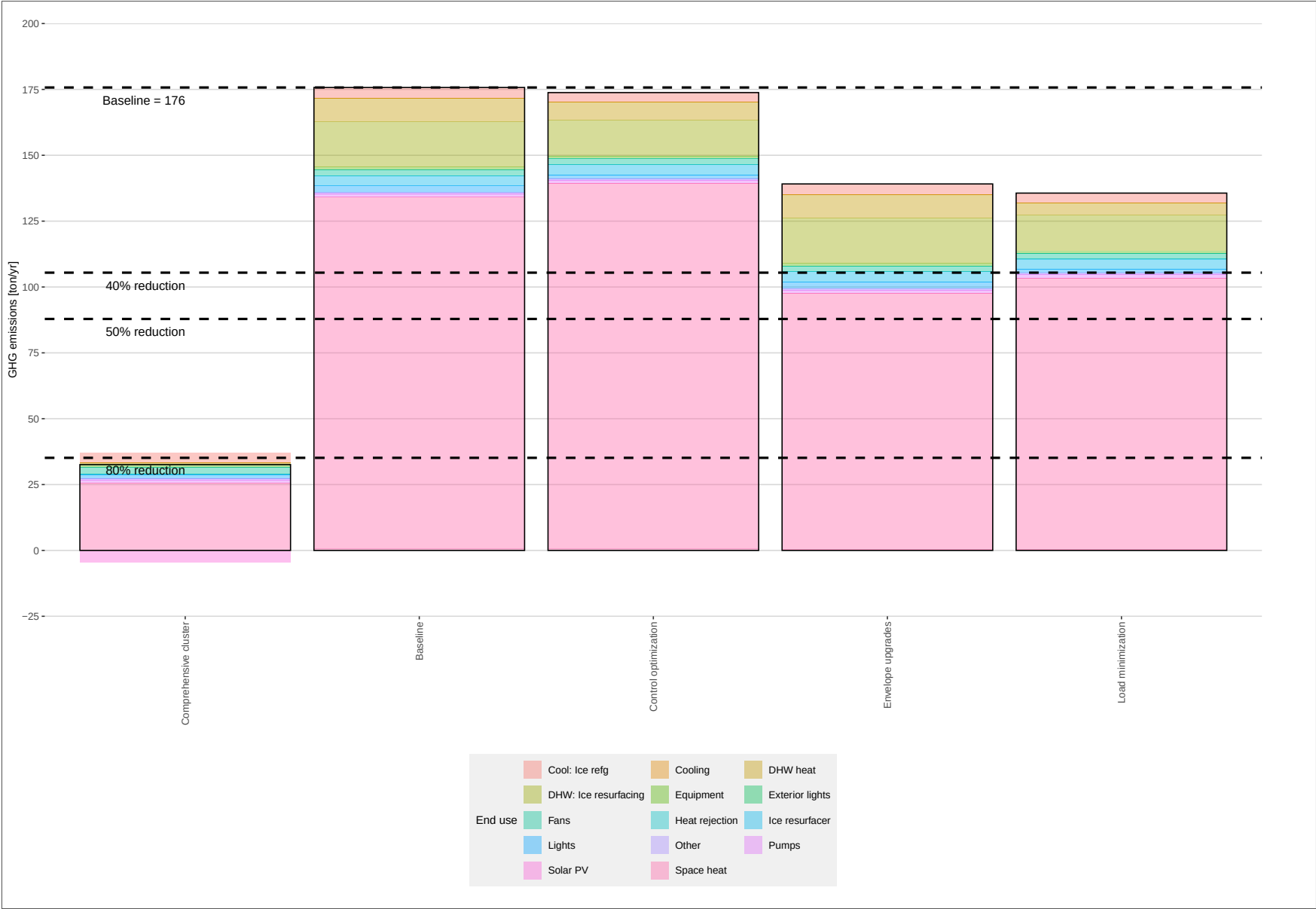


Figure 210: GHG emissions expected yearly for each scenario by end use

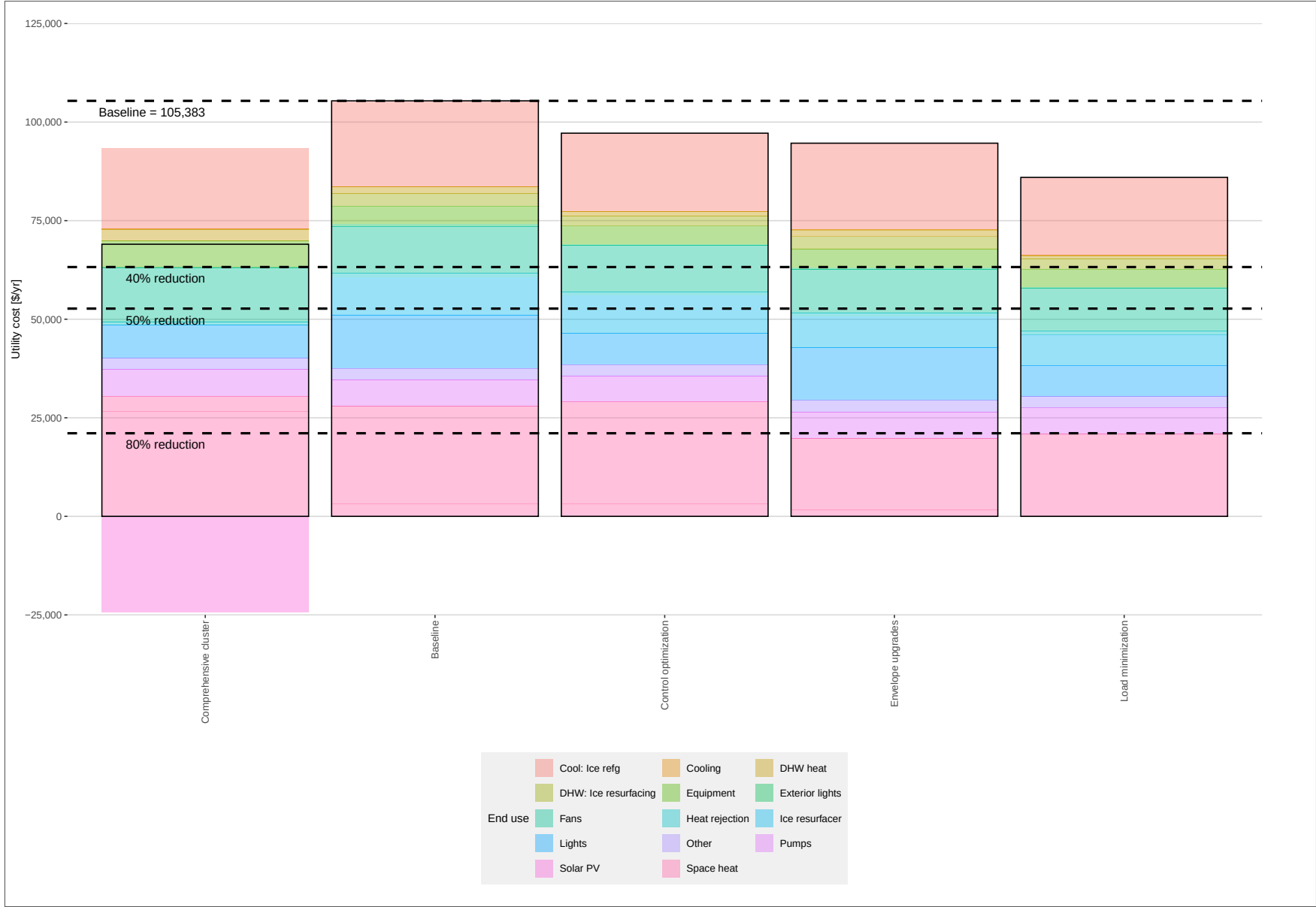


Figure 211: Utility costs expected yearly for each scenario by end use

Financial performance comparison

The following figures compare the financial performance between each scenario.



Figure 212: Project cost expected for each scenario by measure

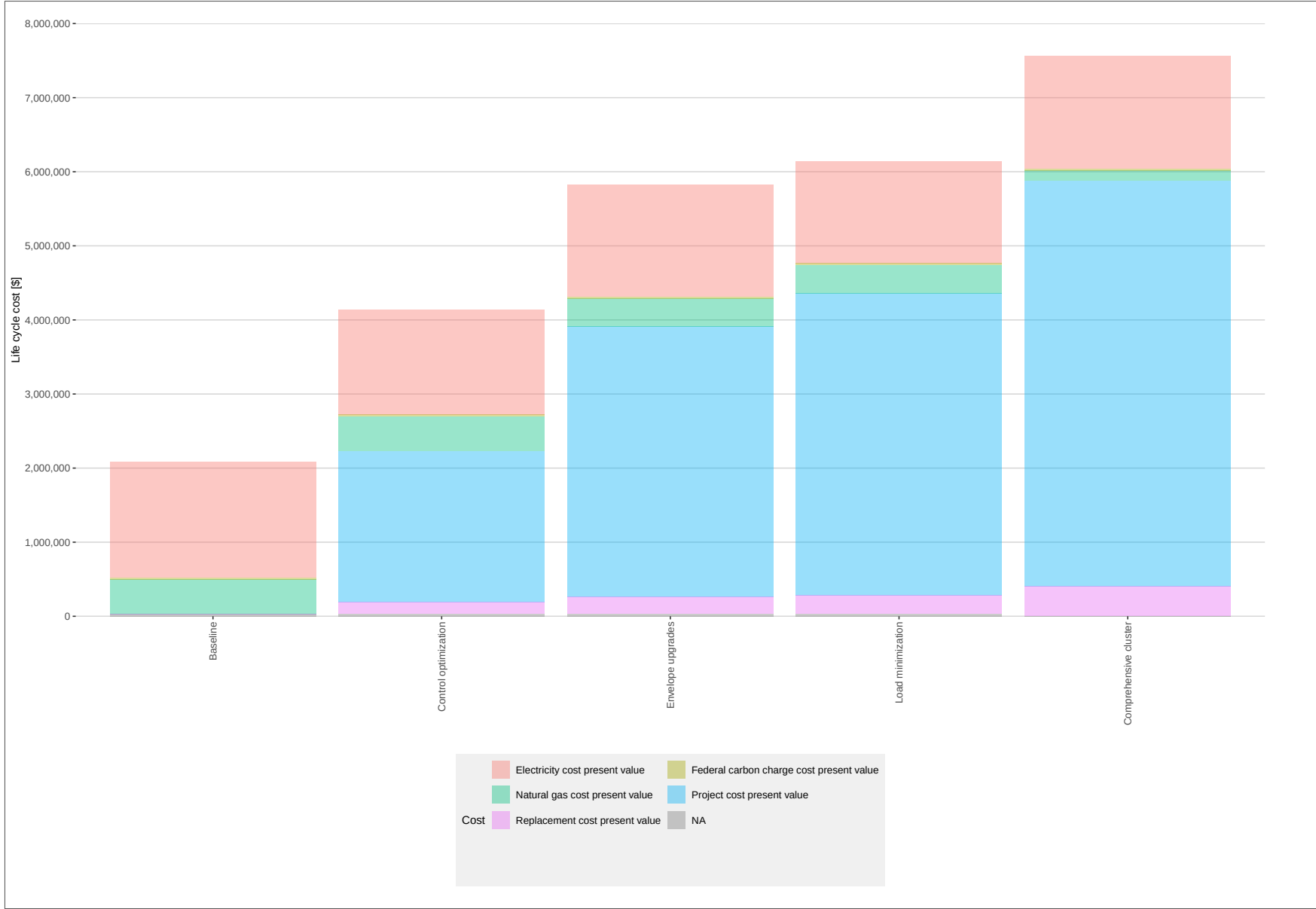


Figure 213: Life cycle cost expected for each scenario by cost item

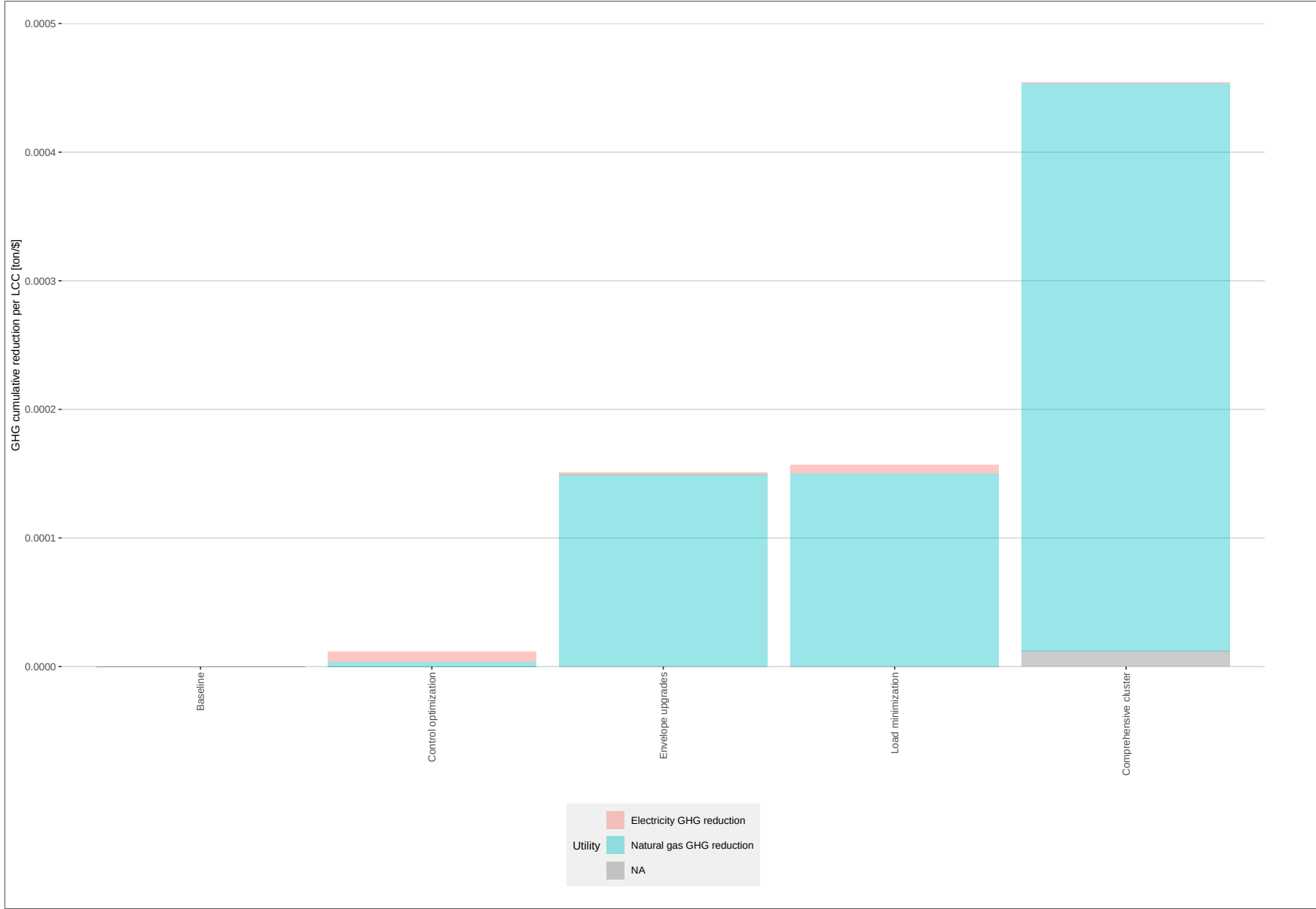


Figure 214: GHG cumulative reduction per life cycle cost (LCC) dollar expected for each scenario by utility

6.5 Plan scenario development

Plan scenario identification and objectives

The plan scenarios that were analyzed and their objectives are summarized in Table 68.

Table 68: Plan scenario identification and objectives

Plan scenario	Objectives
Minimum performance scenario	To achieve a 50% reduction in operational GHG emissions within 10 years and 80% within 20 years. This scenario addresses the minimum performance scenario of FCM's CBR program.
Aggressive deep retrofit	Implement the same measures as in the minimum performance scenario but achieve an 80% reduction in GHG emissions within five years. This scenario addresses the additional scenario requirement of FCM's CBR program.
Comprehensive	To understand the limit of GHG reductions possible by implementing all mutually exclusive measures that have the greatest reduction on GHG emissions and excluding the use of carbon offsets.
Organizational goal alignment	To reduce emissions by 40% GHG emissions from 2019 levels by 2033 and 80% reduction by 2050 of on-site emissions. The remaining 20% is to be addressed through carbon offsets, as noted in the City's Corporate Greenhouse Gas Reduction Plan (GHGRP).
Business as usual	To follow the existing capital renewal plan and replace equipment at the end of its life with like-for-like equipment, meeting minimum energy-efficiency requirements of ASHRAE 90.1.

Plan scenario composition

The plan scenarios were composed with the intent of achieving the objective of each plan scenario, as outlined in Table 68. Results of the plan scenario composition are presented in Figure 215, which is a measure implementation timeline plot indicating which measures were assumed to be implemented in which plan scenarios and when, and the estimated project cost of each measure. The measures are also colour-coded according to measure group. The same information is included in plan performance analysis results figures in Section 6.6 for ease of reference. The plan scenario composition is also presented in Tables 69 to 74.

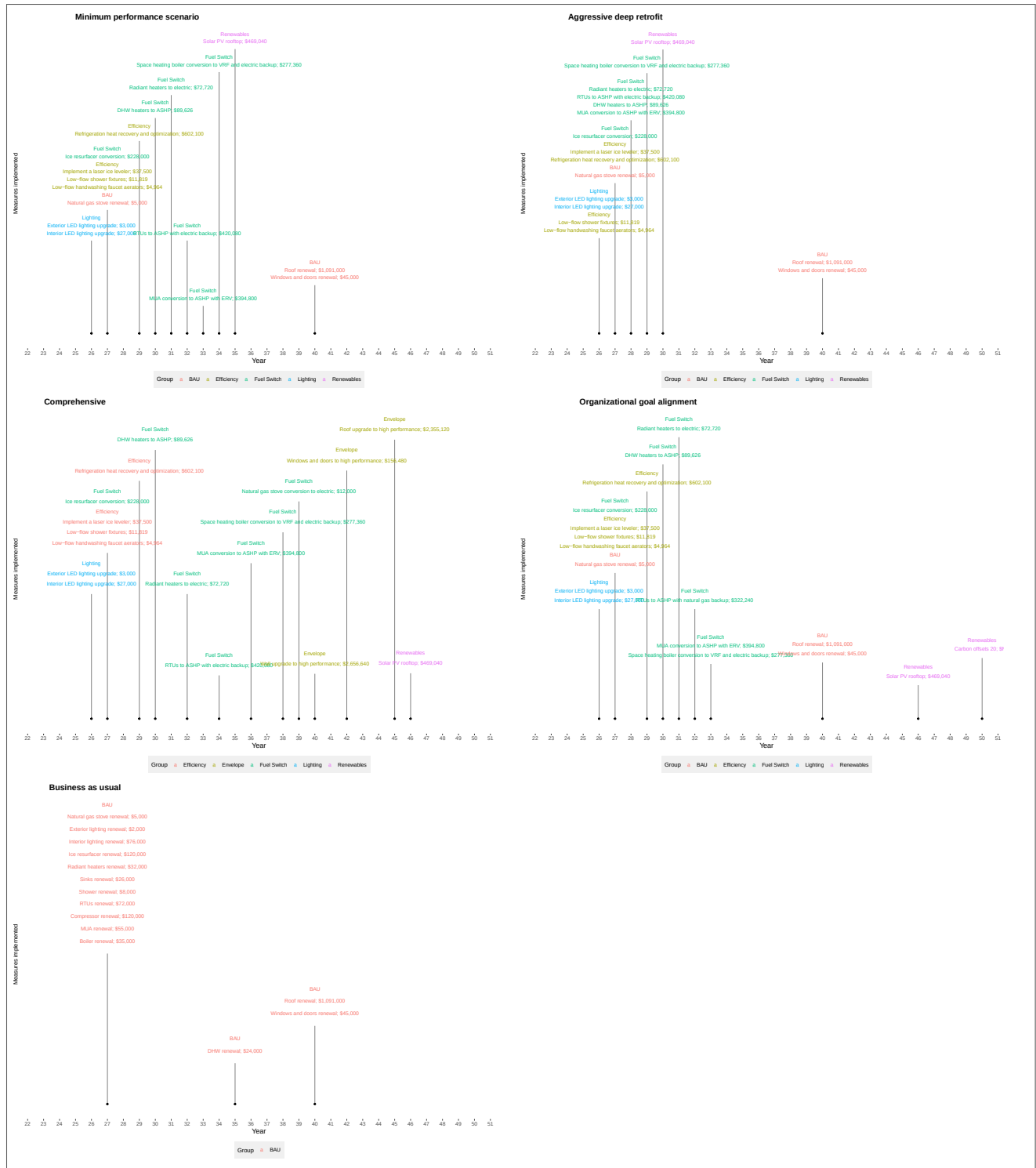


Figure 215: Plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

Table 69: Scenario composition summary

Measure	Minimum performance scenario	Aggressive deep retrofit	Comprehensive	Organizational goal alignment
Carbon offsets 20	✗	✗	✗	✓
Cold water flooding	✗	✗	✗	✗
DHW heaters to ASHP	✓	✓	✓	✓
Exterior LED lighting upgrade	✓	✓	✓	✓
Ice resurfacer conversion	✓	✓	✓	✓
Implement a laser ice leveler	✓	✓	✓	✓
Interior LED lighting upgrade	✓	✓	✓	✓
Low-flow handwashing faucet aerators	✓	✓	✓	✓
Low-flow shower fixtures	✓	✓	✓	✓
MUA conversion to ASHP with ERV	✓	✓	✓	✓
Natural gas stove conversion to electric	✗	✗	✓	✗
Radiant heaters to electric	✓	✓	✓	✓
Refrigeration heat recovery and optimization	✓	✓	✓	✓
Roof upgrade to high performance	✗	✗	✓	✗
RTUs to ASHP with electric backup	✓	✓	✓	✗
RTUs to ASHP with natural gas backup	✗	✗	✗	✓
Solar PV rooftop	✓	✓	✓	✓
Space heating boiler conversion to VRF and electric backup	✓	✓	✓	✓
Wall upgrade to high performance	✗	✗	✓	✗
Windows and doors to high performance	✗	✗	✓	✗
Boiler renewal	✗	✗	✗	✗
Compressor renewal	✗	✗	✗	✗
DHW renewal	✗	✗	✗	✗
Exterior lighting renewal	✗	✗	✗	✗
Exterior walls renewal	✓	✓	✗	✓
Ice resurfacer renewal	✗	✗	✗	✗
Interior lighting renewal	✗	✗	✗	✗
MUA renewal	✗	✗	✗	✗
Natural gas stove renewal	✓	✓	✗	✓
Radiant heaters renewal	✗	✗	✗	✗
Roof renewal	✓	✓	✗	✓
RTUs renewal	✗	✗	✗	✗
Shower renewal	✗	✗	✗	✗
Sinks renewal	✗	✗	✗	✗
Windows and doors renewal	✓	✓	✗	✓

Table 70: Minimum performance scenario measure implementation timeline

Measure	Year
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Ice resurfacers conversion	2027
Implement a laser ice leveler	2027
Low-flow handwashing faucet aerators	2027
Low-flow shower fixtures	2027
Natural gas stove renewal	2027
Refrigeration heat recovery and optimization	2029
DHW heaters to ASHP	2030
Radiant heaters to electric	2031
RTUs to ASHP with electric backup	2032
MUA conversion to ASHP with ERV	2033
Space heating boiler conversion to VRF and electric backup	2034
Solar PV rooftop	2035
Roof renewal	2040
Windows and doors renewal	2040
Exterior walls renewal	2055

Table 71: Aggressive deep retrofit measure implementation timeline

Measure	Year
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Low-flow handwashing faucet aerators	2026
Low-flow shower fixtures	2026
Ice resurfacers conversion	2027
Implement a laser ice leveler	2027
Natural gas stove renewal	2027
Refrigeration heat recovery and optimization	2027
DHW heaters to ASHP	2028
MUA conversion to ASHP with ERV	2028
Radiant heaters to electric	2028
RTUs to ASHP with electric backup	2028
Space heating boiler conversion to VRF and electric backup	2029
Solar PV rooftop	2030
Roof renewal	2040
Windows and doors renewal	2040
Exterior walls renewal	2055

Table 72: Comprehensive measure implementation timeline

Measure	Year
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Ice resurfacer conversion	2027
Implement a laser ice leveler	2027
Low-flow handwashing faucet aerators	2027
Low-flow shower fixtures	2027
Refrigeration heat recovery and optimization	2029
DHW heaters to ASHP	2030
Radiant heaters to electric	2032
RTUs to ASHP with electric backup	2034
MUA conversion to ASHP with ERV	2036
Space heating boiler conversion to VRF and electric backup	2038
Natural gas stove conversion to electric	2039
Wall upgrade to high performance	2040
Windows and doors to high performance	2042
Roof upgrade to high performance	2045
Solar PV rooftop	2046

Table 73: Organizational goal alignment measure implementation timeline

Measure	Year
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Ice resurfacer conversion	2027
Implement a laser ice leveler	2027
Low-flow handwashing faucet aerators	2027
Low-flow shower fixtures	2027
Natural gas stove renewal	2027
Refrigeration heat recovery and optimization	2029
DHW heaters to ASHP	2030
Radiant heaters to electric	2031
RTUs to ASHP with natural gas backup	2032
MUA conversion to ASHP with ERV	2033
Space heating boiler conversion to VRF and electric backup	2033
Roof renewal	2040
Windows and doors renewal	2040
Solar PV rooftop	2046
Carbon offsets 20	2050
Exterior walls renewal	2055

Table 74: Business as usual measure implementation timeline

Measure	Year
Boiler renewal	2027
Compressor renewal	2027
Exterior lighting renewal	2027
Ice resurfacer renewal	2027
Interior lighting renewal	2027
MUA renewal	2027
Natural gas stove renewal	2027
Radiant heaters renewal	2027
RTUs renewal	2027
Shower renewal	2027
Sinks renewal	2027
DHW renewal	2035
Roof renewal	2040
Windows and doors renewal	2040
Exterior walls renewal	2055

6.6 Plan performance analysis

Figures 216 through 219 present the projected yearly electricity use, natural gas use, GHG emissions and life cycle costs associated with each plan scenario.



Figure 216: Electricity yearly utility use projection for each scenario



Figure 217: Natural gas yearly utility use projection for each scenario

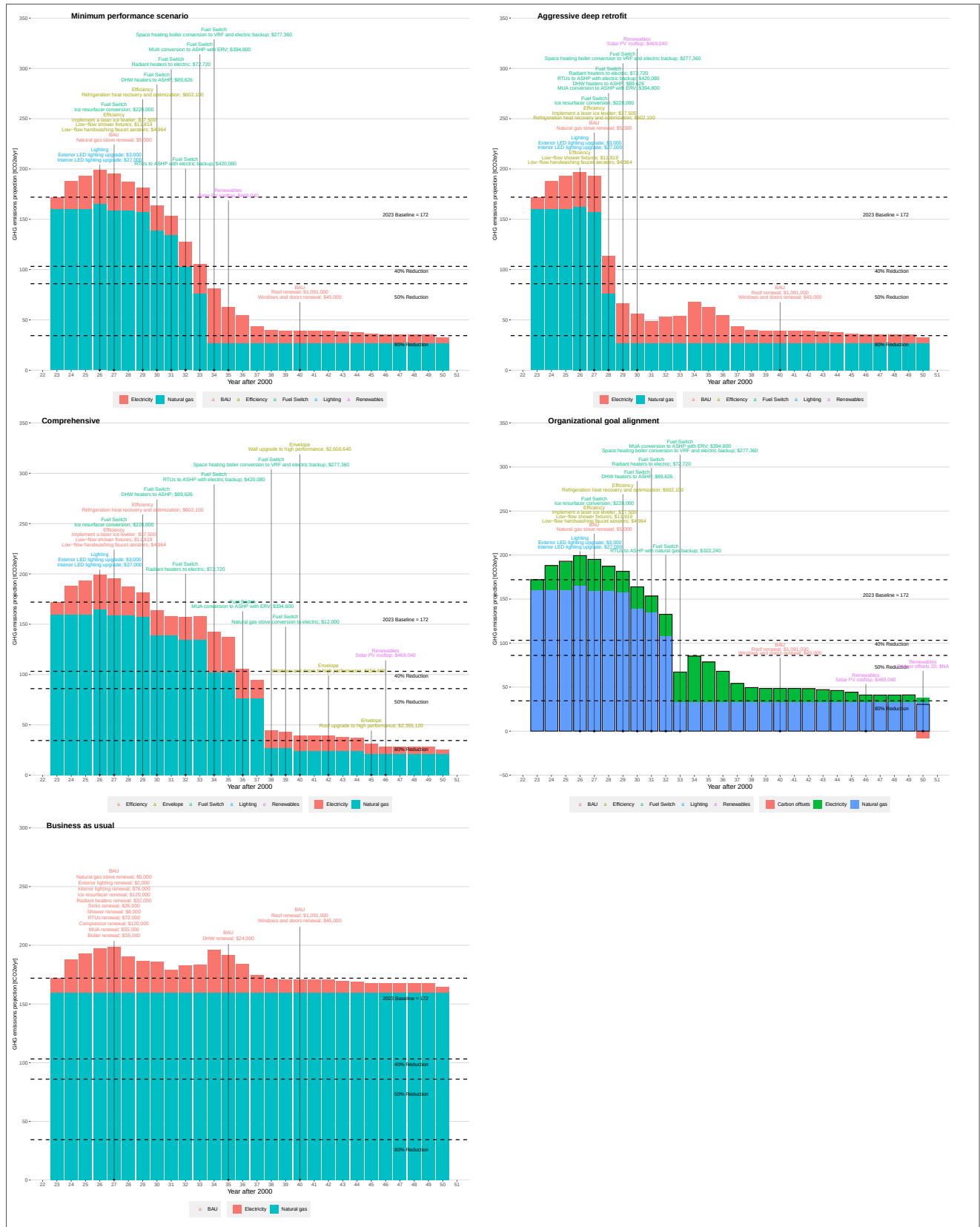


Figure 218: GHG yearly emissions projection for each scenario

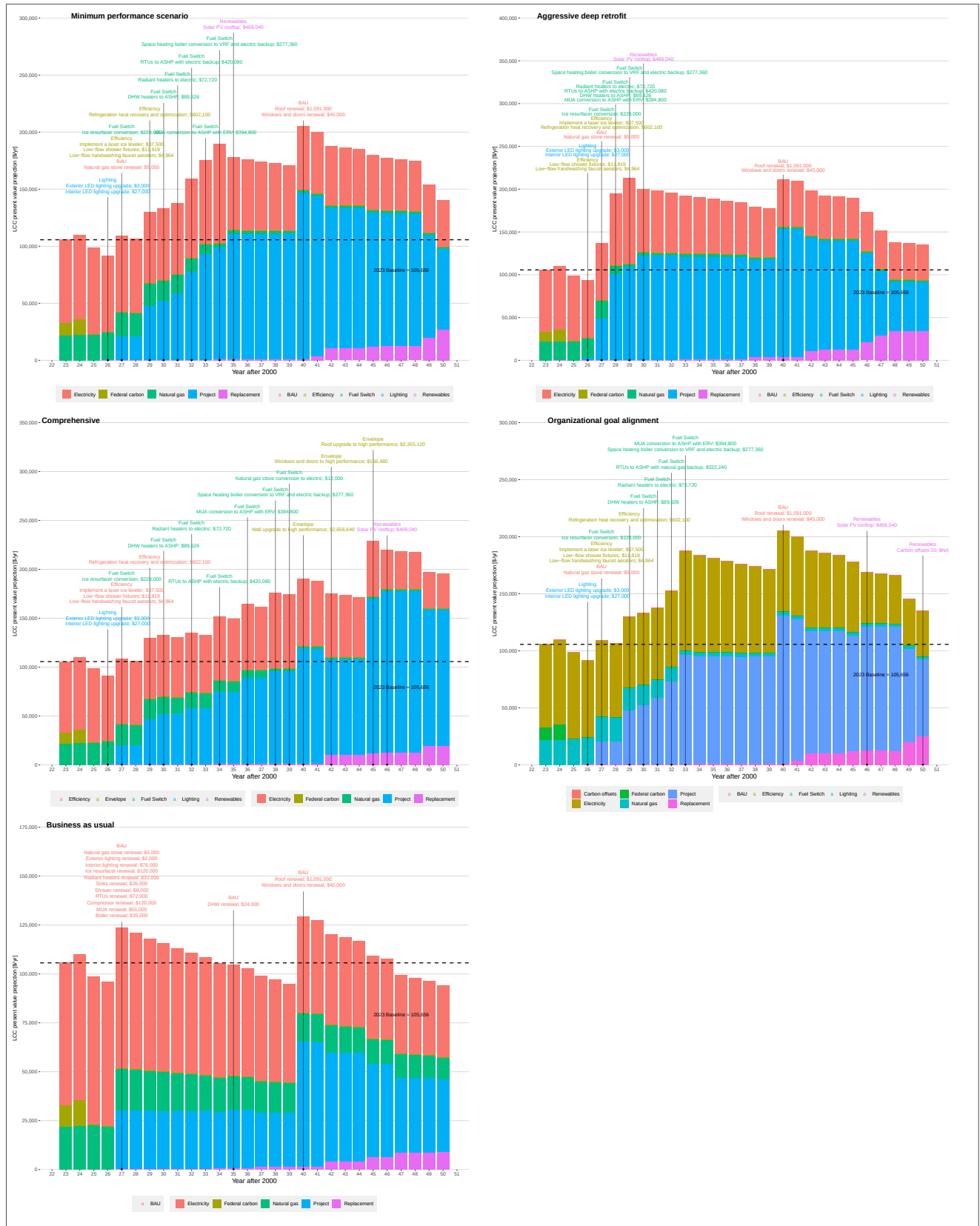


Figure 219: Life cycle yearly cost (after discounting to present value) projection for each scenario

6.7 Plan performance summary

Plan performance summary

Table 75 summarizes the performance of each plan scenario with respect to utility use, GHG emissions, utility cost, and financial metrics. The first half of Table 75 represents the estimated performance in the final year (2050) of the evaluation period. The second half of Table 75 represents the estimated cumulative performance across the entire evaluation period (present to 2050). All final year dollar values are in the value of today's currency. All cumulative dollar values presented in Table 75 are calculated as the simple sum of expenditures over the evaluation period, except for the life cycle cost, which is discounted to present value (as illustrated in Figure 219).

Table 75: Plan performance summary

Section	Description	Unit	Minimum performance scenario	Aggressive deep retrofit	Comprehensive	Organizational goal alignment	Business as usual
Utility use final	Electricity use	[kWh/yr]	576,772	576,772	497,391	555,249	511,953
	Electricity monthly peak (av)	[kW]	124	124	109	121	105
	Electricity yearly peak (max)	[kW]	181	181	155	165	125
	Natural gas use	[m3/yr]	13,986	13,986	10,705	16,908	82,661
GHG emissions final	Electricity GHGs	[tCO2e/yr]	5.5	5.5	4.7	5.3	4.9
	Natural gas GHGs	[tCO2e/yr]	27	27	21	33	160
	Carbon offsets GHGs	[tCO2e/yr]	0.0	0.0	0.0	-7.6	0.0
	Total GHGs	[tCO2e/yr]	33	33	25	30	168
Utility cost final	Electricity utility cost	[\$/yr]	140,617	140,617	121,264	135,370	124,814
	Natural gas utility cost	[\$/yr]	6,330	6,330	4,845	7,653	37,412
	Carbon offsets utility cost	[\$/yr]	0	0	0	471	0
	Federal carbon charge	[\$/yr]	0.00	0.00	0.00	0.00	0.00
	Total utility cost	[\$/yr]	146,947	146,947	126,109	143,493	164,825
Utility use cumulative	Electricity use	[kWh]	15,606,031	15,967,855	16,086,604	17,383,067	14,334,680
	Natural gas use	[m3]	1,050,394	760,345	1,200,407	1,080,482	2,314,498
GHG emissions cumulative	Electricity GHGs	[tCO2e]	563	579	562	614	525
	Natural gas GHGs	[tCO2e]	2,030	1,469	2,320	2,088	4,472
	Carbon offsets GHGs	[tCO2e]	0.0	0.0	0.0	-7.6	0.0
	Total GHGs	[tCO2e]	2,608	2,063	2,897	2,709	5,103
Utility cost cumulative	Electricity utility cost	[\$]	2,972,830	3,027,774	3,069,712	3,323,267	2,709,459
	Natural gas utility cost	[\$]	328,273	239,593	375,939	341,203	812,100
	Carbon offsets utility cost	[\$]	0	0	0	471	0
	Federal carbon charge	[\$]	23,708	23,708	23,708	23,708	23,708
	Total utility cost	[\$]	3,331,088	3,297,352	3,475,636	3,694,926	3,601,688
Financial cumulative	Project cost	[\$]	5,085,440	4,843,013	12,954,793	5,110,770	2,131,423
	Replacement cost	[\$]	1,334,328	1,736,507	901,334	1,234,005	431,551
	Life cycle cost	[\$]	4,392,473	4,780,129	4,443,067	4,357,038	3,075,092

6.8 Scenario analysis discussion

Baseline

- This scenario reflects existing conditions.

Minimum performance scenario

- To meet the FCM minimum performance scenario, significant capital retrofits would be required. Heating system electrification would be required.

Aggressive deep retrofit

- For the aggressive deep retrofit, the same measures as the minimum performance scenario need to be implemented, but on a shorter timeframe.

Organizational goal alignment

- To achieve the organizational goal alignment of 80% reduction in GHG emissions without carbon offsets, the heating systems must be electrified, although natural gas can be used as a backup heating source.

Comprehensive

- The comprehensive scenario demonstrates the upper limit of energy-efficiency that the Shelley Herbert-Shea Memorial Arena could achieve, based on the measures that were analyzed under this Pathway to Decarbonization Feasibility Study.

7 END