PATHWAY TO DECARBONIZATION FEASIBILITY STUDY

CITY OF TEMISKAMING SHORES

HAILEYBURY FIRE HALL
54 Rorke Avenue, Haileybury, ON

WalterFedy Project No: 2023-0734-11

July 21, 2025

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Project Number: 2023-0734-11

July 21, 2025

Mathew Bahm
Director of Recreation
City of Temiskaming Shores
325 Farr Drive
Haileybury, ON P0J 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 Haileybury Fire Hall, which is located at 54 Rorke 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

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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 Haileybury Fire Hall. The objective of this engagement is to identify and analyze measures that reduce utility use, GHG emissions, and utility costs at the Haileybury Fire Hall, 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 2024-04-15 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 Haileybury Fire Hall. 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 Haileybury Fire Hall 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.

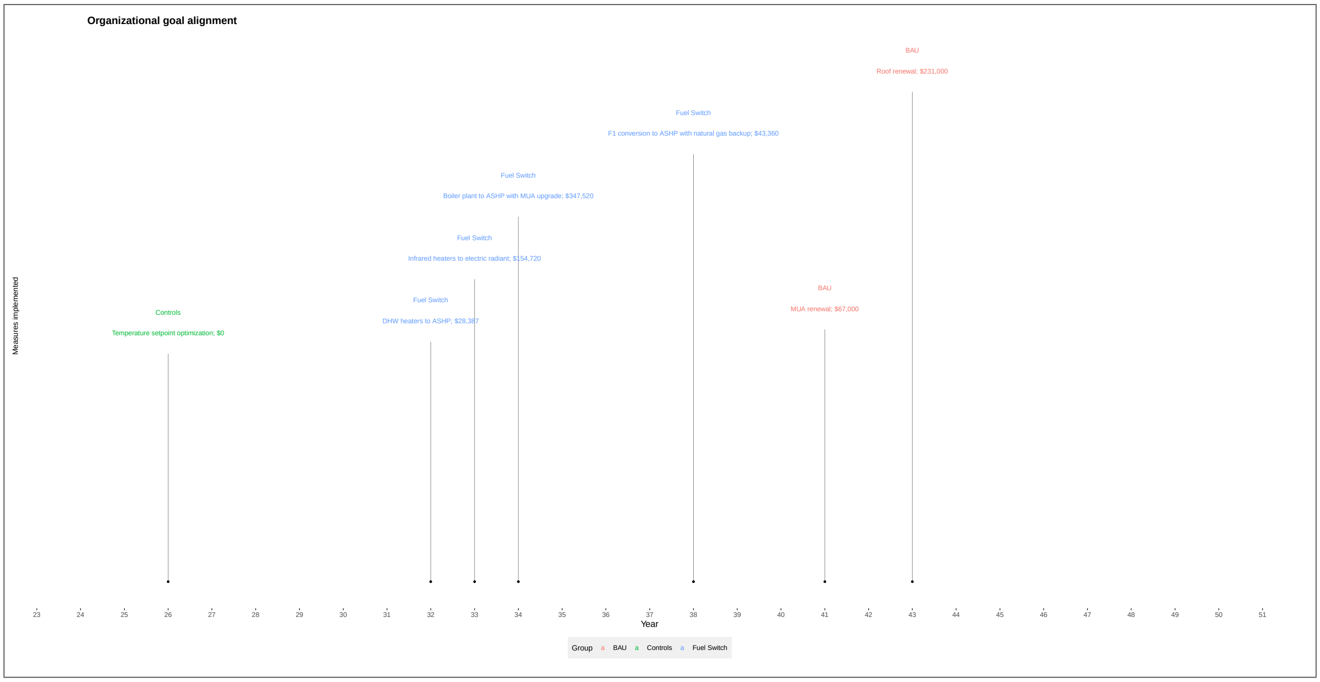


Figure 1: Recommended plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

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

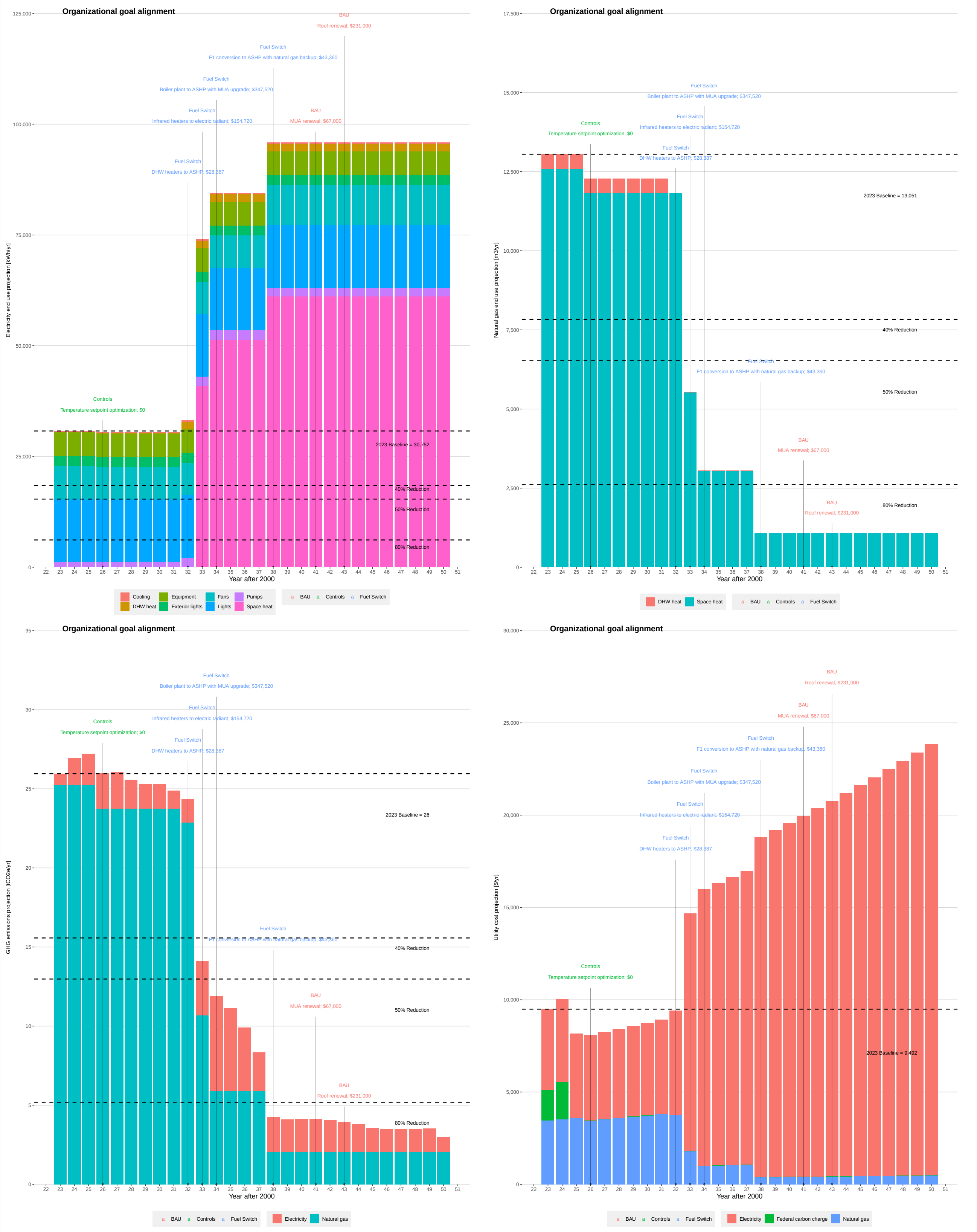


Figure 2: Recommended scenario performance

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]	99,629	99,629	6,845	**95,898**	30,752
	Electricity monthly peak (av)	[kW]	42.4	42.4	37.4	**40.0**	6.9
	Electricity yearly peak (max)	[kW]	61.7	61.7	58.7	**56.0**	7.4
	Natural gas use	[m3/yr]	575	575	414	**1,072**	13,051
GHG emissions final	Electricity GHGs	[tCO2e/yr]	0.95	0.95	0.07	**0.91**	0.29
	Natural gas GHGs	[tCO2e/yr]	1.1	1.1	0.8	**2.1**	25.2
	Carbon offsets GHGs	[tCO2e/yr]	0.00	0.00	0.00	**0.00**	0.00
	Total GHGs	[tCO2e/yr]	2.1	2.1	0.9	**3.0**	25.5
Utility cost final	Electricity utility cost	[$/yr]	24,290	24,290	1,669	**23,380**	7,497
	Natural gas utility cost	[$/yr]	260	260	187	**485**	5,907
	Carbon offsets utility cost	[$/yr]	0.00	0.00	0.00	**0.00**	0.00
	Federal carbon charge	[$/yr]	0.00	0.00	0.00	**0.00**	0.00
	Total utility cost	[$/yr]	24,550	24,550	1,856	**23,865**	13,405
Utility use cumulative	Electricity use	[kWh]	2,015,366	2,457,785	1,530,712	**1,966,860**	861,069
	Natural gas use	[m3]	149,869	74,000	148,490	**156,329**	365,440
GHG emissions cumulative	Electricity GHGs	[tCO2e]	60.7	82.9	53.6	**59.9**	31.6
	Natural gas GHGs	[tCO2e]	290	143	287	**302**	706
	Carbon offsets GHGs	[tCO2e]	0.00	0.00	0.00	**0.00**	0.00
	Total GHGs	[tCO2e]	350	226	341	**362**	738
Utility cost cumulative	Electricity utility cost	[$]	404,138	478,023	291,896	**393,608**	162,754
	Natural gas utility cost	[$]	45,082	21,584	44,504	**47,685**	128,224
	Carbon offsets utility cost	[$]	0.00	0.00	0.00	**0.00**	0.00
	Federal carbon charge	[$]	3,657	3,657	3,657	**3,657**	3,657
	Total utility cost	[$]	452,876	503,263	340,057	**444,950**	294,635
Financial cumulative	Project cost	[$]	1,302,581	1,192,576	4,598,566	**1,270,500**	458,994
	Replacement cost	[$]	523,869	518,613	523,869	**523,869**	0
	Life cycle cost	[$]	795,433	1,038,268	948,694	**780,491**	263,103

1 INTRODUCTION

1.1 Overview

WalterFedy was engaged by the City of Temiskaming Shores to complete a Pathway to Decarbonization Feasibility Study for the Haileybury Fire Hall. 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 Haileybury Fire Hall 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 Haileybury Fire Hall represented 0 tCO2e in 2019, or 0% 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 Haileybury Fire Hall.

Table 2: Asset management summary for this facility

Group	Metric	Unit	Value
Financial	Content Value Estimated	[$]	804,816
	Building Land Tank	[$]	3,032,640
	Replacement Cost	[$]	3,837,456
Information	Install Date	[yr]	2023
	Age	[yrs]	2
Condition Rating	Structure Condition Score	[-]	5
	Final Condition Score	[-]	5
Risk	Probability of Failure	[-]	1
	Consequence of Failure	[-]	5
	Risk Score	[-]	1.8

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 2024-04-15 to review the energy systems applicable to the desired retrofit scenario.

2.2 Facility overview

An overview of the Haileybury Fire Hall is provided in Table 4.

Table 4: Facility overview

Description	Unit	Value
Name	[-]	Haileybury Fire Hall
Address	[-]	54 Rorke Avenue
Location	[-]	Haileybury, ON
Type	[-]	Fire station
Construction year	[-]	2023
Gross floor area	[m2]	790
Gross floor area	[ft2]	8,500

An aerial view of the Haileybury Fire Hall is provided in Figure 3.

Figure 3: Haileybury Fire Hall aerial view

2.3 Building information

Renovations

There have been no renovations to this building.

Additions

There have been no additions to this building.

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
- Parking lot pole lighting
- Natural gas-fired generator

Utility bill responsibility

Utility bill responsibility is as follows:

- Natural gas meter: the City
- Electricity meter: 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: None
- 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:

- IFP and as-built drawings for civil, architectural, structural, mechanical, and electrical.
- Operation and Maintenance Manual.
- History Docket (includes shop drawings).

2.4 Space use

Type summary

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

- SCGA room
- Washrooms with showers
- Washroom
- Maintenance room
- Locker room
- Apparatus bay
- Meeting room
- Electrical/Mechanical room
- Lunchroom
- Offices
- Multipurpose room
- Storage

All spaces are being used as originally intended.

Occupancy scheduling

The facility operation hours are as follows:

- Staff attend site as required, and there are no fixed schedules.

Based on the as-built drawings, it is assumed that this building has a peak occupancy of 65 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]	-	-
Apparatus bay	492	MUA1	Site survey.
Main building	313	F1	Site survey.
Mezzanine and south side	805	Baseboards and in floor heating served by B1	Site survey.

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.

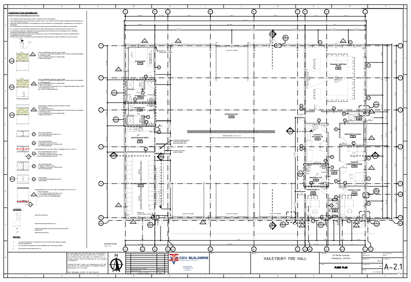


Figure 4: 21 A-2.1-FLOOR PLAN

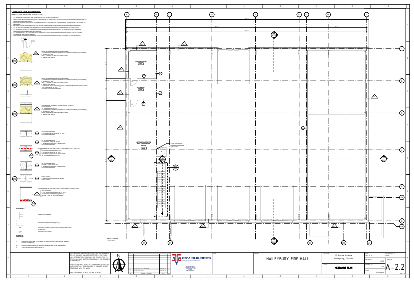


Figure 5: 21 A-2.2-MEZZANINE PLAN

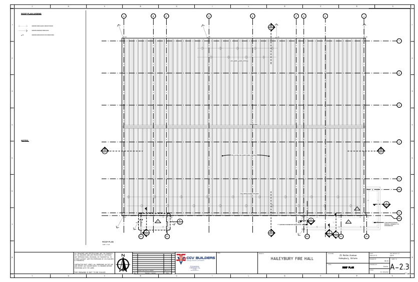


Figure 6: 21 A-2.3-ROOF PLAN

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]
888	850	750	16.4	83.8

Overview

The original architectural drawings were available and provided details on the assemblies.

Roof

R1 had the following composition:

- Metal roof panel system
- 12 inches unfaced blanket insulation
- R1 is assumed to have a U-Value of 0.137 W/m2K

Opaque Walls (above ground)

There were a total of three notable wall assembly types identified. W1 has the following composition (exterior to interior layer):

- 26 gauge stormseal pre-finished wall panel
- 2 layers of 3 inches semi-rigid mineral batt insulation
- 6 inch stand off zee
- 26 gauge linerseal pre-finished liner panel
- 8 inch metal zee girts

W2:

- 26 gauge stormseal pre-finished wall panel
- 2 layers of 3 inches semi-rigid mineral batt insulation
- 6 inch stand off zee
- 26 gauge linerseal pre-finished liner panel
- 8 inch metal zee girts
- 3-5/8 inches 20 gauge metal studs at 16 inches OC
- 7/8 inch furring
- 5/8 inch gypsum board

W3:

- Stone brick veneer
- 5/8 inch plywood
- 7/8 inch furring

- 2 layers of 3 inches semi-rigid mineral batt insulation
- 6 inch stand off zee
- 26 gauge linerseal pre-finished liner panel
- 8 inch metal zee girts

The overall U-Values for these assemblies are assumed to be:

- W1: 0.26 W/m2K
- W2: 0.239 W/m2K
- W3: 0.234 W/m2K

Fenestration

Windows

- The facility has aluminium framed, double pane, 6mm clear, low-e, and argon filled windows.
- Windows are in excellent condition
- The overall U-Value is assumed to be 2.75 W/m2K for the window system with a SHGC of 0.35.

Doors

- The facility has swing doors with glazing, hollow metal doors, and overhead doors. The overhead doors utilize polycarbonate panelling with a U-Value of 2.271 W/m2K. The swing doors have similar specs to the windows.

The overall fenestration-to-wall ratio is estimated to be 12%.

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 0.25 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 7: Hollow metal door with glazing

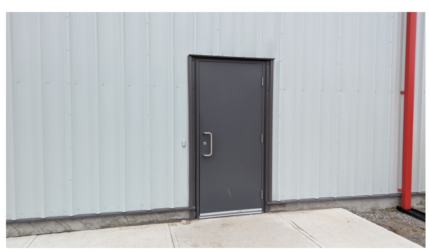


Figure 8: Hollow metal door

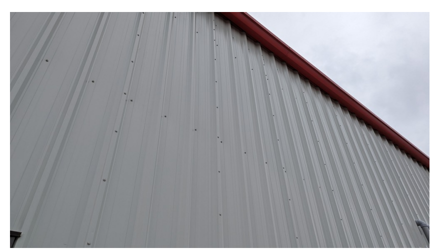


Figure 9: Metal siding


Figure 10: Overhead door at the rear


Figure 11: Overhead doors at the front

Figure 12: Swing door with glazing


Figure 13: Window frame beginning to rust


Figure 14: Window

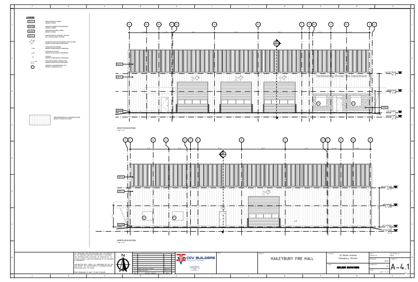


Figure 15: 21 A-4.1-BUILDING ELEVATIONS

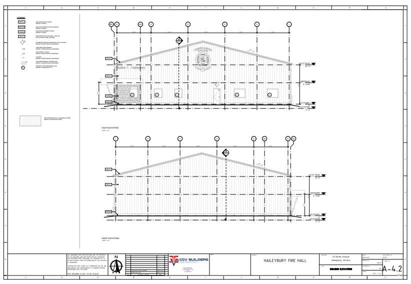


Figure 16: 21 A-4.2-BUILDING ELEVATIONS

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	Captive Aire Systems	A2-D.500-20D	Apparatus bay	3,645	2.00	Nameplate.
F1	Rheem	U96VA0852521 MSB	East section of the building	1,850	0.75	Drawings.
HRV2	Fantech	ATMO	Rooms 111-114, 201	216	0.15	Assumption.
HRV1	Fantech	HERO	F1	280	0.28	Assumption.
EF1a	-	SB#-3H24-7	Apparatus bay	4,050	0.75	Drawings.

Table 8: Water distribution systems summary

Tag	Serves	Flow	Head	Motor output	Data source
-	-	[gpm]	[ft]	[hp]	-
BP1	B1	-	-	0.24	Nameplate.
CP1	In-floor heating	-	-	0.12	Nameplate.
CP2	Baseboard heating	-	-	0.08	Nameplate.

Table 9: Heating systems summary

Tag	Serves	Utility	Efficiency	Output	Data source
-	-	-	[decimal]	[btuh]	-
MUA1_HEAT	MUA1	Natural gas	0.80	335,431	Drawings.
IH1	Apparatus bay - south	Natural gas	0.60	90,000	Drawings.
IH2	Apparatus bay - north	Natural gas	0.60	90,000	Drawings.
B1	-	Natural gas	0.91	160,000	Drawings.
WH1	Domestic hot water	Natural gas	0.95	34,200	Drawings.
WH2	Domestic hot water	Natural gas	0.95	34,200	Drawings.
F1_HEAT	East section of the building	Natural gas	0.98	82,000	Drawings.

Table 10: Cooling systems summary

Tag	Serves	Efficiency	Output	Data source
-	-	[decimal]	[ton]	-
AC1	F1	4.7	4	Nameplate.

System type

The facility utilizes one make-up air unit (MUA1) and a residential-style furnace (F1) complete with DX cooling (AC1). Two heat recovery units (HRV1 and HRV2) provide fresh air to all spaces excluding the apparatus bay. A summary of this system is as follows:

- F1 contains a condensing, natural gas-fired burner complete with a DX coil. The DX coil is connected to AC1 on the exterior.
- HRV1 is connected to F1 and performs heat recovery with exhaust air.
- MUA1 is serves the apparatus bay and has a natural gas-fired burner. It is interlocked with EF1a, which is mounted on the south elevation. The as-built drawing (specifies Greenheck) does not match the unit at the site (Captive Aire).
- HRV2 serves fresh air to the south section of the building on the first floor and the mezzanine. A duct heater was noted in the drawings, however, it was not installed.
- HRV2 is a heat recovery unit serving fresh air to the locker room (111), maintenance work room (112), shower washrooms (113 and 114), and storage (201). Exhaust air is collected from rooms 111, 113, and 114 only. A duct heater was noted in the drawings, however, it was not installed.
- The drawings indicate that there are to be fume extractors (FE1 and FE2). However, these units were not present during the site survey.

Central Plant

- There is one condensing boiler that serves in-floor heating (rooms 111-115) and baseboards (201 and 202).

Distribution system

A total of 3 pumps circulate hot water to baseboards on the mezzanine, and in-floor heating on the south side of the building. They serve the following:

- BP1 serves the primary loop for B1. Flow rates and head information were not readily available.
- CP1 serves the radiant manifold containing the six circuits for in-floor heating on the first floor. The in-floor heating is located in rooms 111-115.
- CP2 serves the baseboards in the utility room and the storage room on the mezzanine floor. The drawings indicate that it is to be connected to a reheat coil, but this change was not identified in the as-built drawings.

The air distribution on the north portion of the building is a single-duct supply with plenum return.

Controls

There is no building automation system at this building.

B1

- B1 is set to 140F. It's assumed that it is a fixed temperature setpoint as there appears to be no outdoor temperature sensor installed.
- The thermostat that controls the in-floor heating loop is located in room 112. It had a setpoint of 23C. No schedule is implemented.
- There is a second thermostat that controls the radiant baseboards located in room 201. It had a temperature setpoint of 20C. No schedule is implemented.
- CP1, CP2, and BP1 are assumed to be controlled by B1.
- It's assumed that the boiler is manually turned off during the cooling season.

MUA1 and EF1a

- MUA1 and EF1A operate based on readings from the CO/NO2 gas detection system, gas detection system override (i.e., manual switch), or temperature setpoint.
- The temperature setpoint is 71F.
- The CO and NO2 detectors are mounted on the north wall of the apparatus bay.

HRV1

- It is controlled by a programmable touchscreen in the corridor. It was set to ECO mode (i.e., auto).
- There is an additional timer button in the kitchen that sets the system to full speed for a short duration.

HRV2

- It is controlled by a programmable touchscreen in room 112. It was set to ECO mode (i.e., auto).
- There is an additional timer button in the washrooms that sets the system to full speed for a short duration.

F1

- F1 is controlled by a smart thermostat located in the corridor. The fan was set to AUTO and temperature setpoints were 06:00-18:00 at 18C, 18:00 to 22:00 at 21C, and 22:00 to 06:00 at 17C. These setpoints were for a typical day.

IH1 and IH2

- IH1 and IH2 are sixty-foot infrared heaters that are controlled by non-programmable thermostats. IH1 has a setpoint of approximately 21C, and IH2 has a setpoint of 20C.

HVAC system documentation

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

Figure 17: AC1

Figure 18: B1

Figure 19: BP1 - boiler pump

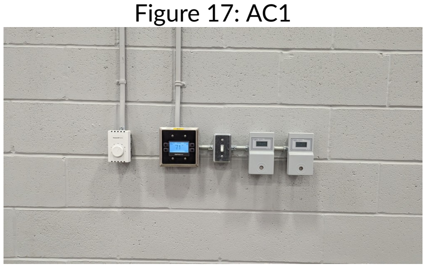


Figure 20: CO and NO2 sensors for MUA1 on the right

Figure 21: EF1a

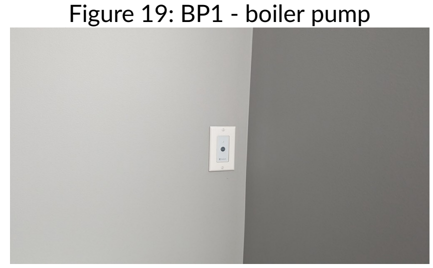


Figure 22: Exhaust fan control in washroom

Figure 23: F1

Figure 24: HRV1 control (left) and F1 control (right)

Figure 25: HRV1 dirty filter

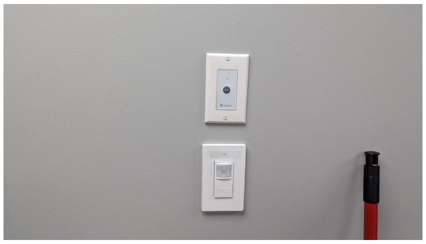


Figure 26: HRV1 exhaust control


Figure 27: HRV1

Figure 28: HRV2


Figure 29: Hydronic baseboard heating in 2nd floor storage room


Figure 30: IH1 - infrared heater


Figure 31: IH2 - infrared heater


Figure 32: MUA1

Figure 33: Temperature settings for F1 on a Monday


Figure 34: Thermostat controlling IH1


Figure 35: Thermostat controlling IH2

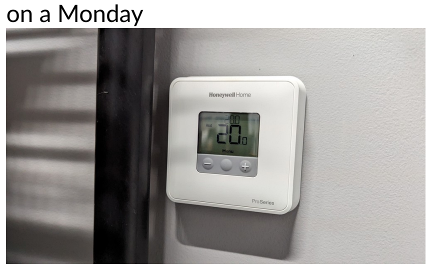


Figure 36: Thermostat for hydronic baseboard heating on 2nd floor

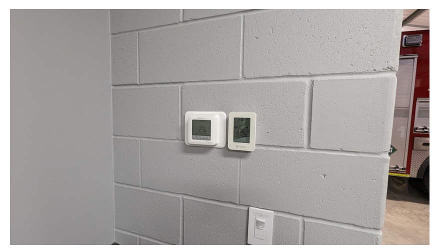


Figure 37: Thermostat for in-floor heating (left) and HRV2 control (right)

Figure 38: Thermostat for MUA1

2.7 Domestic hot water

Overview

Two natural gas-fired DHW heaters are serving this building. WH1 is located in the mechanical room and serves the washrooms, sinks, and pressure washer on the north side of the building. The second tank is located in the utility room and serves the washrooms on the south end of the building. WH1 and WH2 both have a capacity of 40 USG each.

The temperature setpoints on WH1 and WH2 were 140F (Position B) and 150F (Position A), respectively.

Domestic Hot Water documentation

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

Figure 39: WH1

Figure 40: WH1 is set to 140F

Figure 41: WH2 is set to 150F

Figure 42: WH2

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
-	[m2]	[W/m2]	[W]	-
Apparatus bay	492	5.1	2,509	Takeoff.
Main building	313	4.6	1,440	Takeoff.
Mezzanine and south side	805	4.6	3,703	Takeoff.

Interior lighting

Fixtures

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

- Type A1: 2'x4', recessed, LED, 53 W
- Type A2: 2'x4', recessed, LED, 42 W
- Type A3: 1'x4', surface-mounted, LED, 39 W
- Type A4: strip light, suspended, LED, 43.9 W
- Type A5: 1'x4', surface-mounted, LED, 28 W
- Type S1: high bay, suspended, LED, 105 W

Controls

Interior lighting control is done through switch-mounted occupancy sensors and ceiling-mounted occupancy sensors. The lights are typically off, as the building is intermittently occupied.

Exterior lighting

Fixtures

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

- Type P1: Pole, LED, 92W
- Type W1: Wall pack, LED, 73 W

Controls

Exterior lighting is controlled by a outdoor photocell with an astronomic control in the mechanical room. The astronomic control will turn the lights off at midnight and make them available after 06:00.

Lighting system documentation

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


Figure 43: Astronomic control for exterior lights

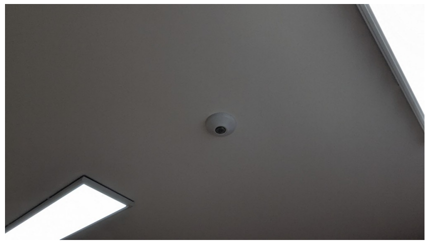


Figure 44: Ceiling mounted occupancy sensor


Figure 45: Occupancy sensor in the apparatus bay


Figure 46: Switch-mounted occupancy sensor


Figure 47: Type A1


Figure 48: Type A2


Figure 49: Type A3


Figure 50: Type A4


Figure 51: Type D1


Figure 52: Type P1


Figure 53: Type P2


Figure 54: Type S1


Figure 55: Type W1

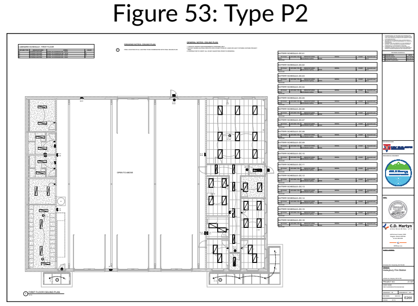


Figure 56: 21 E200-FIRST FLOOR REFLECTIVE CEILING PLAN

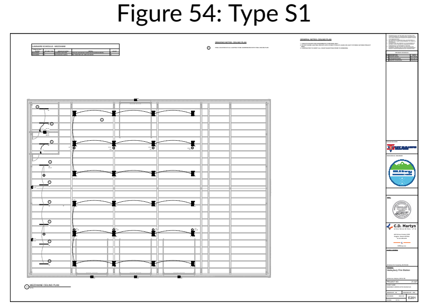


Figure 57: 21 E201-MEZZANINE FLOOR REFLECTIVE CEILING PLAN

2.9 Process and plug loads

Process

Various process loads are present at the facility, including:

- Pressure washer
- Overhead door openers
- Sump pump
- Washing machine
- Air compressor
- Breathable air compressors
- Fire truck load
- IT equipment

Plug loads

Various plug loads are present at the facility, including:

- Office equipment (projector, etc.)
- Personal computers
- Appliances (e.g., dishwasher, kettle, etc.)

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 58: Air compressor


Figure 59: Breathable air compressors


Figure 60: Fire truck plug load


Figure 61: IT equipment


Figure 62: Kitchen appliances


Figure 63: Office equipment


Figure 64: Overhead door opener

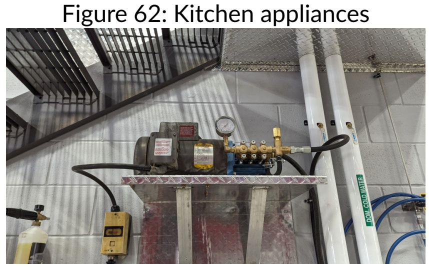


Figure 65: Pressure washer


Figure 66: Sump pump


Figure 67: Treadmills

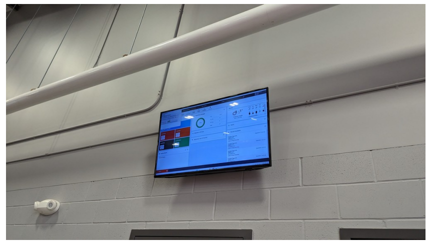


Figure 68: TV in apparatus bay

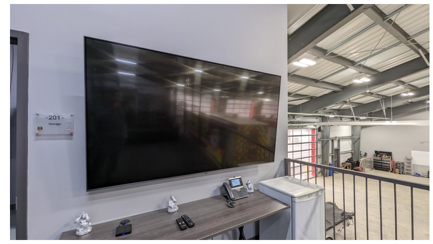


Figure 69: TV in multi-purpose space


Figure 70: Washing machine

2.10 Water fixtures

Water fixture summary

Water fixtures at Haileybury Fire Hall are summarized in Table 12.

Table 12: Water fixture summary

Serves	Unit count	Flow	Volume	Data source
-	-	[gpm]	[gpc]	-
Kitchen faucets	1	2.20	-	Assumption.
Washroom faucets	3	0.50	-	Assumption.
Toilets	3	-	1.60	Assumption.
Urinals	2	-	0.50	Assumption.
Showers	4	1.50	-	Assumption.

Overview

A summary of water fixtures is as follows:

- Three handwashing faucets. They are equipped with motion sensors and are low-flow.
- One kitchen sink.
- 3 toilets.
- 2 urinals.
- 4 showers. They are low flow.

Water fixture documentation

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

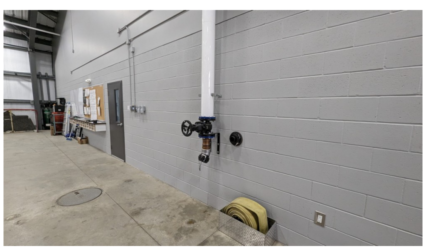


Figure 71: DCW for filling trucks


Figure 72: Handwashing faucet


Figure 73: Kitchen sink

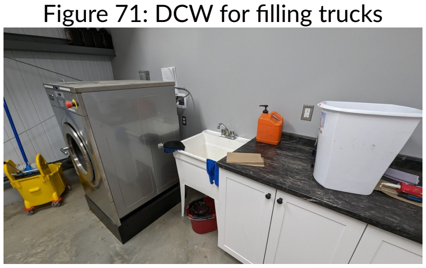


Figure 74: Laundry tub

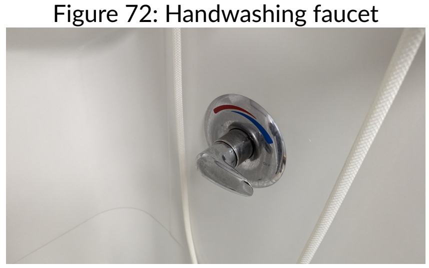


Figure 75: Manual handle for the showers


Figure 76: Pressure washers with DCW and DHW


Figure 77: Shower head

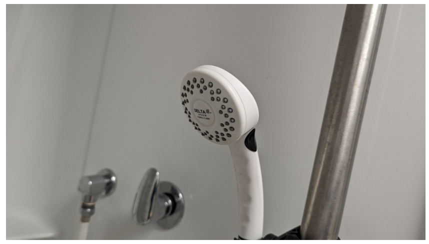


Figure 78: Second showerhead


Figure 79: Toilet


Figure 80: Urinal

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 Energy rate structure.

There is one natural gas meter at this facility.

Utility services documentation

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

Figure 81: Electricity meter

Figure 82: Natural gas meter

2.12 Onsite energy sources

Overview

This site has one 80 kW natural gas-fired emergency generator. Based on operation conditions at City Hall, it is assumed to operate weekly.

There are no renewable energy systems present at this facility.

Onsite energy sources documentation

Onsite energy sources documentation, including available drawings and photos from the site survey, is provided in the following images.

Figure 83: Back up portable generator

Figure 84: Generator

2.13 Electrical infrastructure

Overview

The existing systems is 400A at 240V service running at a maximum load of 12.82 kW, which is approximately 20% of the full load of 76.8 kW of the building. The main building panel, Panel A, only has one available breaker space, and Panel B has plenty of physical space.

Panel summary

The two panels at this site are summarized below:

- Panel A, 400A, 120/240V, 1 phase, 3 wire.
- Panel B, 100A, 120/240V, 1 phase. 3 wire.

Electrical infrastructure documentation

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


Figure 85: Automatic transfer switch

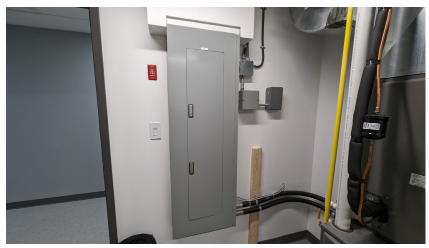


Figure 86: Panel A


Figure 87: Panel B

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 3.8.

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 Haileybury Fire Hall.
   - Electricity; see Section 3.3.
   - Natural gas; see Section 3.4.
3. **Utility use baseline**. The utility use baseline was summarized in Section 3.5, 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

4. **Benchmarking analysis**. The yearly baseline energy use and GHG emissions of Haileybury Fire Hall was compared with those of similar facilities in Section 3.6. 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 Haileybury Fire Hall.
6. **Utility use analysis discussion**. Results of the utility use analysis were studied and discussed in Section 3.8.

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	[tCO2e/kWh]	0.0000554	Environment and Climate Change Canada Data Catalogue, Electricity Grid Intensities-1
Natural gas	[tCO2e/m3]	0.0019324	National Inventory Report, 1990-2023, Table 1-1, Table A61.1-1 and Table A61.1-3

- Utility cost rates for the baseline year of 2024 were assumed as per Table 15. Electricity utility cost rates were assumed based on typical wholesale rates for the General Service Energy 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 (2024)

Utility	Line item	Unit	Value
Electricity	Electricity consumption - Class B	[$/kWh]	0.0200
Electricity	Global adjustment - Class B	[$/kWh]	0.0735
Electricity	Regulatory	[$/kWh]	0.0057
Natural gas	Natural gas (blended)	[$/m3]	0.2600
GHG emissions	Federal carbon charge	[$/tCO2e]	50.0000

3.3 Electricity metered utility use

Hourly electricity use is plotted in Figure 88.

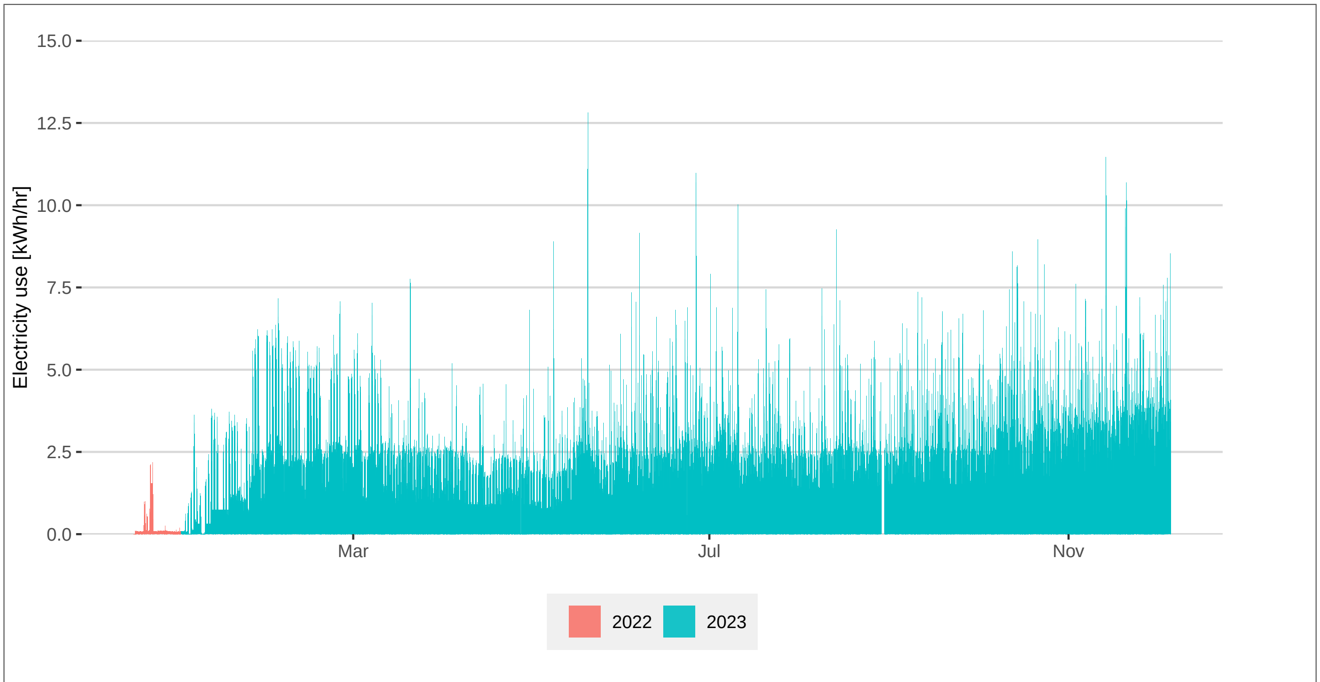


Figure 88: Hourly electricity use

The same hourly electricity use data is plotted in Figure 89, which highlights how electricity use is influenced by year, season, day of week and hour of day. The vertical axis on Figure 89 may be rescaled relative to in Figure 88 for greater resolution.

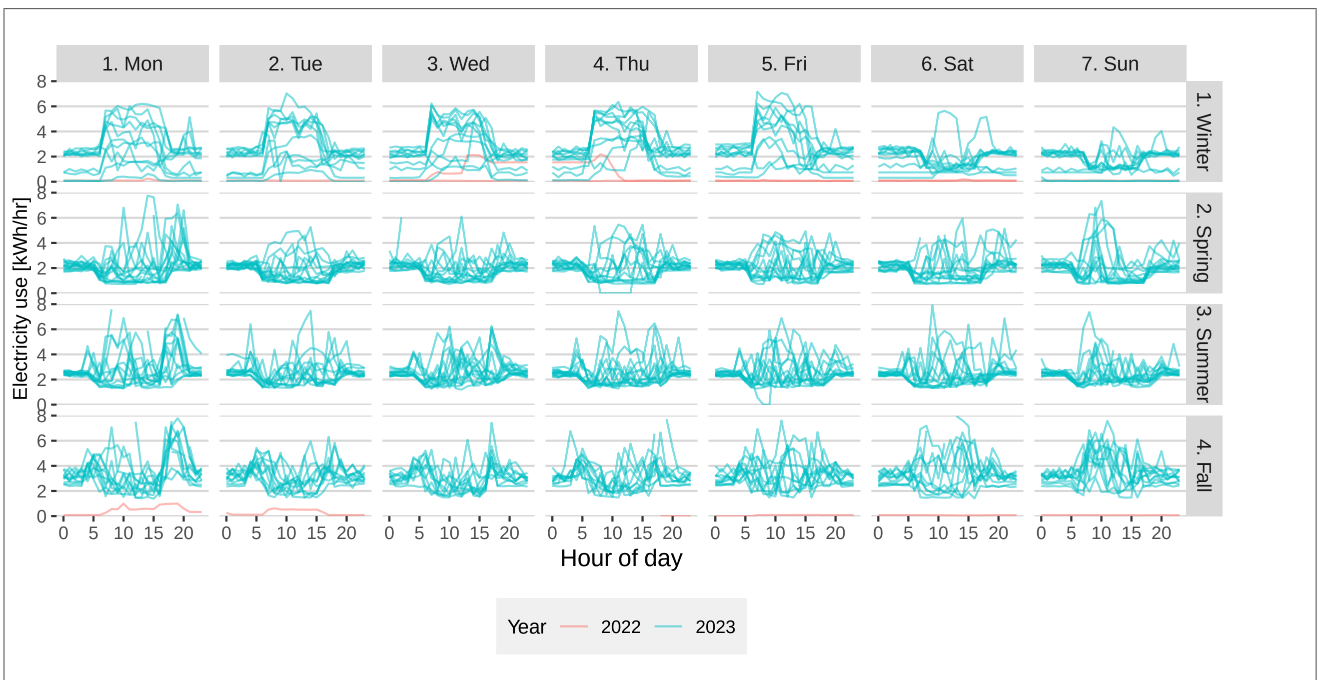


Figure 89: Hourly electricity use hairball plot

Monthly electricity use is plotted in Figure 90.

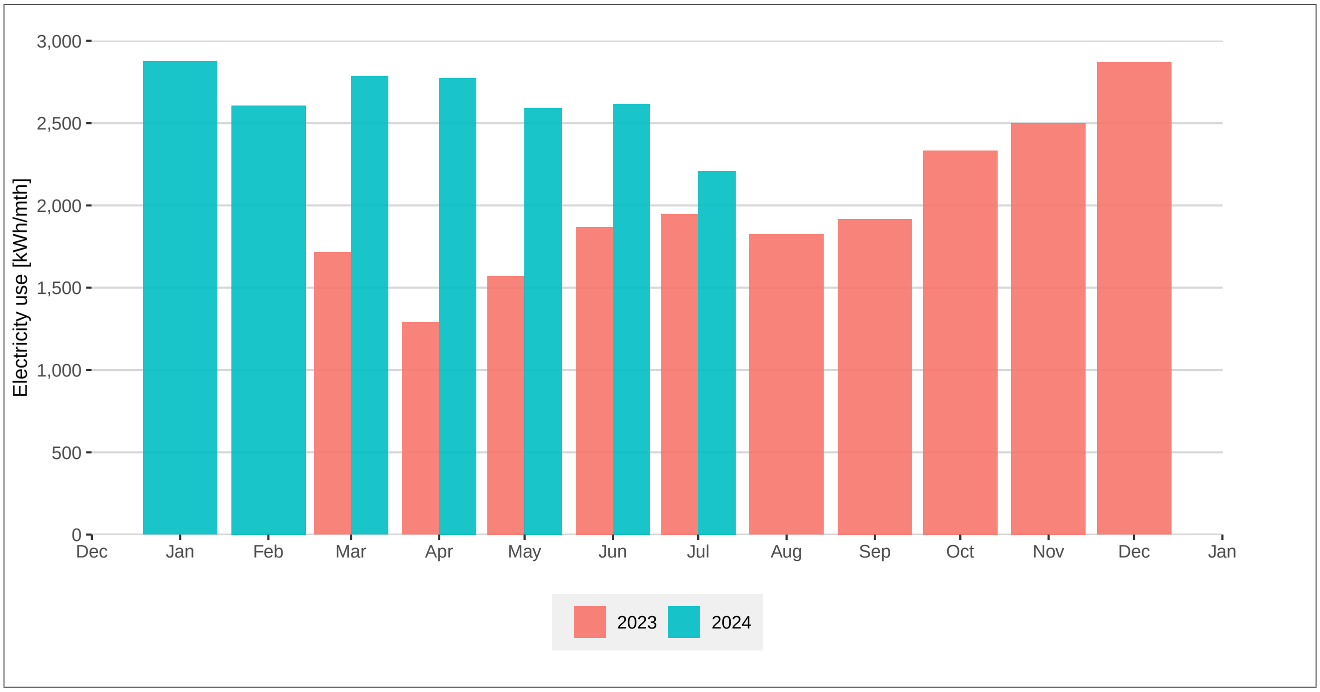


Figure 90: Monthly electricity use

3.4 Natural gas metered utility use

Monthly natural gas use is plotted in Figure 91.

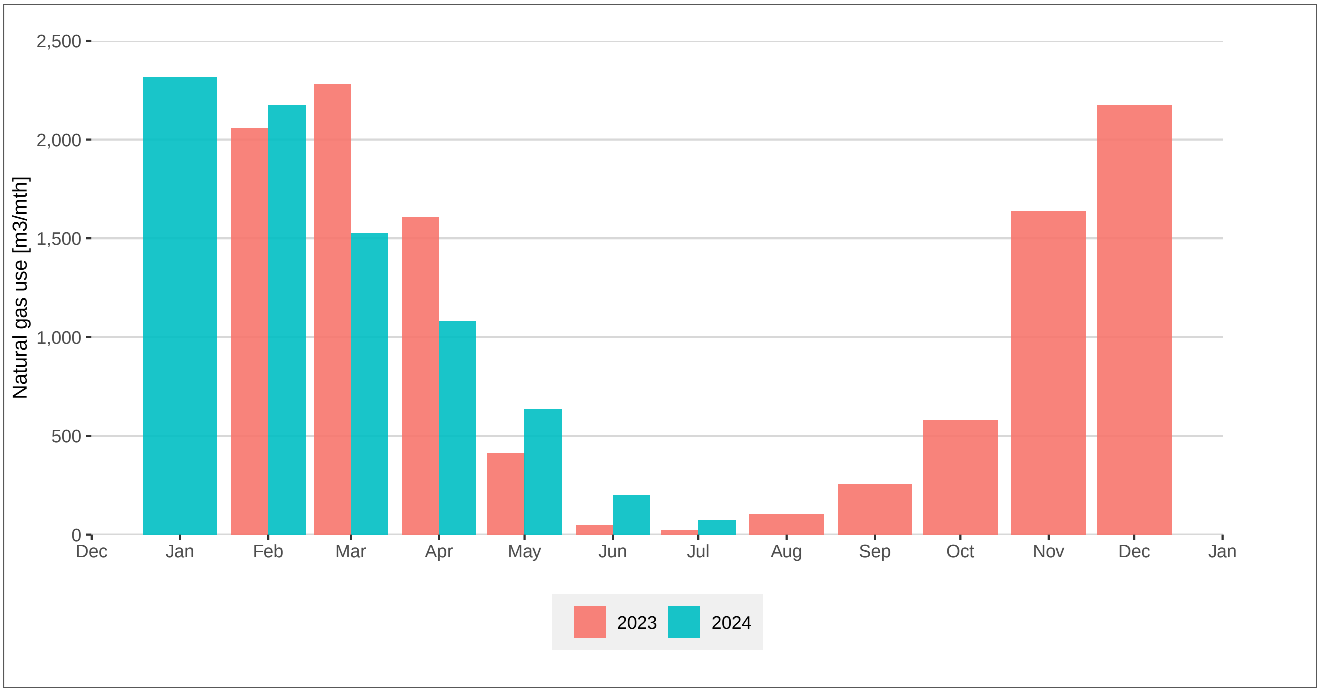


Figure 91: Monthly natural gas use

3.5 Utility use baseline

Baseline year

The baseline year for Haileybury Fire Hall, which is used to establish the baseline performance through the metered utility use data from that year, is as follows.

- **Baseline year**: 2024.

Baseline performance

Baseline utility use performance for the baseline year of 2024 is summarized in Table 16.

Table 16: Baseline utility use performace

Category	Utility	Unit	Value
Utility use	Electricity use	[kWh/yr]	30,752
	Natural gas use	[m3/yr]	13,051
	Carbon offset use	[tCO2e/yr]	0
Equivalent energy use	Electricity energy	[kWh/yr]	30,752
	Natural gas energy	[kWh/yr]	137,780
	Total energy	[kWh/yr]	168,533
GHG emissions	Electricity GHGs	[tCO2e/yr]	2
	Natural gas GHGs	[tCO2e/yr]	25
	Carbon offsets GHGs	[tCO2e/yr]	0
	Total GHGs	[tCO2e/yr]	27
Utility cost	Electricity utility cost	[$/yr]	3,051
	Natural gas utility cost	[$/yr]	3,393
	Carbon offsets utility cost	[$/yr]	0
	Federal carbon charge	[$/yr]	1,261
	Total utility cost	[$/yr]	7,705

3.6 Benchmarking analysis

Benchmarking analysis results are presented in the following figures.

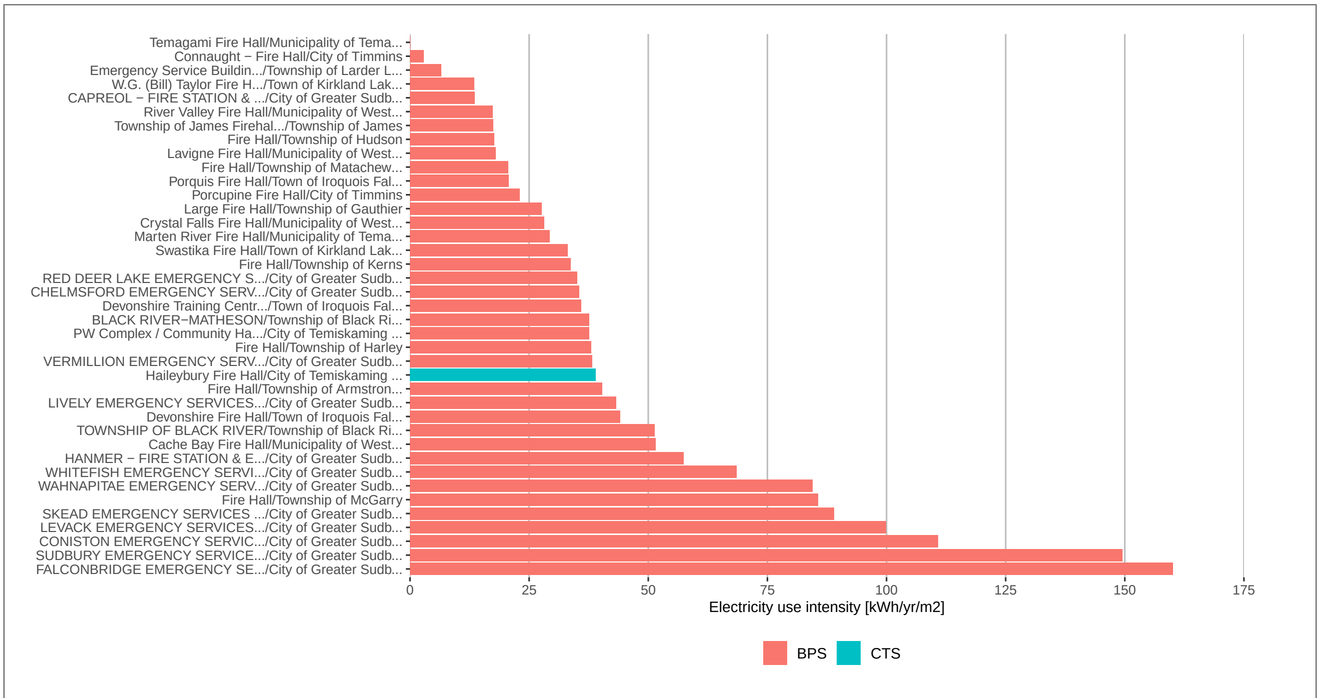


Figure 92: Electricity use intensity benchmarking analysis comparison

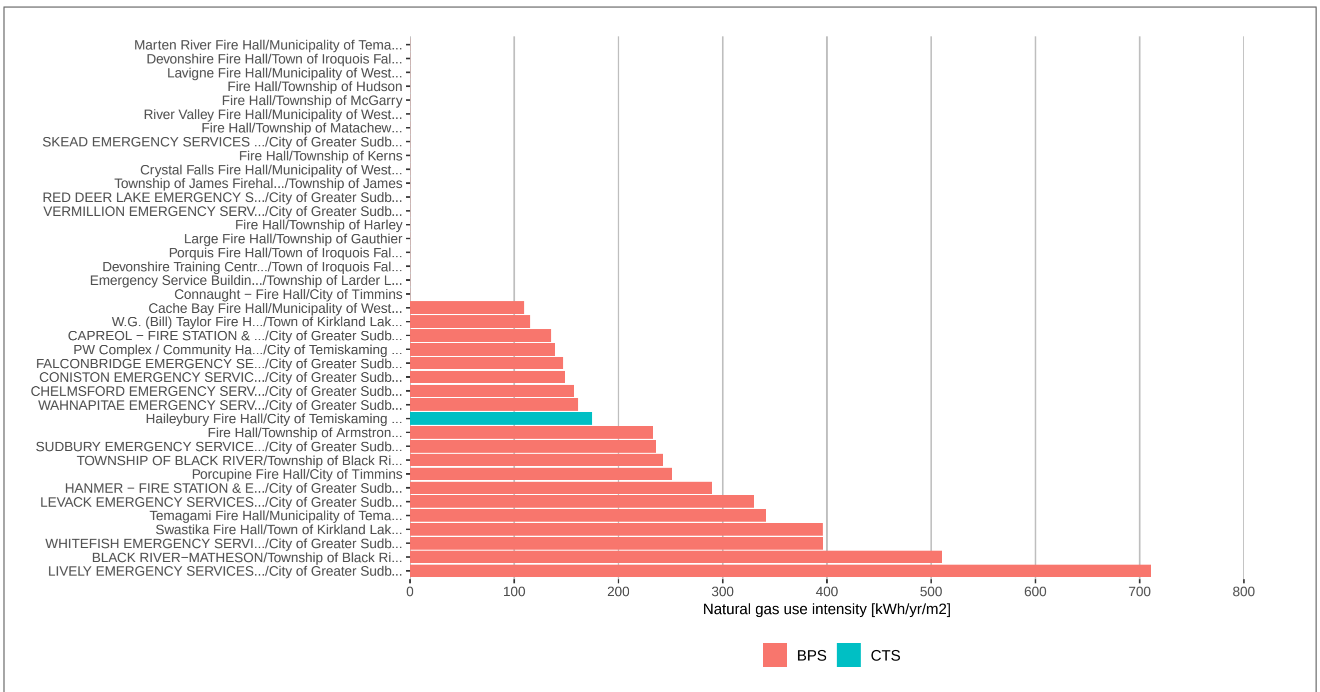


Figure 93: Natural gas use intensity benchmarking analysis comparison

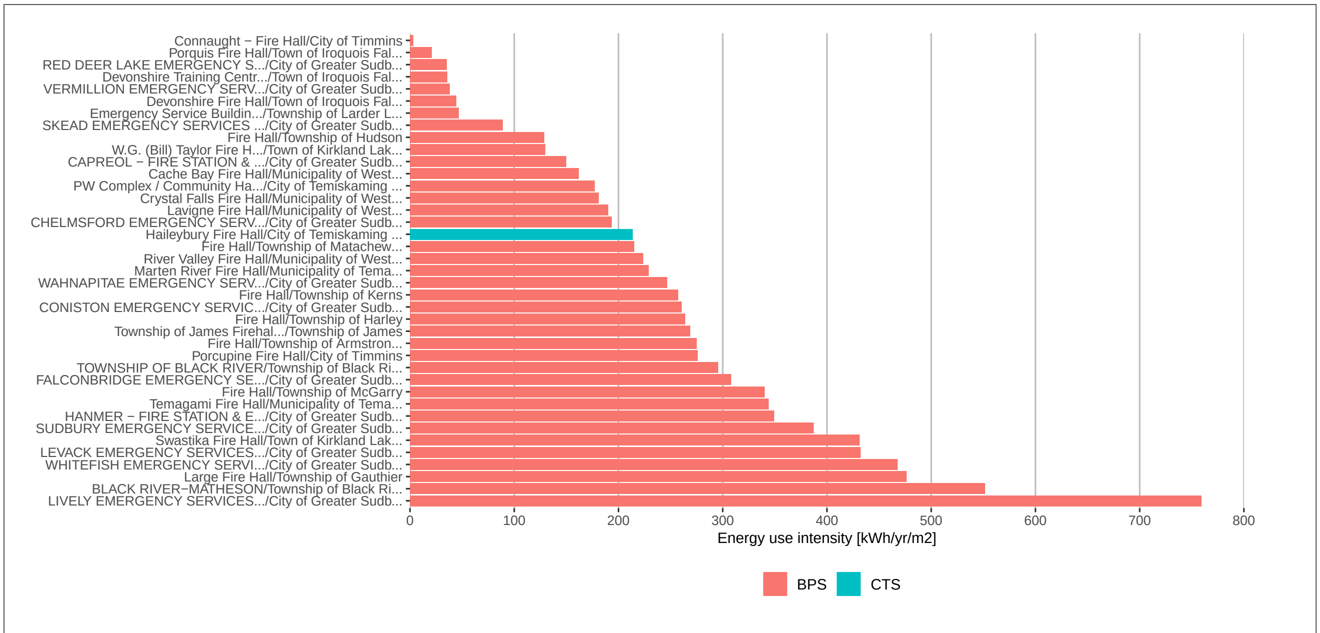


Figure 94: Total energy use intensity benchmarking analysis comparison

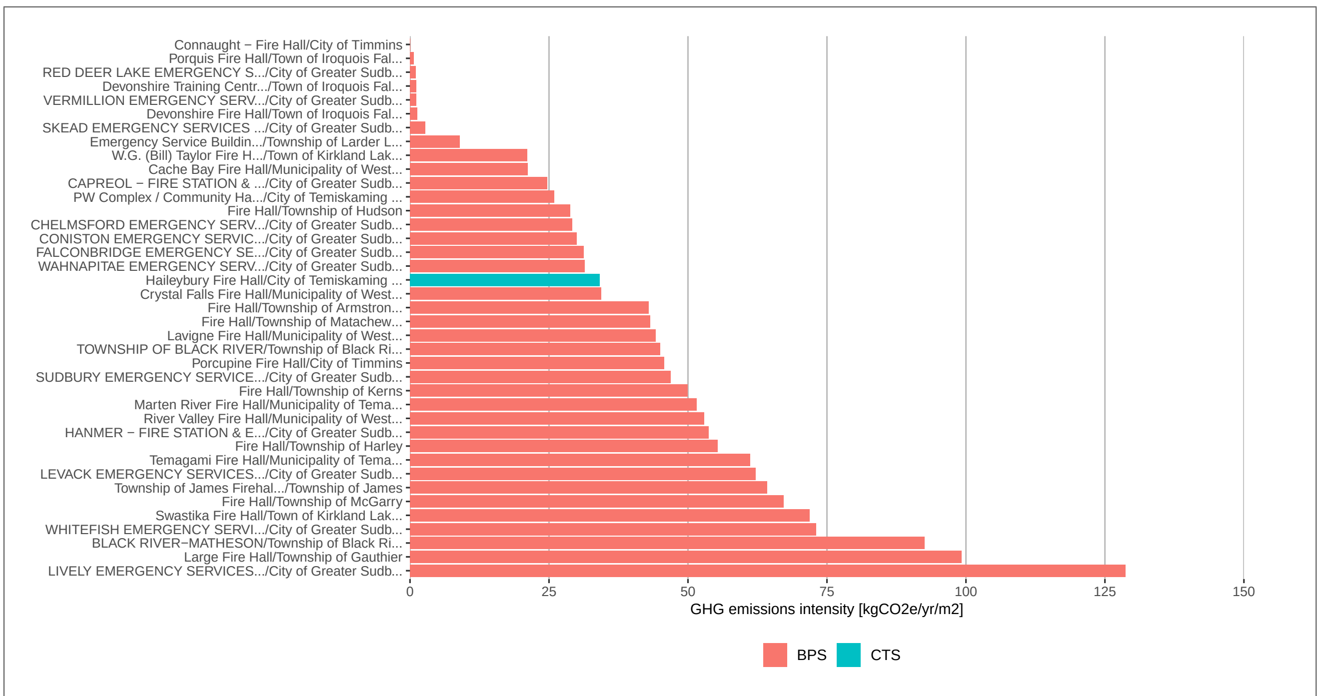


Figure 95: GHG emissions intensity benchmarking analysis comparison

3.7 ENERGY STAR Portfolio Manager benchmarking analysis

The scorecard is shown in Figure 96.

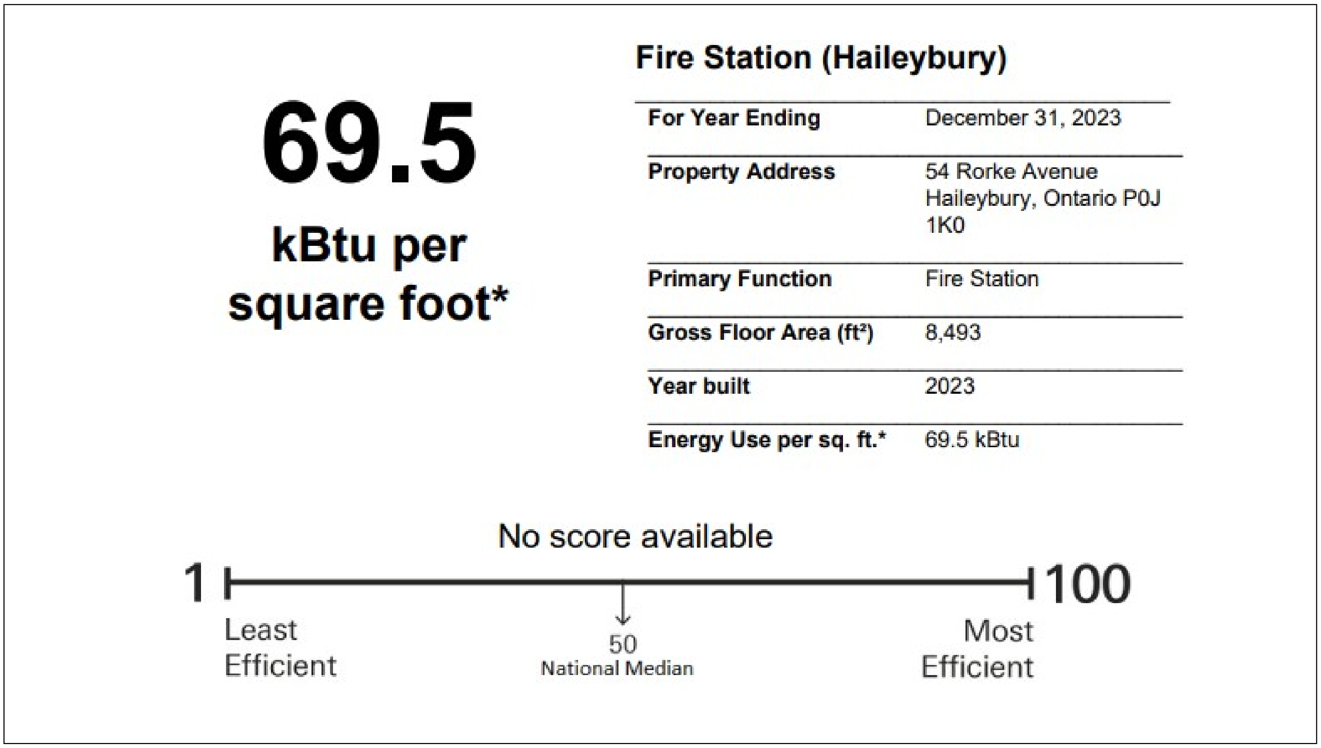


Figure 96: Energy Star energy performance scorecard.

3.8 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 2.

Due to how new the building is, the newest available utility use data was used for model calibration. As such, the data of interest is from August 2023 to July 2024.

Also note that the utility use baseline is listed as 2024, although it is better represented as August 2023 to July 2024. Weather data from 2023 was used for this calibration.

Due to the limited availability of data, it is difficult to ascertain trends; the observations that could be gleaned from available data are listed below.

Electricity - Hourly

- Hourly electricity consumption typically peaks during the summer, most likely due to cooling.
- Hourly consumption is typically under 7.5 kWh and above 1 kWh.

Electricity - Monthly

- **2023**: 2023 did not have a complete year of data, although the consumption is seen to increase from March to December, which is likely a result of the building gradually coming online.
- **2024**: Electricity consumption remains relatively consistent from January to June.

Natural gas

- Natural gas consumption follows expectation, and is highest during the heating season and very low during the cooling season.

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	Cooling	Cooling energy use.
	Equipment	Equipment energy use.
	Exterior lights	Exterior lighting energy use.
	Fans	Fan motor energy use.
	Lights	Lighting energy use.
	Pumps	Pump motor energy use.
Natural gas	DHW heat	Domestic hot water heating energy use.
	Space heat	Space heating energy use.

   (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 97. See Table 17 for end use definitions.

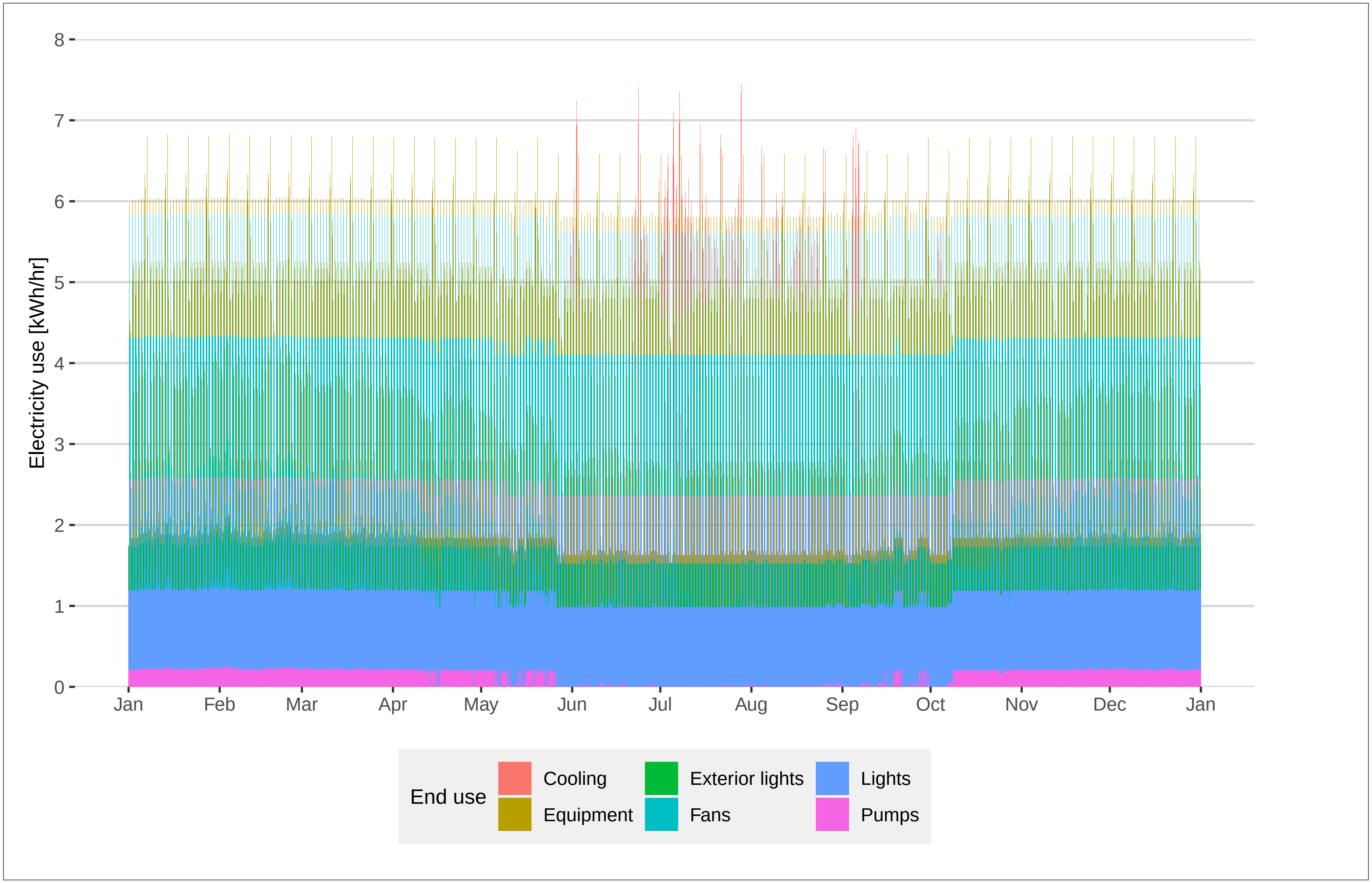


Figure 97: Hourly electricity utility use by end use (made by calibrated energy model)

Natural gas

The hourly natural gas utility use profile by end use made by the energy model is plotted in Figure 98. See Table 17 for end use definitions.

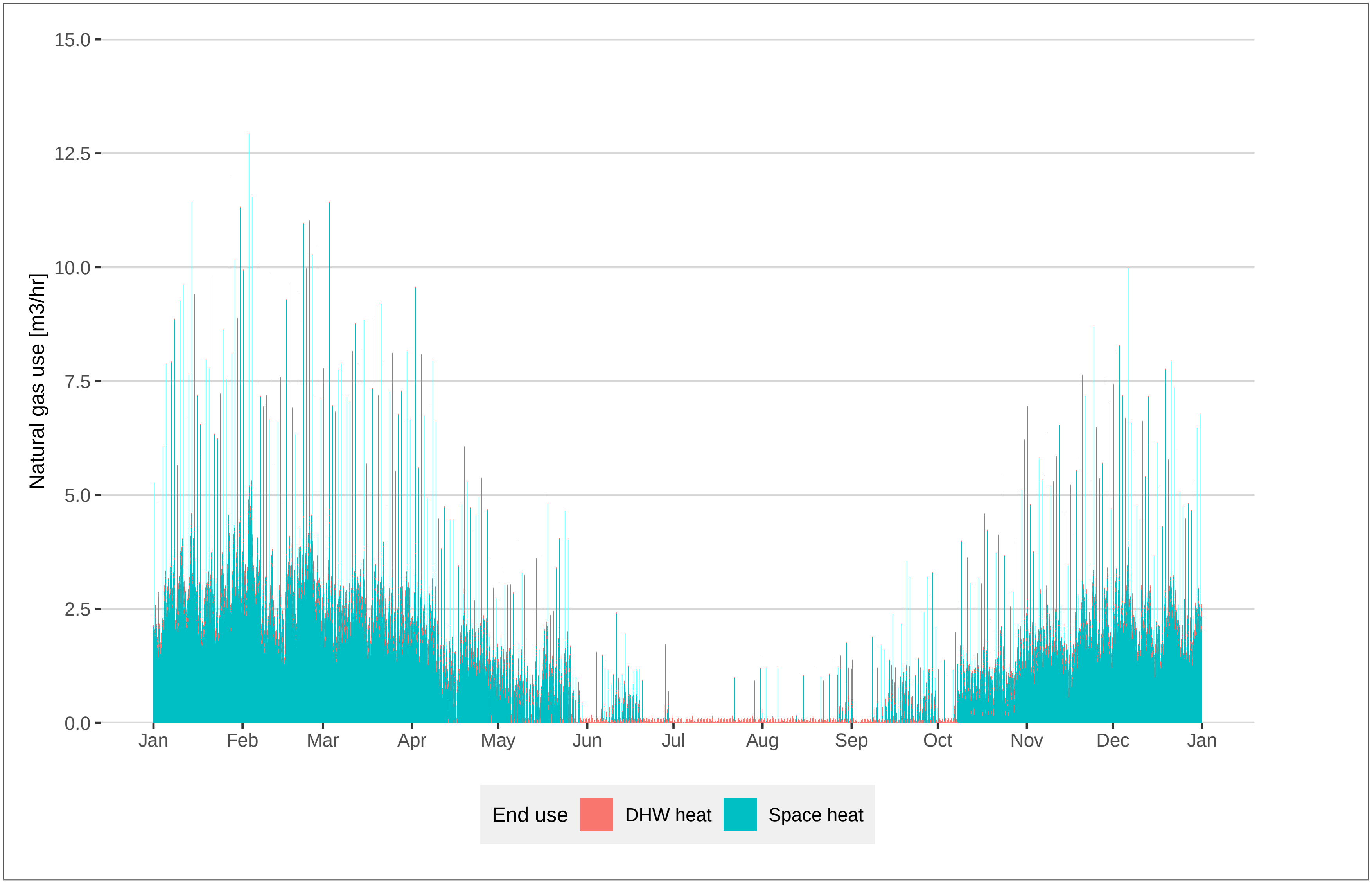


Figure 98: Hourly natural gas utility use by end use (made by calibrated energy model)

4.3 Monthly utility use profiles

Monthly utility use profiles for each modelled utility are presented in Figure 99.

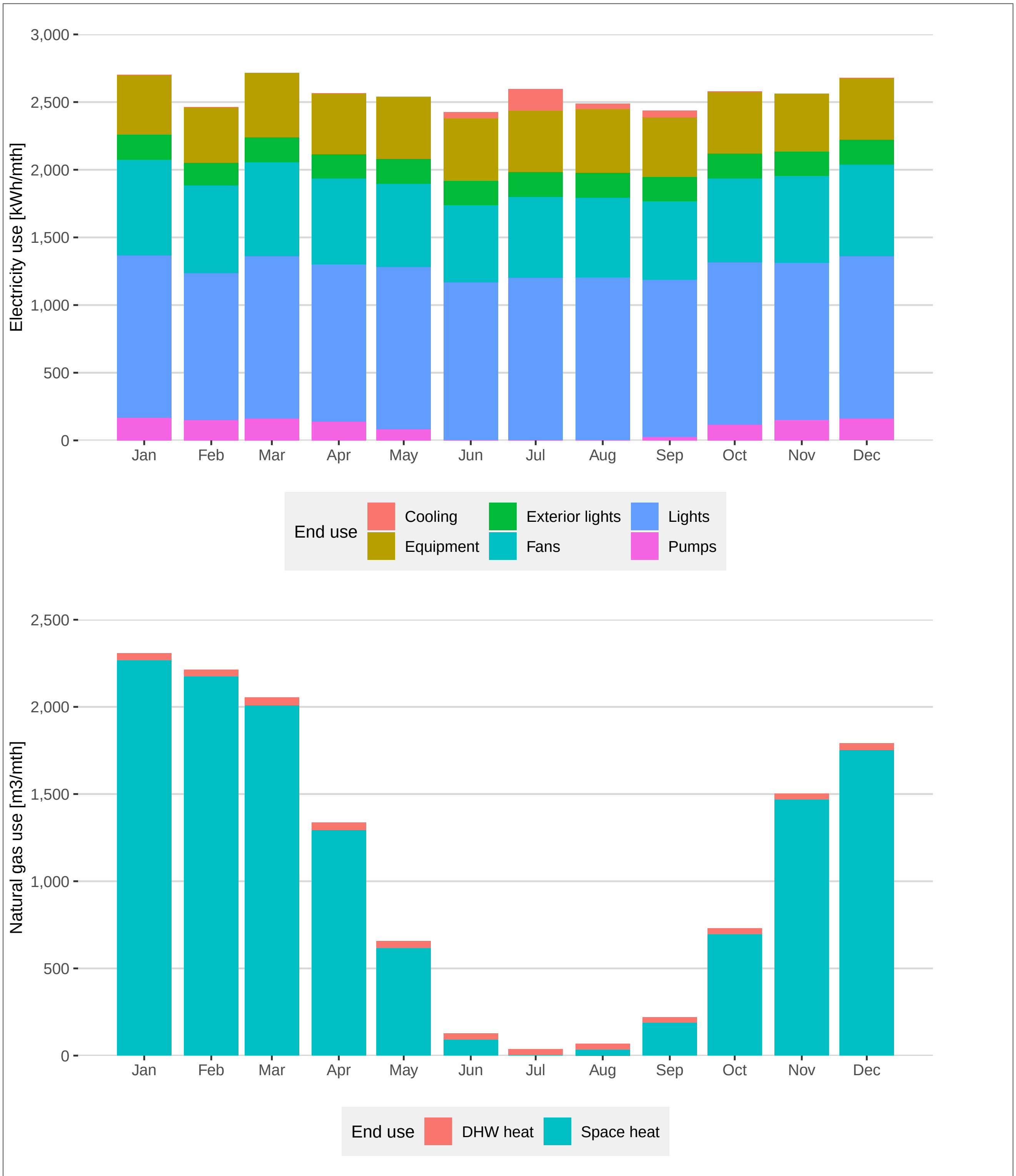


Figure 99: Monthly utility use profiles for each modelled utility

4.4 Calibration analysis

Electricity

Figure 100 compares the metered utility use with the modelled use to check how well the model is calibrated.

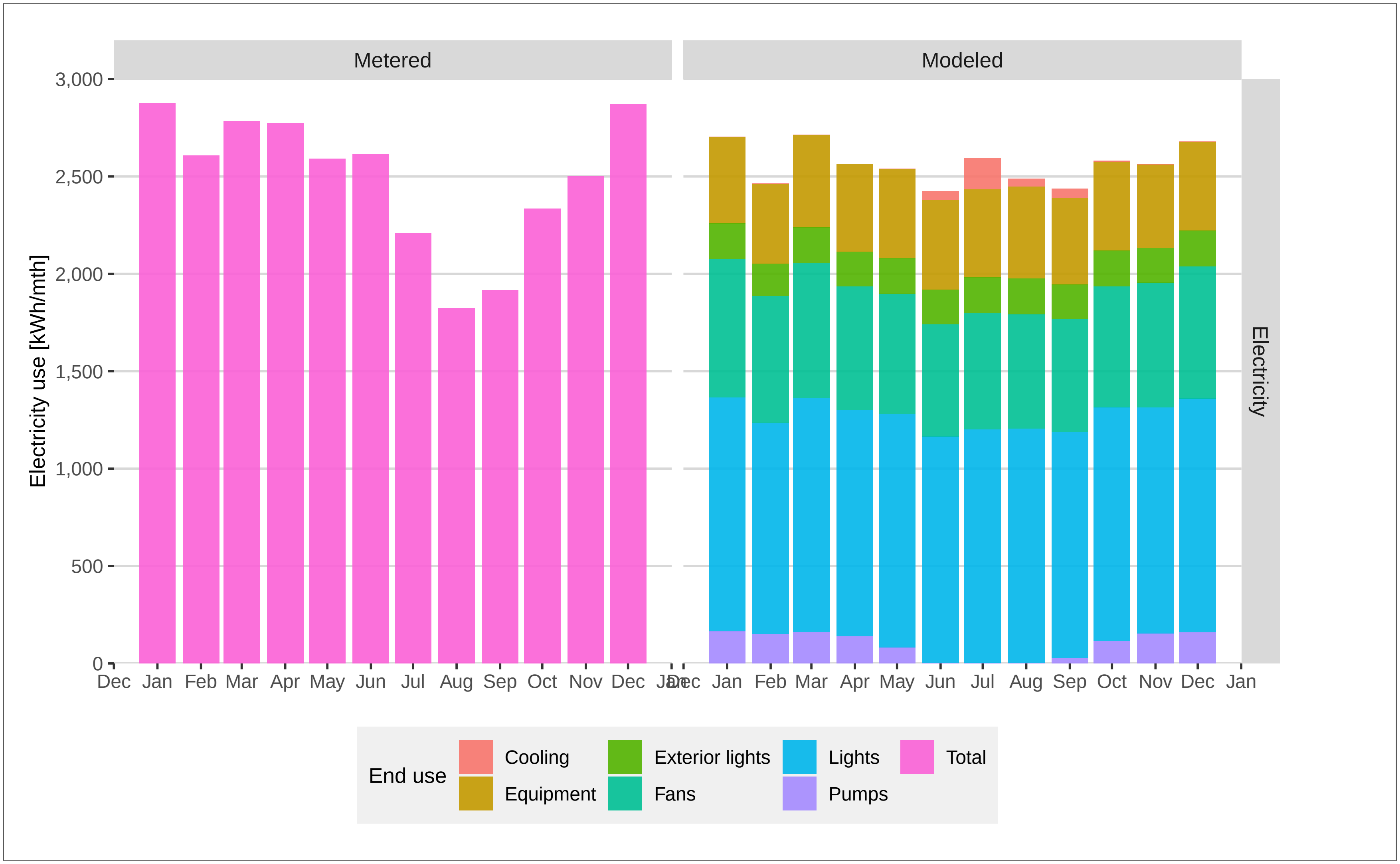


Figure 100: Electricity calibration analysis (metered vs modelled utility use)

Natural gas

Figure 101 compares the metered utility use with the modelled use to check how well the model is calibrated.

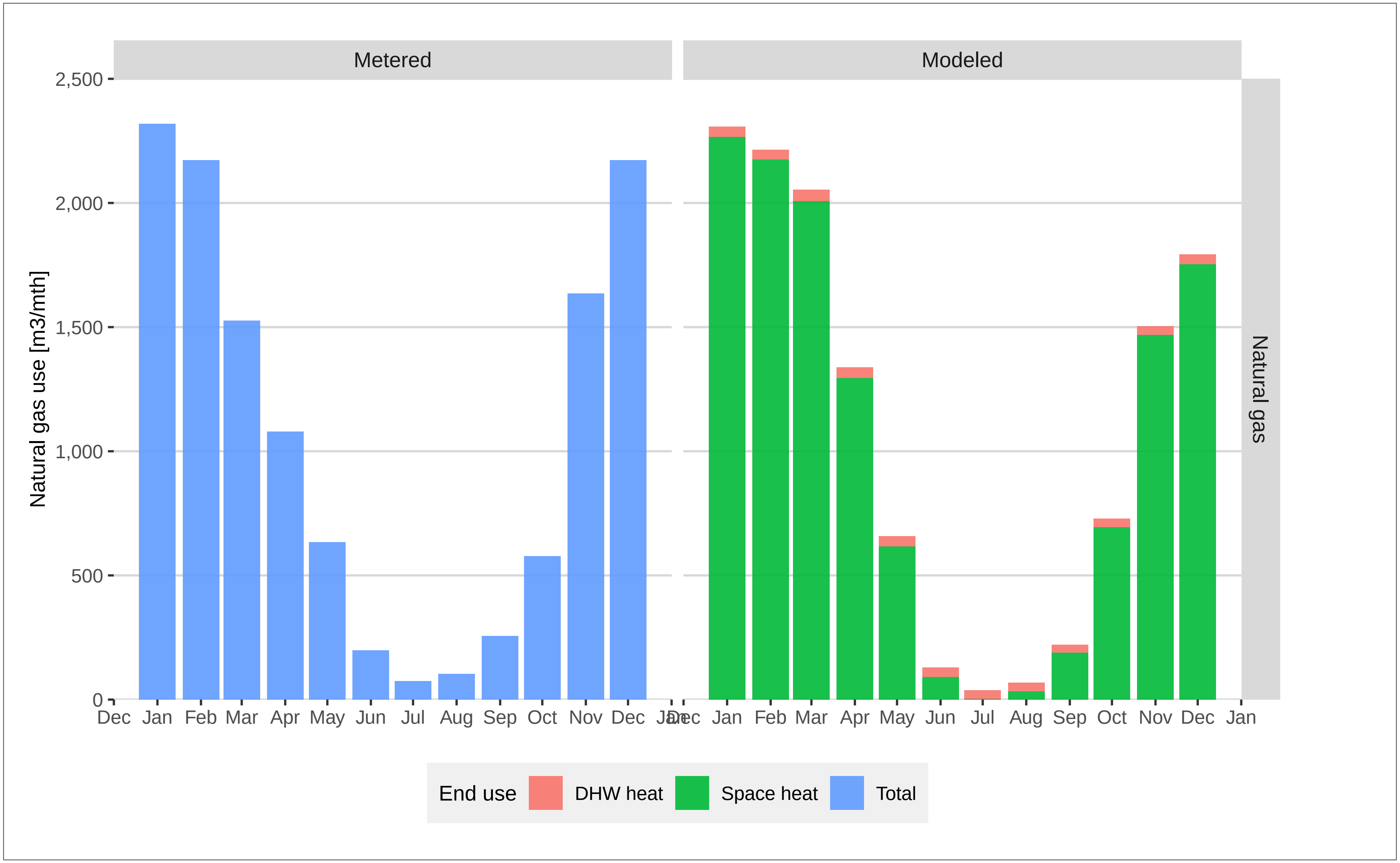


Figure 101: Natural gas calibration analysis (metered vs modelled utility use)

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 (RMBE)**. 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	-3.1	Pass
	Root mean square error	[%]	< 15	12.7	Pass
Natural gas	Mean bias error	[%]	< +/- 5	-2.6	Pass
	Root mean square error	[%]	< 15	20.9	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 100 and 101 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.
- 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 in March and April. Another note is that, due to the limited availability of data, the majority of these readings were estimated or taken when the facility was not yet fully online. Additionally, because 2023 weather data was used, this adds an additional source of discrepancy when comparing the 2024 metered data to the modelled data. These issues make it difficult to calibrate the model.
- 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 from information gained during the site survey, 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 MUA, F1, and B1.
- 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 100 indicates reasonably strong agreement between modelled and metered data.
- From July to October, the modelled data was higher than the metered data. This is likely because the data after July was from 2023, and the facility grand opening did not occur until October 2023. It is believed that the modelled electricity consumption is more representative of the facility's existing conditions.
- The peak and trough hourly consumption align with the metered interval data.

Natural gas

- Figure 101 indicates good agreement between modelled and metered data.
- To achieve better alignment between the modelled and metered natural gas use, a relatively low infiltration rate was assumed for the building (0.25 lps/m2 envelope). In addition, although the unit heater temperature was observed to be 71F during the site survey, it was assumed that this temperature is varied and kept at an average of 66F throughout the year.

4.5 End use analysis

Electricity

The yearly electricity end use breakdown calculated by the energy model is plotted in Figure 102. See Table 17 for end use definitions.

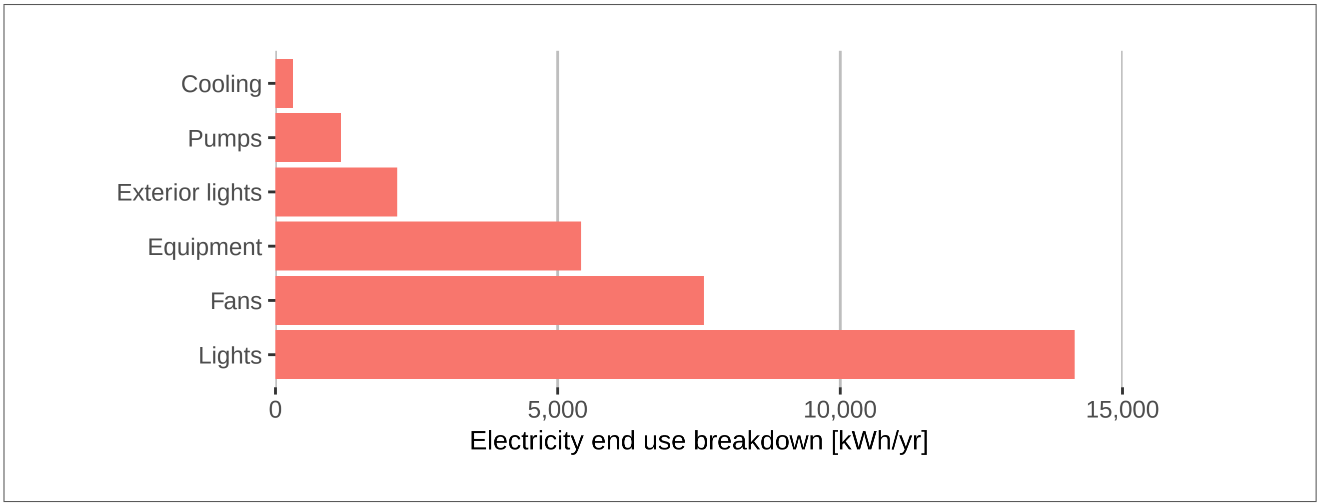


Figure 102: Electricity end use breakdown (calculated by calibrated energy model)

Natural gas

The yearly natural gas end use breakdown calculated by the energy model is plotted in Figure 103. See Table 17 for end use definitions.

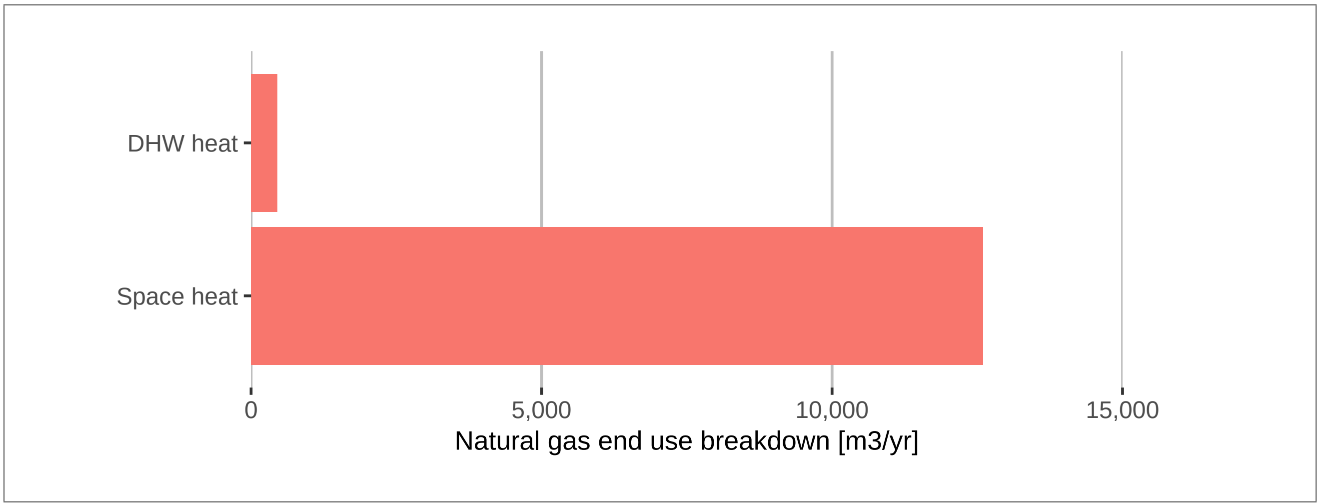


Figure 103: Natural gas end use breakdown (calculated by calibrated energy model)

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 5.14). 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 2025 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 5.15.

4. **Measure analysis summary**. Measure analysis results for all measures were summarized in table format in Section 5.16.

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	Carbon offsets	Class B HOEP	Class B GA	Class B regulatory
-	[$/m3]	[$/tCO2e]	[$/tCO2e]	[$/kWh]	[$/kWh]	[$/kWh]
2024	0.2705	80	30.6	0.0208	0.0765	0.0059
2025	0.2759	0	31.21	0.0212	0.078	0.006
2026	0.2814	0	31.84	0.0216	0.0796	0.0061
2027	0.287	0	32.47	0.022	0.0812	0.0062
2028	0.2927	0	33.12	0.0224	0.0828	0.0063
2029	0.2986	0	33.78	0.0228	0.0845	0.0064
2030	0.3046	0	34.46	0.0233	0.0862	0.0065
2031	0.3107	0	35.15	0.0238	0.0879	0.0066
2032	0.3169	0	35.85	0.0243	0.0897	0.0067
2033	0.3232	0	36.57	0.0248	0.0915	0.0068
2034	0.3297	0	37.3	0.0253	0.0933	0.0069
2035	0.3363	0	38.05	0.0258	0.0952	0.007
2036	0.343	0	38.81	0.0263	0.0971	0.0071
2037	0.3499	0	39.58	0.0268	0.099	0.0072
2038	0.3569	0	40.38	0.0273	0.101	0.0073
2039	0.364	0	41.18	0.0278	0.103	0.0074
2040	0.3713	0	42.01	0.0284	0.1051	0.0075
2041	0.3787	0	42.85	0.029	0.1072	0.0077
2042	0.3863	0	43.7	0.0296	0.1093	0.0079
2043	0.394	0	44.58	0.0302	0.1115	0.0081
2044	0.4019	0	45.47	0.0308	0.1137	0.0083
2045	0.4099	0	46.38	0.0314	0.116	0.0085
2046	0.4181	0	47.31	0.032	0.1183	0.0087
2047	0.4265	0	48.25	0.0326	0.1207	0.0089
2048	0.435	0	49.22	0.0333	0.1231	0.0091
2049	0.4437	0	50.2	0.034	0.1256	0.0093
2050	0.4526	0	51.21	0.0347	0.1281	0.0095

- 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|.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|.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|.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|.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|.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	
Boiler plant to ASHP with MUA upgrade	Analyzed.
Carbon offsets 20	Analyzed.
DHW heaters to ASHP	Analyzed.
F1 conversion to ASHP with electric backup	Analyzed.
F1 conversion to ASHP with natural gas backup	Analyzed.
Infrared heaters to electric radiant	Analyzed.
Roof upgrade to high performance	Analyzed.
Solar PV rooftop	Analyzed.
Temperature setpoint optimization	Analyzed.
Wall upgrade to high performance	Analyzed.
Windows and doors to high performance	Analyzed.
Boiler renewal	Business as usual.
DHW renewal	Business as usual.
Exterior walls renewal	Business as usual.
Furnace renewal	Business as usual.
Infrared renewal	Business as usual.
MUA renewal	Business as usual.
Roof renewal	Business as usual.
Windows and doors renewal	Business as usual.
Faucet aerators	Not analyzed: already have 0.5 gpm installed.
Low-flow shower fixtures	Not analyzed: already have 1.5 gpm installed.
Solar PV canopy	Not analyzed: interference issues with the fire trucks.
Exterior LED lighting upgrade	Not analyzed: LED lights and controls already implemented.
Interior LED lighting upgrade	Not analyzed: LED lights and controls already implemented.
Implement a OA temperature reset schedule for B1	Not analyzed: minimal energy savings.

5.4 Boiler plant to ASHP with MUA upgrade

Measure description

Existing condition

There is one gas-fired condensing boiler that serves in-floor heating (rooms 111-115) and baseboards (201 and 202). There is also a makeup air unit that serves the apparatus bay.

Opportunity

Convert the boiler plant to a hybrid ASHP and natural gas-fired boiler plant, in which ASHP is the primary heat source, and natural gas is the backup. This option is considered a potentially more cost-efficient option for GHG abatement than complete conversion to ASHP.

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 due to electricity having a lower GHG intensity than natural gas. Reduced natural gas use and increased electricity use would be expected as a result.

Design description

Overview

Add a 20T ASHP and 200USG buffer tank and maintain the existing boiler for supplemental heating. The unit shall be sized to provide baseload heating for hydronic coils, the radiant floor, and a new connection to the MUA.

The new A2W heat pump shall be installed at grade outside of the 2nd floor utility room. Glycol piping shall be routed back to the mechanical room and tie into the existing hydronic system. Loading for this measure assumes the existing loads will be operated at a lower temperature and the MUA is retrofitted such that the associate load on the hot water plant is reduced.

The sequence of operations shall be as follows:

- The heat pump shall be operated to maintain the buffer tank temperature based on an outdoor reset.
- A warm weather shut down temperature shall ensure the system does not operate in heating when the outdoor temperature exceeds 12C.
- The boiler shall be controlled based on an outdoor reset to maintain a supply temperature to the building and shall be optimized based on the building load and capacity of the heat pump.

MUA upgrade

Replace the gas-fired heating section of the MUA with a glycol-to-air coil capable of supplying 200kBTU of heat at 120F entering glycol temperature and up to 400kBTU at 160F.

Supply new pumps, piping, and all accessories for a complete connection to the new ASHP and boiler system.

Electrical

Electrically this measure may be possible; however, a fluke meter recording peak demand at maximum 15-minute intervals is required to ensure sufficient capacity. The addition of the ASHP will add approximately 30 kW of power to the existing system, which will put the system at 42.82 kW, which is approximately 56% of the full load of the electrical capacity of the building. Panel A does not have the breaker capacity, and Panel B does not have the electrical capacity. Space will need to be made on Panel A to power another small 200A panel to accommodate the additional equipment.

Project cost estimate

Table 24: Project cost estimate (Boiler plant to ASHP with MUA upgrade)

Category	Line item	Unit	Value
Construction	ASHP Supply	[$]	90,000
	ASHP Install	[$]	60,000
	MUA Upgrade	[$]	50,000
	Electrical contingency (does not include service upgrade)	[$]	20,000
	General requirements (25%)	[$]	55,000
Contingency	Subtotal after Construction	[$]	275,000
	Design Contingency (25%)	[$]	68,800
	Construction Contingency (10%)	[$]	27,500
Design, Contractors, PM	Subtotal after Contingency	[$]	371,300
	Engineering Design and Field Review (10%)	[$]	37,100
	Contractor Fee (7%)	[$]	26,000
Total	Total	[$]	434,400

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 91%.
- **Proposed**. Primary heating for the boiler plant is performed by air-source heat pumps with an average heating COP of 3. Backup heating is provided through natural gas when the outdoor air temperature is below -15 C. The MUA is converted from a natural gas-fired burner to a glycol coil connected to the hydronic loop.

Utility analysis results

Table 25: Boiler plant to ASHP with MUA upgrade analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	30,752	40,786	-10,034	-32.6
	Natural gas use	[m3/yr]	13,051	10,678	2,373	18.2
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	30,752	40,786	-10,034	-32.6
	Natural gas energy	[kWh/yr]	137,780	112,725	25,056	18.2
	Total energy	[kWh/yr]	168,533	153,511	15,022	8.9
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.7	2.3	-0.56	-32.6
	Natural gas GHGs	[tCO2e/yr]	25.2	20.6	4.6	18.2
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	26.9	22.9	4.0	15.0
Utility cost	Electricity utility cost	[$/yr]	3,051	4,046	-995	-32.6
	Natural gas utility cost	[$/yr]	3,393	2,776	617	18.2
	Carbon offsets utility cost	[$/yr]	0	0	0	—
	Federal carbon charge	[$/yr]	1,261	1,032	229	18.2
	Total utility cost	[$/yr]	7,705	7,854	-149	-1.9
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[$]	0	434,400	—	—
	Incentive amount	[$]	0	86,880	—	—
	Incremental project cost	[$]	0	347,520	—	—
	Life cycle cost	[$]	170,908	614,222	—	—
	Net present value	[$]	0	-443,315	—	—
	Project cost per GHG reduction	[$yr/tCO2e]	—	86,224	—	—
	Simple payback period	[yr]	—	—	—	—

5.5 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.

Net emissions = Embodied carbon + Operational carbon - 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 m^3 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 26: Carbon offsets 20 analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	30,752	30,752	0	0
	Natural gas use	[m3/yr]	13,051	13,051	0	0
	Carbon offset use	[tCO2e/yr]	0	5.4	-5.4	–
Equivalent energy use	Electricity energy	[kWh/yr]	30,752	30,752	0	0
	Natural gas energy	[kWh/yr]	137,780	137,780	0	0
	Total energy	[kWh/yr]	168,533	168,533	0	0
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.7	1.7	0	0
	Natural gas GHGs	[tCO2e/yr]	25.2	25.2	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	-5.4	5.4	–
	Total GHGs	[tCO2e/yr]	26.9	21.5	5.4	20.0
Utility cost	Electricity utility cost	[$/yr]	3,051	3,051	0	0
	Natural gas utility cost	[$/yr]	3,393	3,393	0	0
	Carbon offsets utility cost	[$/yr]	0	162	-162	–
	Federal carbon charge	[$/yr]	1,261	1,261	0	0
	Total utility cost	[$/yr]	7,705	7,867	-162	-2.1
Financial	Assumed life	[yrs]	15	20	–	–
	Project cost	[$]	0	–	–	–
	Incentive amount	[$]	0	0	–	–
	Incremental project cost	[$]	0	–	–	–
	Life cycle cost	[$]	170,908	173,854	–	–
	Net present value	[$]	0	-2,946	–	–
	Project cost per GHG reduction	[$yr/tCO2e]	–	–	–	–
	Simple payback period	[yr]	–	–	–	–

5.6 DHW heaters to ASHP

Measure description

Existing condition

Two natural gas-fired DHW heaters are serving this building. WH1 is located in the mechanical room and serves the washrooms, sinks, and pressure washer on the north side of the building. The second tank is located in the utility room and serves the washrooms on the south end of the building. WH1 and WH2 both have a capacity of 40 USG each.

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 WH1 and WH2 be replaced with hybrid heat pump hot water heaters that extract heat from the space for hot water.

The water heaters shall be equivalent to AO Smith Proterra 80USG models.

Project cost estimate

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

Category	Line item	Unit	Value
Materials and labour	AO Smith 80 USG Proterra (x2)	[$]	10,000
	Installation	[$]	6,000
	Electrical work	[$]	3,000
Contingency	Subtotal after Materials and labour	[$]	19,000
	General Contingency (50%)	[$]	9,500
Total	Total	[$]	28,500

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 95%.
- **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]	30,752	33,486	-2,734	-8.9
	Natural gas use	[m3/yr]	13,051	12,598	454	3.5
	Carbon offset use	[tCO2e/yr]	0	0	0	–
Equivalent energy use	Electricity energy	[kWh/yr]	30,752	33,486	-2,734	-8.9
	Natural gas energy	[kWh/yr]	137,780	132,992	4,788	3.5
	Total energy	[kWh/yr]	168,533	166,478	2,055	1.2
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.7	1.9	-0.15	-8.9
	Natural gas GHGs	[tCO2e/yr]	25.2	24.3	0.88	3.5
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	–
	Total GHGs	[tCO2e/yr]	26.9	26.2	0.73	2.7
Utility cost	Electricity utility cost	[$/yr]	3,051	3,322	-271	-8.9
	Natural gas utility cost	[$/yr]	3,393	3,275	118	3.5
	Carbon offsets utility cost	[$/yr]	0	0	0	–
	Federal carbon charge	[$/yr]	1,261	1,217	43.8	3.5
	Total utility cost	[$/yr]	7,705	7,814	-109	-1.4
Financial	Assumed life	[yrs]	15	15	–	–
	Project cost	[$]	0	28,500	–	–
	Incentive amount	[$]	0	113	–	–
	Incremental project cost	[$]	0	28,387	–	–
	Life cycle cost	[$]	170,908	209,386	–	–
	Net present value	[$]	0	-38,478	–	–
	Project cost per GHG reduction	[$yr/tCO2e]	–	39,151	–	–
	Simple payback period	[yr]	–	–	–	–

5.7 F1 conversion to ASHP with electric backup

Measure description

Existing condition

F1 contains a condensing, natural gas-fired burner complete with a DX coil. The DX coil is connected to AC1 on the exterior.

Opportunity

Replace the furnace 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 due to electricity having a lower GHG intensity than natural gas. Reduced natural gas use and increased electricity use would be expected as a result.

Design description

Overview

Replace existing Furnace/AC combo with a Cold Climate ASHP with backup electric resistance. The following units shall be supplied:

- Moovair - Central-Moov 5T Capacity with 20kW backup electric

Alternate manufacturers include Daikin, Mitsubishi, Panasonic, LG, Samsung, and Fujitsu.

Electrical

The ASHP with the electric backup will add approximately 12 kW of power to the existing system, which will put the system at 40.32 kW, which is approximately 53% of the full load of the electrical capacity of the building.

Panel A does not have the breaker capacity, and Panel B does not have the electrical capacity. Space will need to be made on Panel A to power another small 200A panel to accommodate the additional equipment.

Project cost estimate

Table 29: Project cost estimate (F1 conversion to ASHP with electric backup)

Category	Line item	Unit	Value
Construction	Supply	[$]	10,000
	Install	[$]	10,000
	Electrical contingency	[$]	20,000
	General requirements (25%)	[$]	10,000
Contingency	Subtotal after Construction	[$]	50,000
	Design Contingency (25%)	[$]	12,500
	Construction Contingency (10%)	[$]	5,000
Design, Contractors, PM	Subtotal after Contingency	[$]	67,500
	Engineering Design and Field Review (10%)	[$]	6,800
	Contractor Fee (7%)	[$]	4,700
Total	Total	[$]	79,000

Utility analysis

Utility analysis methodology

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

- **Baseline**: F1 provides space heating and cooling through natural gas-fired burners and DX, respectively. The existing heat efficiency and cooling COP are 98% and 4.7, respectively.
- **Proposed**: F1 provides 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 30: F1 conversion to ASHP with electric backup analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	30,752	43,468	-12,716	-41.3
	Natural gas use	[m3/yr]	13,051	11,089	1,963	15.0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	30,752	43,468	-12,716	-41.3
	Natural gas energy	[kWh/yr]	137,780	117,063	20,718	15.0
	Total energy	[kWh/yr]	168,533	160,531	8,002	4.7
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.7	2.4	-0.70	-41.3
	Natural gas GHGs	[tCO2e/yr]	25.2	21.4	3.8	15.0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	26.9	23.8	3.1	11.5
Utility cost	Electricity utility cost	[$/yr]	3,051	4,312	-1,261	-41.3
	Natural gas utility cost	[$/yr]	3,393	2,883	510	15.0
	Carbon offsets utility cost	[$/yr]	0	0	0	—
	Federal carbon charge	[$/yr]	1,261	1,071	190	15.0
	Total utility cost	[$/yr]	7,705	8,267	-562	-7.3
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[$]	0	79,000	—	—
	Incentive amount	[$]	0	15,800	—	—
	Incremental project cost	[$]	0	63,200	—	—
	Life cycle cost	[$]	170,908	272,496	—	—
	Net present value	[$]	0	-101,589	—	—
	Project cost per GHG reduction	[$yr/tCO2e]	—	20,467	—	—
	Simple payback period	[yr]	—	—	—	—

5.8 F1 conversion to ASHP with natural gas backup

Measure description

Existing condition

F1 contains a condensing, natural gas-fired burner complete with a DX coil. The DX coil is connected to AC1 on the exterior.

Opportunity

Replace the furnace 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 due to electricity having a lower GHG intensity than natural gas. Reduced natural gas use and increased electricity use would be expected as a result.

Design description

Overview

This measure adds a heat pump section to the gas-fired furnace located in the building 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. The following units shall be provided:

- Moovair indoor unit model CUB60 and outdoor unit model DMA60

Electrical

The ASHP will add approximately 12 kW of power to the existing system, which will put the system at 25 kW, which is approximately 25% of the full load of the electrical capacity of the building. Panel A does not have the breaker capacity, and Panel B does not have the electrical capacity. Space will need to be made on Panel A to power another small 200A panel to accommodate the additional equipment.

Project cost estimate

Table 31: Project cost estimate (F1 conversion to ASHP with natural gas backup)

Category	Line item	Unit	Value
Construction	Equipment	[$]	7,500
	Installation	[$]	8,000
	Electrical contingency	[$]	12,000
	General requirements (25%)	[$]	6,900
Contingency	Subtotal after Construction	[$]	34,400
	Design Contingency (25%)	[$]	8,600
	Construction Contingency (10%)	[$]	3,400
Design, Contractors, PM	Subtotal after Contingency	[$]	46,400
	Engineering Design and Field Review (10%)	[$]	4,600
	Contractor Fee (7%)	[$]	3,200
Total	Total	[$]	54,200

Utility analysis

Utility analysis methodology

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

- **Baseline**: F1 provides space heating and cooling through natural gas-fired burners and DX, respectively. The existing heat efficiency and cooling COP are 98% and 4.7, respectively.
- **Proposed**: F1 provides 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 32: F1 conversion to ASHP with natural gas backup analysis results summary

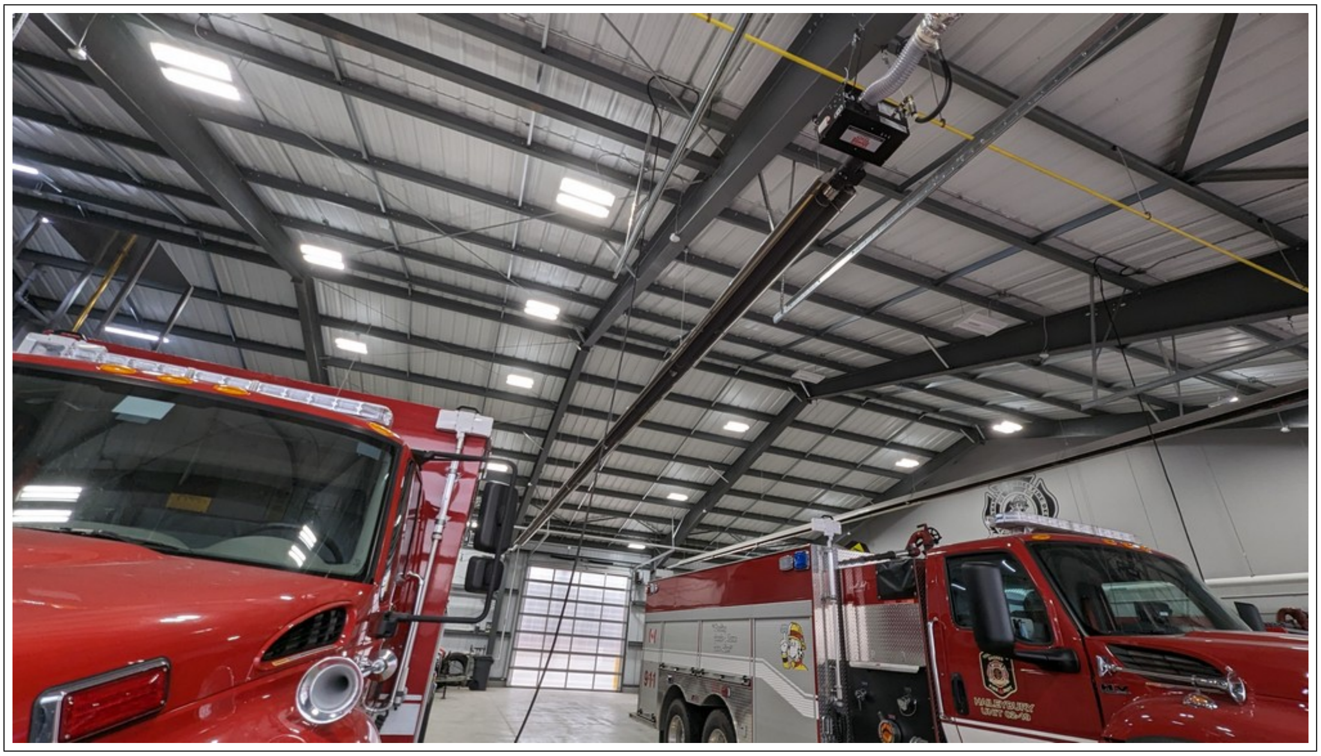
Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	30,752	38,413	-7,660	-24.9
	Natural gas use	[m3/yr]	13,051	11,741	1,310	10.0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	30,752	38,413	-7,660	-24.9
	Natural gas energy	[kWh/yr]	137,780	123,948	13,833	10.0
	Total energy	[kWh/yr]	168,533	162,360	6,172	3.7
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.7	2.1	-0.42	-24.9
	Natural gas GHGs	[tCO2e/yr]	25.2	22.7	2.5	10.0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	26.9	24.8	2.1	7.8
Utility cost	Electricity utility cost	[$/yr]	3,051	3,811	-760	-24.9
	Natural gas utility cost	[$/yr]	3,393	3,053	341	10.0
	Carbon offsets utility cost	[$/yr]	0	0	0	—
	Federal carbon charge	[$/yr]	1,261	1,134	127	10.0
	Total utility cost	[$/yr]	7,705	7,998	-293	-3.8
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[$]	0	54,200	—	—
	Incentive amount	[$]	0	10,840	—	—
	Incremental project cost	[$]	0	43,360	—	—
	Life cycle cost	[$]	170,908	238,009	—	—
	Net present value	[$]	0	-67,102	—	—
	Project cost per GHG reduction	[$yr/tCO2e]	—	20,573	—	—
	Simple payback period	[yr]	—	—	—	—

5.9 Infrared heaters to electric radiant

Measure description

Existing condition

Gas-fired infrared heaters serve the apparatus bay.



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 radiant tube heaters currently serving the apparatus bay. To match the existing service area of the gas-fired units, nine ceiling-hung 4.5 kW electric units will be required and located accordingly. The new unit controls are to implemented with a combination of occupancy/motion detection and manual enable. Electrical upgrades may be required to accommodate the new units.

Electrical

The radiant heaters will add approximately 40.5 kW of power to the existing system, which will put the system at 53.32 kW, which is approximately 69% of the full load of the electrical capacity of the building. Panel A does not have the breaker capacity, and Panel B does not have the electrical capacity. Space will need to be made on Panel A to power another small 200A panel to accommodate the additional equipment.

Project cost estimate

Table 33: Project cost estimate (Infrared heaters to electric radiant)

Category	Line item	Unit	Value
Construction	Supply and install	[$]	27,000
	Electrical	[$]	71,000
	General requirements (25%)	[$]	24,500
Contingency	Subtotal after Construction	[$]	122,500
	Design Contingency (25%)	[$]	30,600
	Construction Contingency (10%)	[$]	12,200
Design, Contractors, PM	Subtotal after Contingency	[$]	165,300
	Engineering Design and Field Review (10%)	[$]	16,500
	Contractor Fee (7%)	[$]	11,600
Total	Total	[$]	193,400

Utility analysis

Utility analysis methodology

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

- **Baseline**. The infrared heaters are gas-fired with an average thermal efficiency of 70%.
- **Proposed**. The infrared heaters are electric, with an efficiency of 100%.

Utility analysis results

Table 34: Infrared heaters to electric radiant analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	30,752	81,486	-50,733	-165
	Natural gas use	[m3/yr]	13,051	5,370	7,681	58.9
	Carbon offset use	[tCO2e/yr]	0	0	0	–
Equivalent energy use	Electricity energy	[kWh/yr]	30,752	81,486	-50,733	-165
	Natural gas energy	[kWh/yr]	137,780	56,693	81,087	58.9
	Total energy	[kWh/yr]	168,533	138,179	30,354	18.0
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.7	4.5	-2.8	-165
	Natural gas GHGs	[tCO2e/yr]	25.2	10.4	14.8	58.9
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	–
	Total GHGs	[tCO2e/yr]	26.9	14.9	12.0	44.7
Utility cost	Electricity utility cost	[$/yr]	3,051	8,083	-5,033	-165
	Natural gas utility cost	[$/yr]	3,393	1,396	1,997	58.9
	Carbon offsets utility cost	[$/yr]	0	0	0	–
	Federal carbon charge	[$/yr]	1,261	519	742	58.9
	Total utility cost	[$/yr]	7,705	9,999	-2,294	-29.8
Financial	Assumed life	[yrs]	15	15	–	–
	Project cost	[$]	0	193,400	–	–
	Incentive amount	[$]	0	38,680	–	–
	Incremental project cost	[$]	0	154,720	–	–
	Life cycle cost	[$]	170,908	456,764	–	–
	Net present value	[$]	0	-285,856	–	–
	Project cost per GHG reduction	[$yr/tCO2e]	–	12,859	–	–
	Simple payback period	[yr]	–	–	–	–

5.10 Roof upgrade to high performance

Measure description

Existing condition

The roof is a metal roof panel system with 12 inches of unfaced blanket insulation.

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

When inspecting the roof for deterioration, you can enhance its performance by following these steps: Remove the existing metal roofing, then add a layer of sheathing, followed by an air barrier and 8 to 12 inches of rigid insulation with thermally broken girts. Finally, install a new layer of metal roofing on top. By placing the insulation above the existing framing, you ensure that the performance is not compromised by the steel present within the insulating layer.

Project cost estimate

Table 35: Project cost estimate (Roof upgrade to high performance)

Category	Line item	Unit	Value
Construction	Roof replacement	[$]	316,000
	General requirements (25%)	[$]	79,000
Contingency	Subtotal after Construction	[$]	395,000
	Design Contingency (25%)	[$]	98,800
	Construction Contingency (10%)	[$]	39,500
Design, Contractors, PM	Subtotal after Contingency	[$]	533,300
	Engineering Design and Field Review (10%)	[$]	53,300
	Contractor Fee (7%)	[$]	37,300
Total	Total	[$]	623,900

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 0.024 BTU/hr.ft2.F (R41.7) was assumed.
- **Proposed**. An average roof U-value of 0.014 BTU/hr.ft2.F (R73.7) was assumed.

Utility analysis results

Table 36: Roof upgrade to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	30,752	30,618	134	0.44
	Natural gas use	[m3/yr]	13,051	12,512	539	4.1
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	30,752	30,618	134	0.44
	Natural gas energy	[kWh/yr]	137,780	132,090	5,690	4.1
	Total energy	[kWh/yr]	168,533	162,708	5,825	3.5
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.7	1.7	0.01	0.44
	Natural gas GHGs	[tCO2e/yr]	25.2	24.2	1.0	4.1
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	26.9	25.9	1.0	3.9
Utility cost	Electricity utility cost	[$/yr]	3,051	3,037	13.3	0.44
	Natural gas utility cost	[$/yr]	3,393	3,253	140	4.1
	Carbon offsets utility cost	[$/yr]	0	0	0	—
	Federal carbon charge	[$/yr]	1,261	1,209	52.1	4.1
	Total utility cost	[$/yr]	7,705	7,499	206	2.7
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[$]	0	623,900	—	—
	Incentive amount	[$]	0	124,780	—	—
	Incremental project cost	[$]	0	499,120	—	—
	Life cycle cost	[$]	170,908	695,238	—	—
	Net present value	[$]	0	-524,331	—	—
	Project cost per GHG reduction	[$yr/tCO2e]	—	475,787	—	—
	Simple payback period	[yr]	—	>20	—	—

5.11 Solar PV rooftop

Measure description

Existing condition

There is no solar PV on the roof and available roof space.

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.

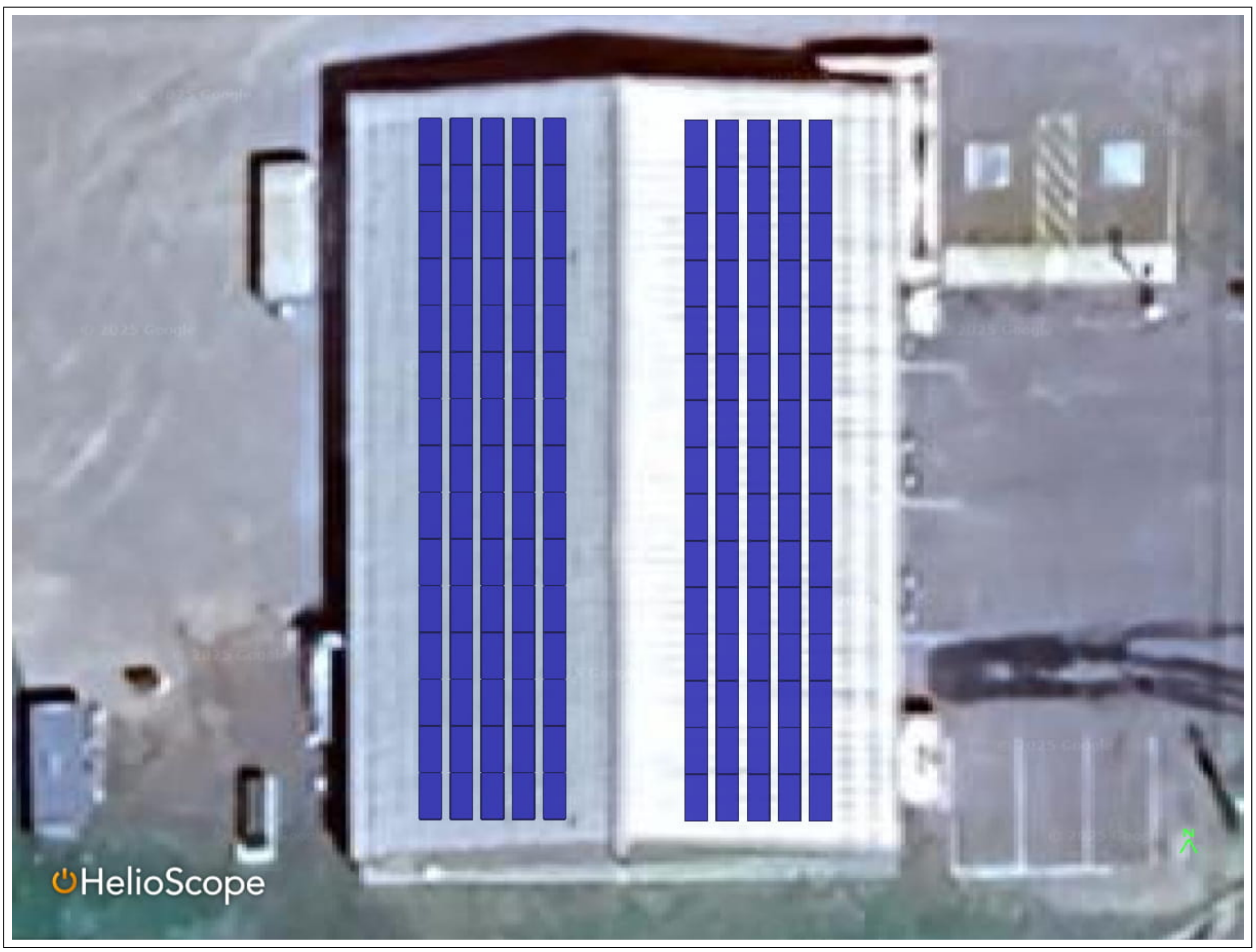
Utility-savings mechanism

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) = 64 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 incoming load of the solar. A service upgrade to a 208V -3P system would be required to accommodate the full solar load.

Project cost estimate

Table 37: Project cost estimate (Solar PV rooftop)

Category	Line item	Unit	Value
Materials and labour	Solar PV electricity system installed (assuming 64 kW at 2000 $/kW)	[$]	128,000
	Electrical	[$]	200,000
Contingency	Subtotal after Materials and labour	[$]	328,000
	General Contingency (20%)	[$]	65,600
	Design Contingency (10%)	[$]	32,800
Total	Total	[$]	426,400

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. Note that if this measure is installed as a standalone measure then the solar PV system should be reduced in size to avoid exporting net annual electricity to the grid.

Utility analysis results

Table 38: Solar PV rooftop analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	30,752	-41,568	72,321	235
	Natural gas use	[m3/yr]	13,051	13,051	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	–
Equivalent energy use	Electricity energy	[kWh/yr]	30,752	-41,568	72,321	235
	Natural gas energy	[kWh/yr]	137,780	137,780	0	0
	Total energy	[kWh/yr]	168,533	96,212	72,321	42.9
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.7	-2.3	4.0	235
	Natural gas GHGs	[tCO2e/yr]	25.2	25.2	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	–
	Total GHGs	[tCO2e/yr]	26.9	22.9	4.0	14.9
Utility cost	Electricity utility cost	[$/yr]	3,051	0	3,051	100
	Natural gas utility cost	[$/yr]	3,393	3,393	0	0
	Carbon offsets utility cost	[$/yr]	0	0	0	–
	Federal carbon charge	[$/yr]	1,261	1,261	0	0
	Total utility cost	[$/yr]	7,705	4,654	3,051	39.6
Financial	Assumed life	[yrs]	15	30	–	–
	Project cost	[$]	0	426,400	–	–
	Incentive amount	[$]	0	85,280	–	–
	Incremental project cost	[$]	0	341,120	–	–
	Life cycle cost	[$]	170,908	258,663	–	–
	Net present value	[$]	0	-87,755	–	–
	Project cost per GHG reduction	[$yr/tCO2e]	–	85,140	–	–
	Simple payback period	[yr]	–	>20	–	–

5.12 Temperature setpoint optimization

Measure description

Existing condition

There are several temperatures which can be relaxed to reduce energy consumption, including:

- The MUA is set to 71F (21.6C), which is higher than the infrared heaters. It is recommended that it be reduced to 12C minimum for the MUA and that the infrared setpoints be 18C.
- Room 201 temperature: Set to 20C; could be reduced to 15C.
- Infloor heating: Set to 23C; could be reduced to 18C or set to a schedule.
- F1 setpoint: The temperature increases from 18C to 21C in the evening; could be kept at 18C in the evenings.
- WH2 setpoint: Set to 150F; could be reduced to 140F.

Opportunity

Relax temperature setpoints where appropriate.

Utility-savings mechanism

Optimizing temperature setpoints will reduce heating and cooling energy use by not excessively conditioning an unoccupied space.

Design description

Overview

Optimize temperature setpoints.

It is assumed that staff can implement these changes. Therefore, no project cost is associated with this measure.

Project cost estimate

Table 39: Project cost estimate (Temperature setpoint optimization)

Category	Line item	Unit	Value
Materials and labour	Temperature setpoint optimization	[$]	0
Contingency	Subtotal after Materials and labour	[$]	0
	General Contingency (50%)	[$]	0
Total	Total	[$]	0

Utility analysis

Utility analysis methodology

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

- **Baseline**. The MUA is assumed to be set to an average temperature of 66F. The F1 setpoint is 21C (69.8F) in the evening. The WH2 setpoint is 150F.
- **Proposed**. The MUA is assumed to be set to an average temperature of 64F. The F1 setpoint is reduced to 18C (64.4F) in the evening. The WH2 setpoint is reduced to 140F.

Utility analysis results

Table 40: Temperature setpoint optimization analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	30,752	30,495	258	0.84
	Natural gas use	[m3/yr]	13,051	12,283	769	5.9
	Carbon offset use	[tCO2e/yr]	0	0	0	–
Equivalent energy use	Electricity energy	[kWh/yr]	30,752	30,495	258	0.84
	Natural gas energy	[kWh/yr]	137,780	129,666	8,114	5.9
	Total energy	[kWh/yr]	168,533	160,161	8,372	5.0
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.7	1.7	0.01	0.84
	Natural gas GHGs	[tCO2e/yr]	25.2	23.7	1.5	5.9
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	–
	Total GHGs	[tCO2e/yr]	26.9	25.4	1.5	5.6
Utility cost	Electricity utility cost	[$/yr]	3,051	3,025	25.6	0.84
	Natural gas utility cost	[$/yr]	3,393	3,194	200	5.9
	Carbon offsets utility cost	[$/yr]	0	0	0	–
	Federal carbon charge	[$/yr]	1,261	1,187	74.3	5.9
	Total utility cost	[$/yr]	7,705	7,405	300	3.9
Financial	Assumed life	[yrs]	15	15	–	–
	Project cost	[$]	0	0	–	–
	Incentive amount	[$]	0	0	–	–
	Incremental project cost	[$]	0	0	–	–
	Life cycle cost	[$]	170,908	166,520	–	–
	Net present value	[$]	0	4,388	–	–
	Project cost per GHG reduction	[$yr/tCO2e]	–	0	–	–
	Simple payback period	[yr]	–	0.0	–	–

5.13 Wall upgrade to high performance

Measure description

Existing condition

There are three main wall assembly types; two with 26 gauge stormseal pre-finished wall panels, and one with stone brick veneer.

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

In the future, approximately 20 years from now, it may be beneficial to enhance the building envelope. This could be achieved in one of two ways:

- By removing the existing metal siding and replacing it with insulated metal panels, provided the current girts are structurally strong enough to support them.
- By taking off the siding and installing a layer of sheathing. This could then be followed by either an Exterior Insulation and Finish System (EIFS) with an acrylic stucco finish, or by creating an air barrier on the sheathing and using thermally broken girts along with batt insulation and new metal siding.

In both scenarios, it will be necessary to assess the structural capacity of the girts.

Project cost estimate

Table 41: Project cost estimate (Wall upgrade to high performance)

Category	Line item	Unit	Value
Construction	Wall upgrade	[$]	686,000
	General requirements (25%)	[$]	171,500
Contingency	Subtotal after Construction	[$]	857,500
	Design Contingency (25%)	[$]	214,400
	Construction Contingency (10%)	[$]	85,800
Design, Contractors, PM	Subtotal after Contingency	[$]	1,157,700
	Engineering Design and Field Review (10%)	[$]	115,800
	Contractor Fee (7%)	[$]	81,000
Total	Total	[$]	1,354,500

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 0.042 BTU/hr.ft2.F (R23.8) was assumed.
- **Proposed**. An average wall U-value of 0.023 BTU/hr.ft2.F (R44) was assumed. Infiltration flow was assumed to be reduced by 10% in total relative to the Baseline for affected spaces.

Utility analysis results

Table 42: Wall upgrade to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	30,752	30,604	149	0.48
	Natural gas use	[m3/yr]	13,051	11,635	1,417	10.9
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	30,752	30,604	149	0.48
	Natural gas energy	[kWh/yr]	137,780	122,823	14,958	10.9
	Total energy	[kWh/yr]	168,533	153,426	15,106	9.0
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.7	1.7	0.01	0.48
	Natural gas GHGs	[tCO2e/yr]	25.2	22.5	2.7	10.9
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	26.9	24.2	2.7	10.2
Utility cost	Electricity utility cost	[$/yr]	3,051	3,036	14.8	0.48
	Natural gas utility cost	[$/yr]	3,393	3,025	368	10.9
	Carbon offsets utility cost	[$/yr]	0	0	0	—
	Federal carbon charge	[$/yr]	1,261	1,124	137	10.9
	Total utility cost	[$/yr]	7,705	7,185	520	6.7
Financial	Assumed life	[yrs]	15	75	—	—
	Project cost	[$]	0	1,354,500	—	—
	Incentive amount	[$]	0	270,900	—	—
	Incremental project cost	[$]	0	1,083,600	—	—
	Life cycle cost	[$]	170,908	514,549	—	—
	Net present value	[$]	0	-343,641	—	—
	Project cost per GHG reduction	[$yr/tCO2e]	—	394,587	—	—
	Simple payback period	[yr]	—	>20	—	—

5.14 Windows and doors to high performance

Measure description

Existing condition

The facility has aluminium framed, double pane, 6mm clear, low-e, and argon filled windows. The facility has swing doors with glazing, hollow metal doors, and overhead doors. The overhead doors utilize polycarbonate panelling.

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 the existing windows sometime in the future, with Passive House certified, triple-glazed thermally broken windows, in aluminum, wood or vinyl.

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 curtain wall/window 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.

All of the replacement doors should be installed with a transition membrane that connects the insulated frame with the air barrier on the walls, to prevent loss of thermal performance through air leakage.

Project cost estimate

Table 43: Project cost estimate (Windows and doors to high performance)

Category	Line item	Unit	Value
Construction	Window and door replacement	[$]	85,000
	General requirements (25%)	[$]	21,200
Contingency	Subtotal after Construction	[$]	106,200
	Design Contingency (25%)	[$]	26,600
	Construction Contingency (10%)	[$]	10,600
Design, Contractors, PM	Subtotal after Contingency	[$]	143,400
	Engineering Design and Field Review (10%)	[$]	14,300
	Contractor Fee (7%)	[$]	10,000
Total	Total	[$]	167,700

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 0.4 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 44: Windows and doors to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	30,752	30,701	51.7	0.17
	Natural gas use	[m3/yr]	13,051	10,839	2,213	17.0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	30,752	30,701	51.7	0.17
	Natural gas energy	[kWh/yr]	137,780	114,421	23,359	17.0
	Total energy	[kWh/yr]	168,533	145,122	23,411	13.9
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.7	1.7	0.00	0.17
	Natural gas GHGs	[tCO2e/yr]	25.2	20.9	4.3	17.0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	26.9	22.6	4.3	15.9
Utility cost	Electricity utility cost	[$/yr]	3,051	3,046	5.1	0.17
	Natural gas utility cost	[$/yr]	3,393	2,818	575	17.0
	Carbon offsets utility cost	[$/yr]	0	0	0	—
	Federal carbon charge	[$/yr]	1,261	1,047	214	17.0
	Total utility cost	[$/yr]	7,705	6,911	794	10.3
Financial	Assumed life	[yrs]	15	40	—	—
	Project cost	[$]	0	167,700	—	—
	Incentive amount	[$]	0	33,540	—	—
	Incremental project cost	[$]	0	134,160	—	—
	Life cycle cost	[$]	170,908	241,528	—	—
	Net present value	[$]	0	-70,620	—	—
	Project cost per GHG reduction	[$yr/tCO2e]	—	31,356	—	—
	Simple payback period	[yr]	—	>20	—	—

5.15 Measure risk analysis

Utility use sensitivity

Figure 104 indicates how sensitive cumulative electricity and natural gas use are to variations in each risk parameter.

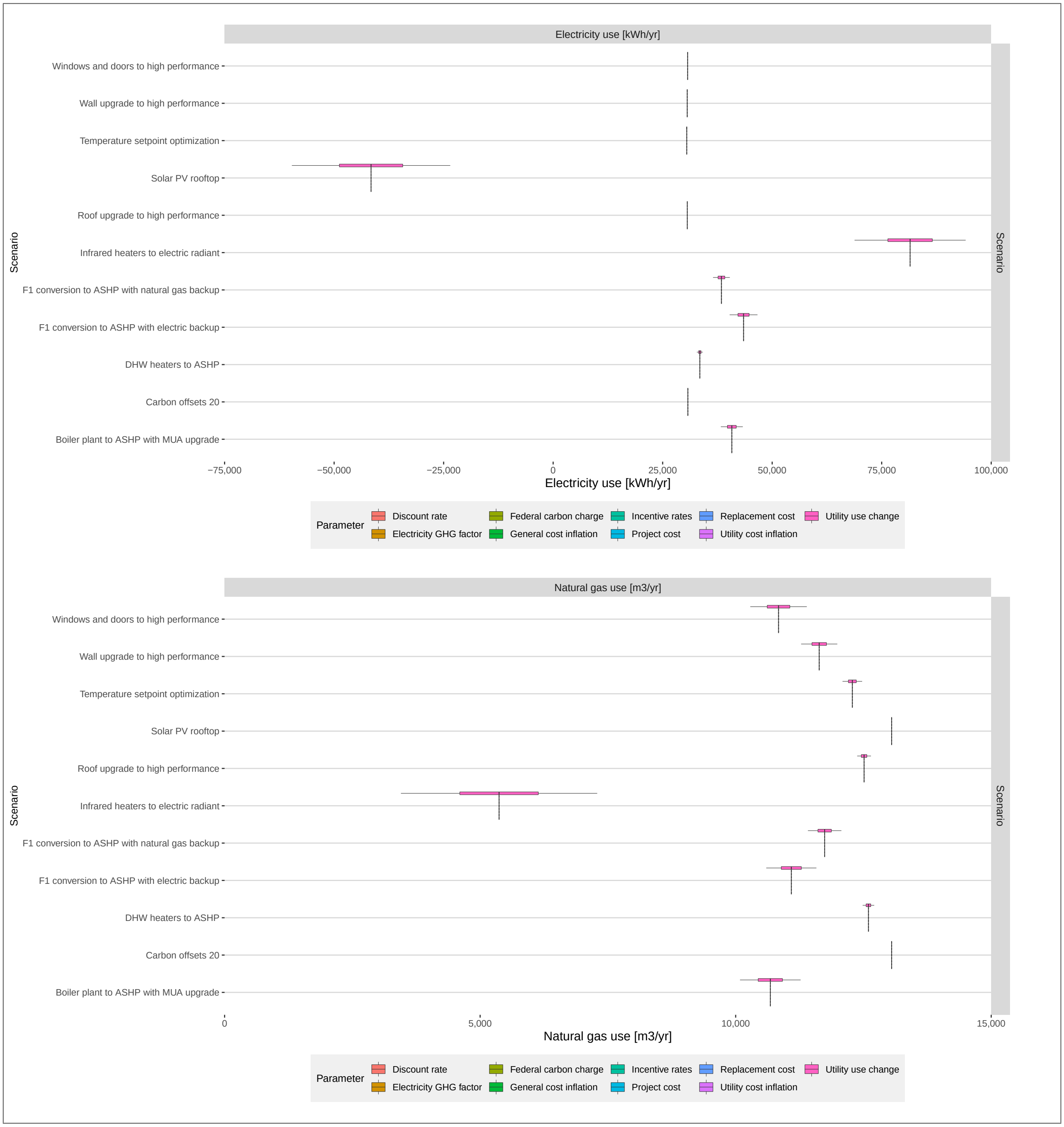


Figure 104: Utility cumulative use sensitivity analysis

GHG emissions and life cycle cost sensitivity

Figure 105 indicates how sensitive cumulative GHG emissions and life cycle costs are to variations in each risk parameter.

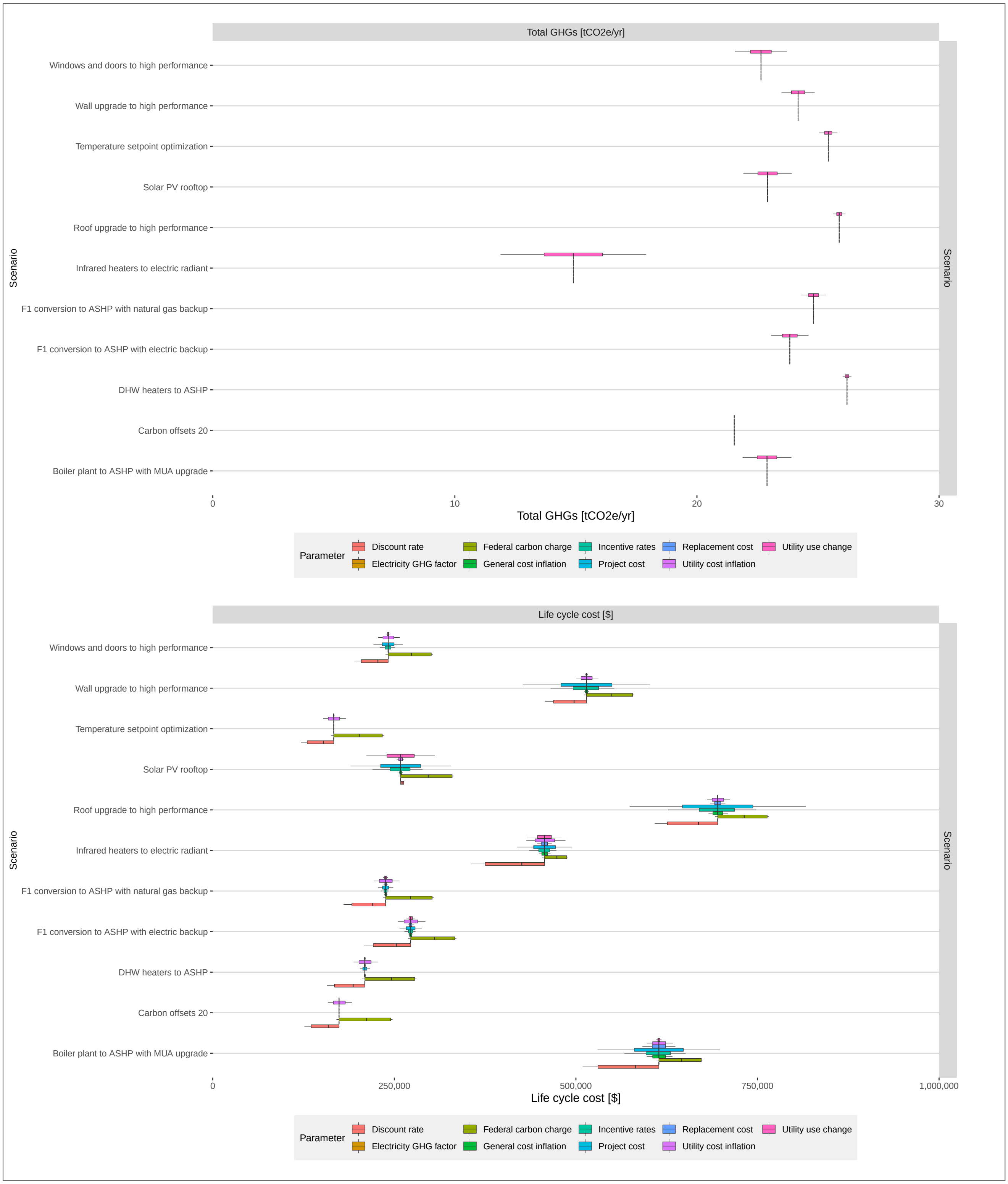


Figure 105: GHG cumulative emissions and life cycle cost sensitivity analysis

5.16 Measure analysis summary

For each analyzed measure, the analysis results are summarized in Table 45.

Table 45: 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**	**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]	[%]	[kWh/yr]	[%]	[tCO2e/yr]	[%]	[$/yr]	[%]	[yrs]	[$]	[$]	[$]	[$]	[$]	[$yr/tCO2e]	[yr]
Baseline	30,752	100.0	13,051	100.0	168,533	100.0	27	100.0	7,705	100.0	15	0	0	0	170,908	0	-	-
Boiler plant to ASHP with MUA upgrade	-10,034	-32.6	2,373	18.2	15,022	8.9	4	15.0	-149	-1.9	15	434,400	86,880	347,520	614,222	-443,314	86,224	-2,333
Carbon offsets 20	0	0.0	0	0.0	0	0.0	5	20.0	-162	-2.1	20	-	0	-	173,853	-2,946	-	-
DHW heaters to ASHP	-2,734	-8.9	454	3.5	2,055	1.2	1	2.7	-109	-1.4	15	28,500	113	28,387	209,386	-38,478	39,151	-259
F1 conversion to ASHP with electric backup	-12,716	-41.3	1,963	15.0	8,002	4.7	3	11.5	-562	-7.3	15	79,000	15,800	63,200	272,496	-101,589	20,467	-113
F1 conversion to ASHP with natural gas backup	-7,660	-24.9	1,310	10.0	6,172	3.7	2	7.8	-293	-3.8	15	54,200	10,840	43,360	238,009	-67,102	20,573	-148
Infrared heaters to electric radiant	-50,733	-165.0	7,681	58.9	30,354	18.0	12	44.7	-2,294	-29.8	15	193,400	38,680	154,720	456,764	-285,856	12,859	-67
Roof upgrade to high performance	134	0.4	539	4.1	5,825	3.5	1	3.9	206	2.7	20	623,900	124,780	499,120	695,238	-524,331	475,787	2,428
Solar PV rooftop	72,321	235.2	0	0.0	72,321	42.9	4	14.9	3,051	39.6	30	426,400	85,280	341,120	258,663	-87,755	85,140	112
Temperature setpoint optimization	258	0.8	769	5.9	8,372	5.0	1	5.6	300	3.9	15	0	0	0	166,520	4,388	0	0
Wall upgrade to high performance	149	0.5	1,417	10.9	15,107	9.0	3	10.2	520	6.7	75	1,354,500	270,900	1,083,600	514,549	-343,641	394,587	2,084
Windows and doors to high performance	52	0.2	2,213	17.0	23,411	13.9	4	15.9	794	10.3	40	167,700	33,540	134,160	241,528	-70,620	31,356	169
Total project cost	-	-	-	-	-	-	-	-	-	-	-	3,362,000	-	-	-	-	-	-
Boiler renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	30	10,000	0	10,000	179,003	-8,095	-	-
DHW renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	8,000	0	8,000	180,356	-9,448	-	-
Exterior walls renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	75	5,000	0	5,000	172,527	-1,619	-	-
Furnace renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	9,000	0	9,000	181,537	-10,630	-	-
Infrared renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	11,000	0	11,000	182,826	-11,919	-	-
MUA renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	67,000	0	67,000	243,504	-72,596	-	-
Roof renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	231,000	0	231,000	411,017	-240,109	-	-
Windows and doors renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	76,000	0	76,000	217,050	-46,143	-	-
BAU measure totals	-	-	-	-	-	-	-	-	-	-	-	417,000	-	-	-	-	-	-

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 46.
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 46.

Table 46: 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 106 and Table 47 present the results of this exercise, indicating which measures were assigned to which scenario.

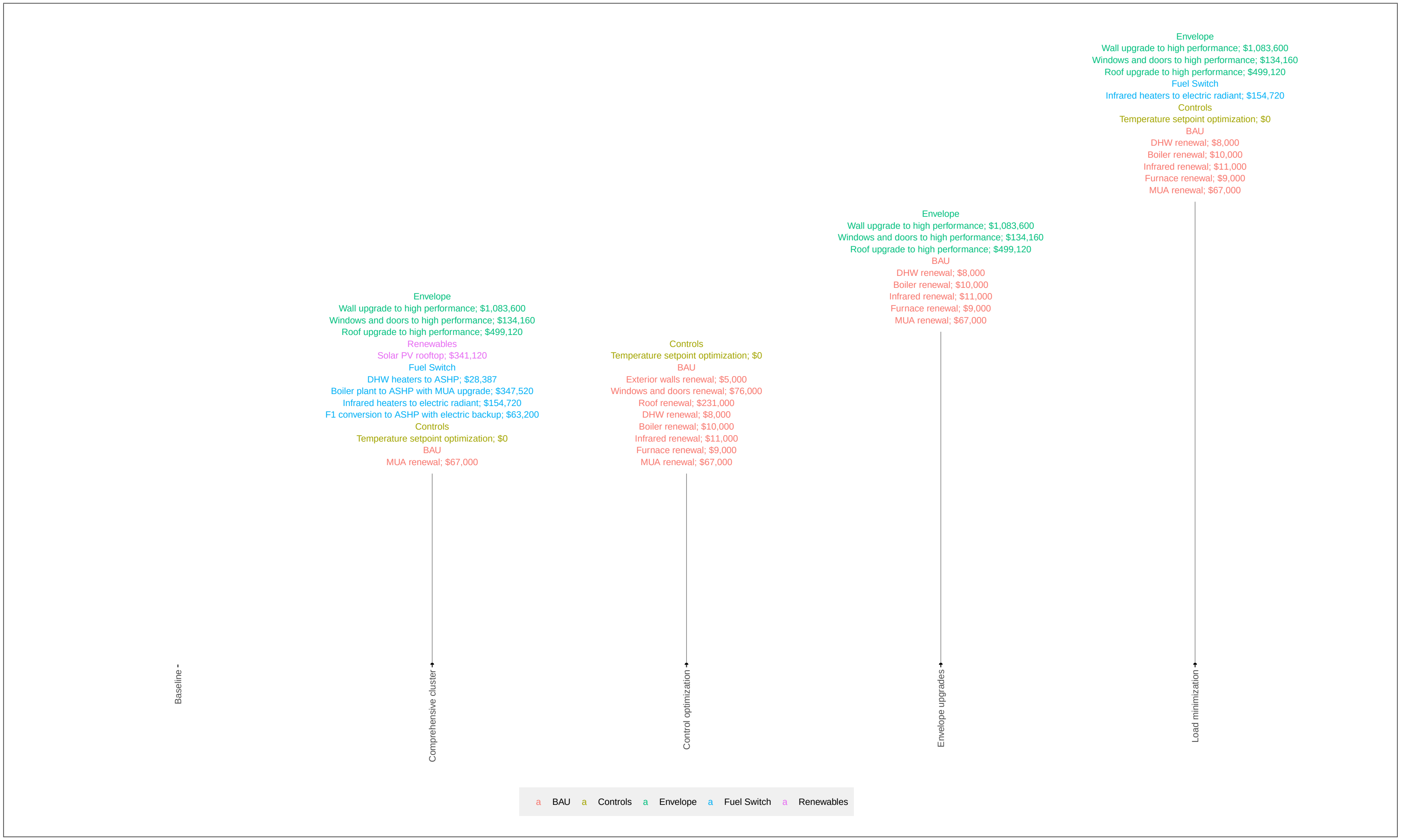


Figure 106: Scenario composition

Table 47: Cluster composition

Measure	Control optimization	Envelope upgrades	Load minimization	Comprehensive cluster
Boiler plant to ASHP with MUA upgrade	✖	✖	✖	✔
Carbon offsets 20	✖	✖	✖	✖
DHW heaters to ASHP	✖	✖	✖	✔
F1 conversion to ASHP with electric backup	✖	✖	✖	✔
F1 conversion to ASHP with natural gas backup	✖	✖	✖	✖
Infrared heaters to electric radiant	✖	✖	✔	✔
Roof upgrade to high performance	✖	✔	✔	✔
Solar PV rooftop	✖	✖	✖	✔
Temperature setpoint optimization	✔	✖	✔	✔
Wall upgrade to high performance	✖	✔	✔	✔
Windows and doors to high performance	✖	✔	✔	✔
Boiler renewal	✔	✔	✔	✖
DHW renewal	✔	✔	✔	✖
Exterior walls renewal	✔	✖	✖	✖
Furnace renewal	✔	✔	✔	✖
Infrared renewal	✔	✔	✔	✖
MUA renewal	✔	✔	✔	✔
Roof 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 48, 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 48: Scenario analysis summary

Measure ID		Utility use				Equivalent energy use		GHG emissions		Utility cost		Financial							
Scenario	**Measure name**	**Electricity use reduction**	**Electricity use reduction**	**Natural gas use reduction**	**Natural gas 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]	[%]	[kWh/yr]	[%]	[tCO2e/yr]	[%]	[$/yr]	[%]	[yrs]	[$]	[$]	[$]	[$]	[$]	[$yr/tCO2e]	[yr]
Comprehensive cluster	Combined	23,907	77.7	12,638	96.8	157,321	93.3	26	95.6	6,878	89.3	-	3,374,800	655,973	2,718,827	1,983,669	-1,812,761	105,605	395
Comprehensive cluster	Wall upgrade to high performance	149	0.5	1,417	10.9	15,107	9.0	3	10.2	520	6.7	75	1,354,500	270,900	1,083,600	514,549	-343,641	394,587	2,084
Comprehensive cluster	Windows and doors to high performance	52	0.2	2,213	17.0	23,411	13.9	4	15.9	794	10.3	40	167,700	33,540	134,160	241,528	-70,620	31,356	169
Comprehensive cluster	Roof upgrade to high performance	134	0.4	539	4.1	5,825	3.5	1	3.9	206	2.7	20	623,900	124,780	499,120	695,238	-524,331	475,787	2,428
Comprehensive cluster	Solar PV rooftop	72,321	235.2	0	0.0	72,321	42.9	4	14.9	3,051	39.6	30	426,400	85,280	341,120	258,663	-87,755	85,140	112
Comprehensive cluster	DHW heaters to ASHP	-2,734	-8.9	454	3.5	2,055	1.2	1	2.7	-109	-1.4	15	28,500	113	28,387	209,386	-38,478	39,151	-259
Comprehensive cluster	Boiler plant to ASHP with MUA upgrade	-10,034	-32.6	2,373	18.2	15,022	8.9	4	15.0	-149	-1.9	15	434,400	86,880	347,520	614,222	-443,314	86,224	-2,333
Comprehensive cluster	Infrared heaters to electric radiant	-50,733	-165.0	7,681	58.9	30,354	18.0	12	44.7	-2,294	-29.8	15	193,400	38,680	154,720	456,764	-285,856	12,859	-67
Comprehensive cluster	Temperature setpoint optimization	258	0.8	769	5.9	8,372	5.0	1	5.6	300	3.9	15	0	0	0	166,520	4,388	0	0
Comprehensive cluster	F1 conversion to ASHP with electric backup	-12,716	-41.3	1,963	15.0	8,002	4.7	3	11.5	-562	-7.3	15	79,000	15,800	63,200	272,496	-101,589	20,467	-113
Comprehensive cluster	MUA renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	67,000	0	67,000	243,504	-72,596	-	-
Control optimization	Combined	258	0.8	769	5.9	8,372	5.0	1	5.6	300	3.9	-	417,000	0	417,000	549,096	-378,188	278,079	1,392
Control optimization	Temperature setpoint optimization	258	0.8	769	5.9	8,372	5.0	1	5.6	300	3.9	15	0	0	0	166,520	4,388	0	0
Control optimization	Exterior walls renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	75	5,000	0	5,000	172,527	-1,619	-	-
Control optimization	Windows and doors renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	76,000	0	76,000	217,050	-46,143	-	-
Control optimization	Roof renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	231,000	0	231,000	411,017	-240,109	-	-
Control optimization	DHW renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	8,000	0	8,000	180,356	-9,448	-	-
Control optimization	Boiler renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	30	10,000	0	10,000	179,003	-8,095	-	-
Control optimization	Infrared renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	11,000	0	11,000	182,826	-11,919	-	-
Control optimization	Furnace renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	9,000	0	9,000	181,537	-10,630	-	-
Control optimization	MUA renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	67,000	0	67,000	243,504	-72,596	-	-
Envelope upgrades	Combined	283	0.9	3,745	28.7	39,820	23.6	7	26.9	1,364	17.7	-	2,251,100	429,220	1,821,880	1,167,861	-996,953	251,200	1,336
Envelope upgrades	Wall upgrade to high performance	149	0.5	1,417	10.9	15,107	9.0	3	10.2	520	6.7	75	1,354,500	270,900	1,083,600	514,549	-343,641	394,587	2,084
Envelope upgrades	Windows and doors to high performance	52	0.2	2,213	17.0	23,411	13.9	4	15.9	794	10.3	40	167,700	33,540	134,160	241,528	-70,620	31,356	169
Envelope upgrades	Roof upgrade to high performance	134	0.4	539	4.1	5,825	3.5	1	3.9	206	2.7	20	623,900	124,780	499,120	695,238	-524,331	475,787	2,428
Envelope upgrades	DHW renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	8,000	0	8,000	180,356	-9,448	-	-
Envelope upgrades	Boiler renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	30	10,000	0	10,000	179,003	-8,095	-	-
Envelope upgrades	Infrared renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	11,000	0	11,000	182,826	-11,919	-	-
Envelope upgrades	Furnace renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	9,000	0	9,000	181,537	-10,630	-	-
Envelope upgrades	MUA renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	67,000	0	67,000	243,504	-72,596	-	-
Load minimization	Combined	-26,797	-87.1	8,609	66.0	64,088	38.0	15	56.3	412	5.3	-	2,444,500	467,900	1,976,600	1,393,727	-1,222,820	130,456	4,798
Load minimization	Wall upgrade to high performance	149	0.5	1,417	10.9	15,107	9.0	3	10.2	520	6.7	75	1,354,500	270,900	1,083,600	514,549	-343,641	394,587	2,084
Load minimization	Windows and doors to high performance	52	0.2	2,213	17.0	23,411	13.9	4	15.9	794	10.3	40	167,700	33,540	134,160	241,528	-70,620	31,356	169
Load minimization	Roof upgrade to high performance	134	0.4	539	4.1	5,825	3.5	1	3.9	206	2.7	20	623,900	124,780	499,120	695,238	-524,331	475,787	2,428
Load minimization	Infrared heaters to electric radiant	-50,733	-165.0	7,681	58.9	30,354	18.0	12	44.7	-2,294	-29.8	15	193,400	38,680	154,720	456,764	-285,856	12,859	-67
Load minimization	Temperature setpoint optimization	258	0.8	769	5.9	8,372	5.0	1	5.6	300	3.9	15	0	0	0	166,520	4,388	0	0
Load minimization	DHW renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	8,000	0	8,000	180,356	-9,448	-	-
Load minimization	Boiler renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	30	10,000	0	10,000	179,003	-8,095	-	-
Load minimization	Infrared renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	11,000	0	11,000	182,826	-11,919	-	-
Load minimization	Furnace renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	9,000	0	9,000	181,537	-10,630	-	-
Load minimization	MUA renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	67,000	0	67,000	243,504	-72,596	-	-

Utility use comparison

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

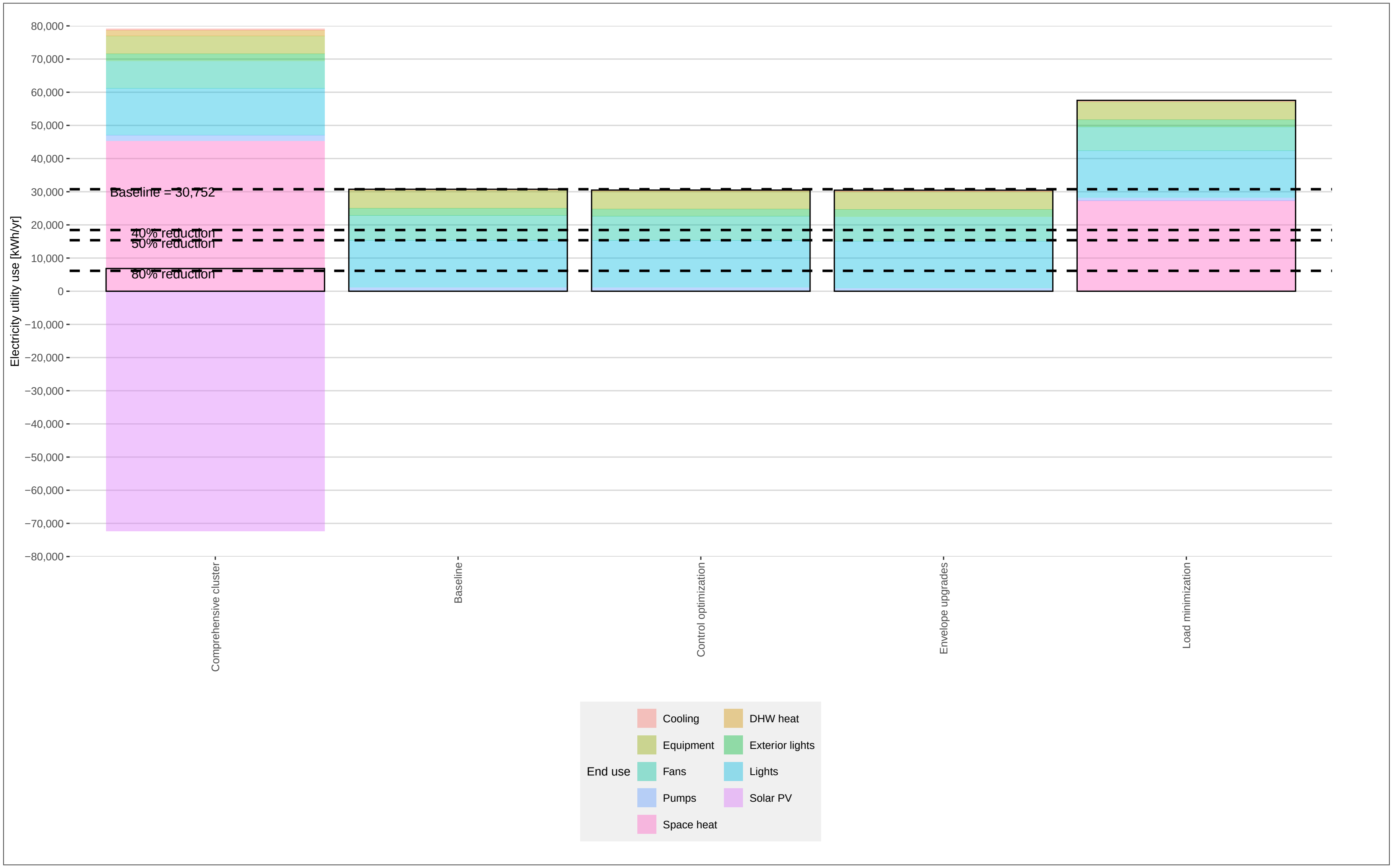


Figure 107: Electricity utility use expected yearly for each scenario by end use

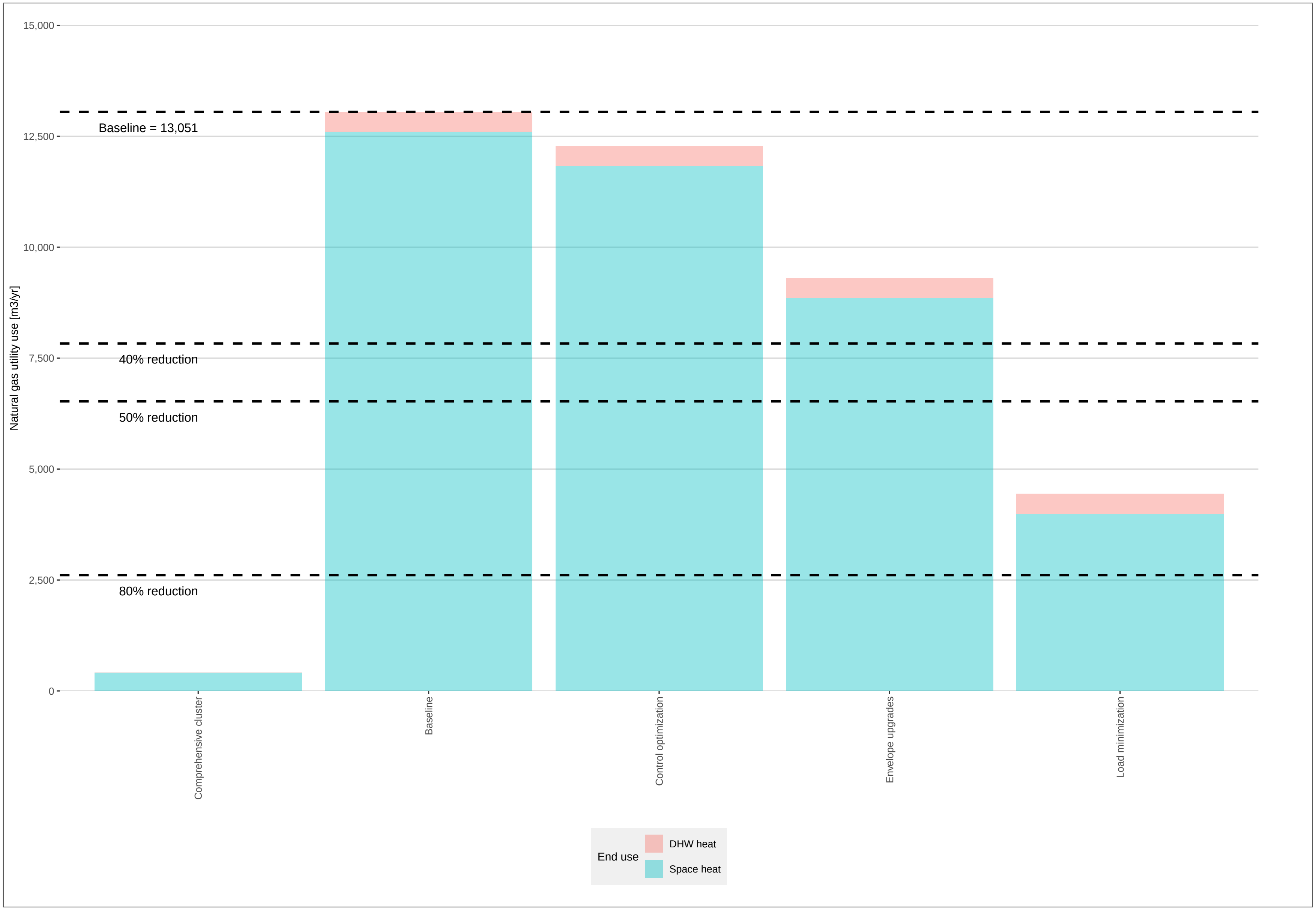


Figure 108: Natural gas utility use expected yearly for each scenario by end use

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.

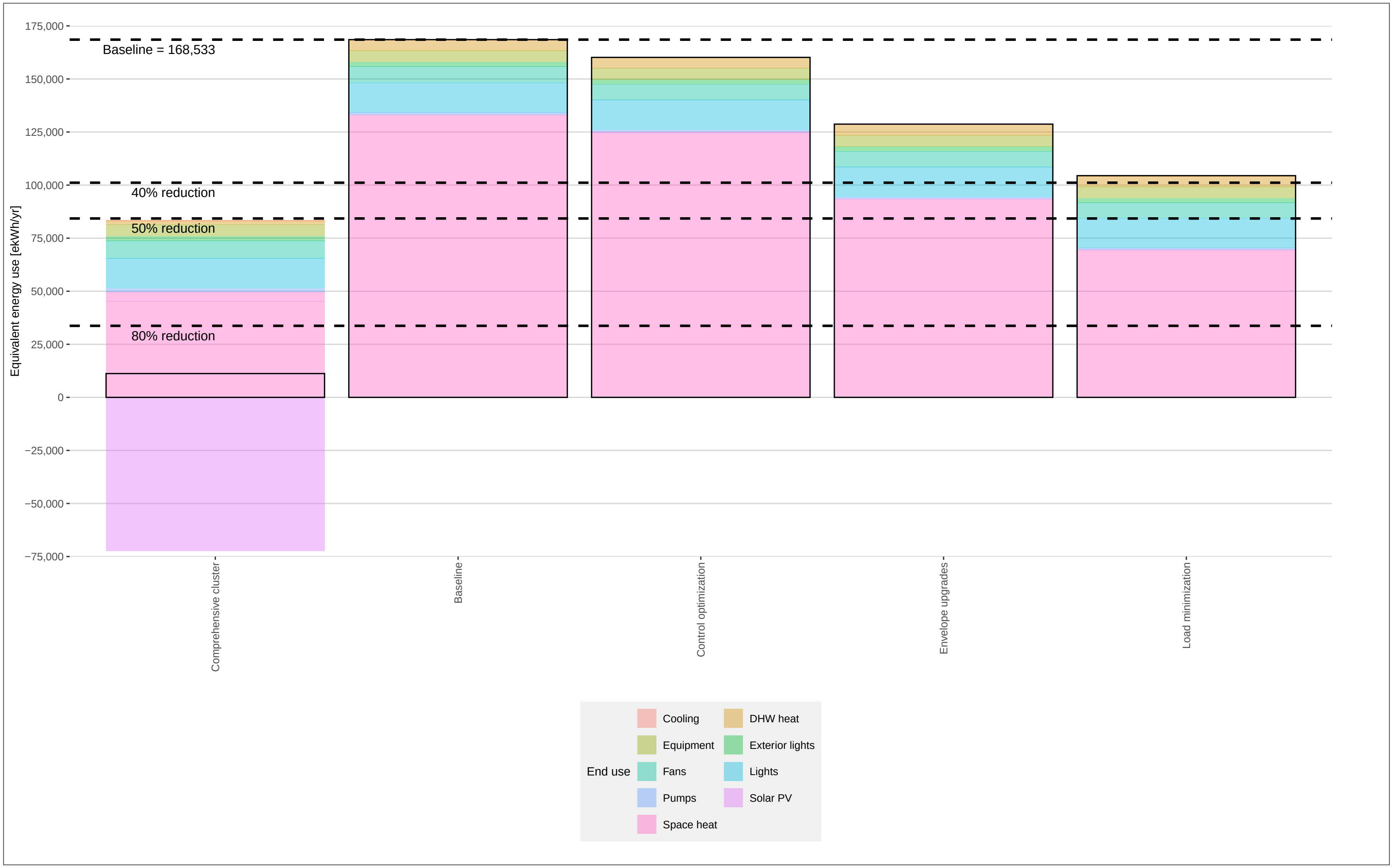


Figure 109: Equivalent energy use expected yearly for each scenario by end use

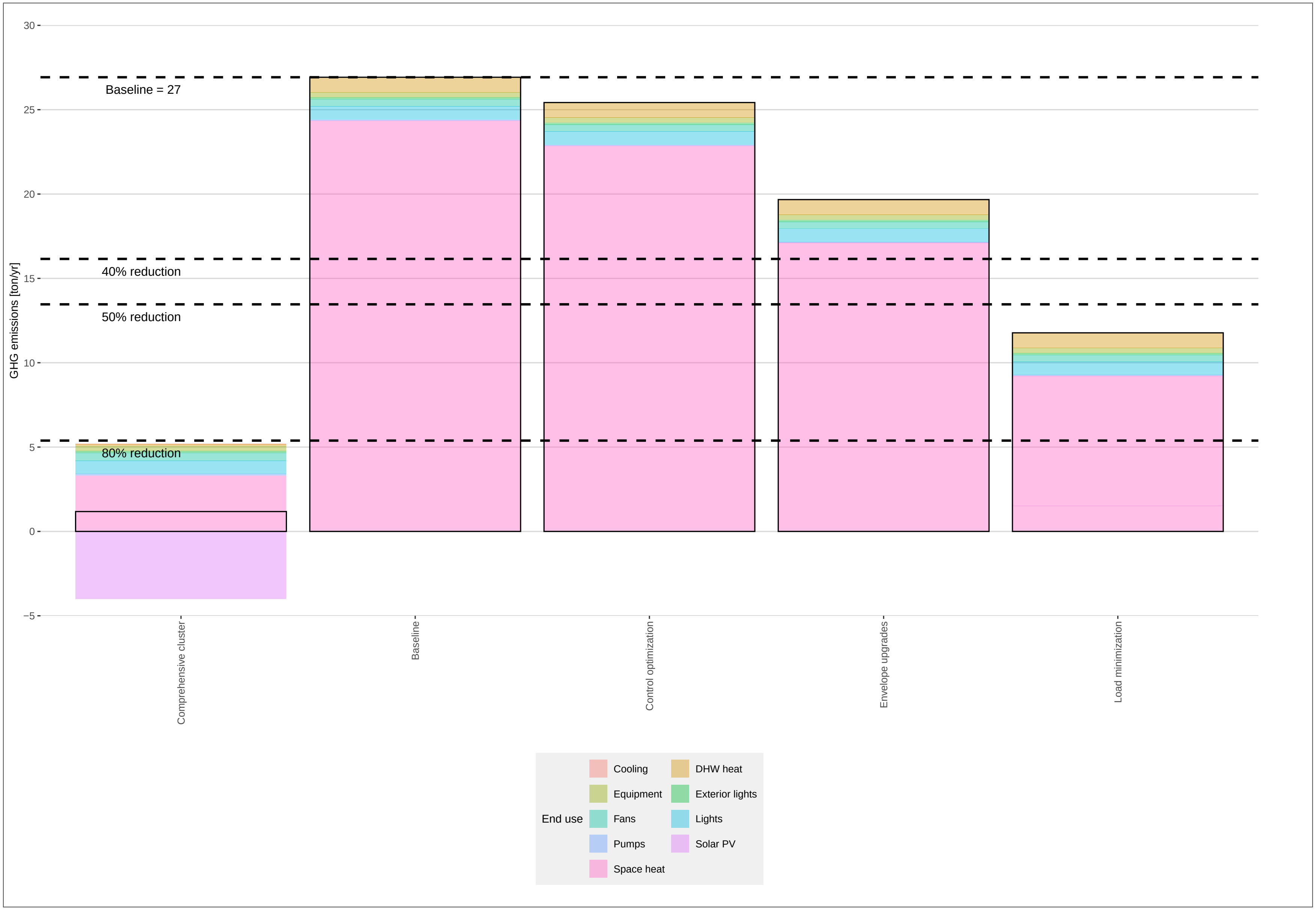


Figure 110: GHG emissions expected yearly for each scenario by end use

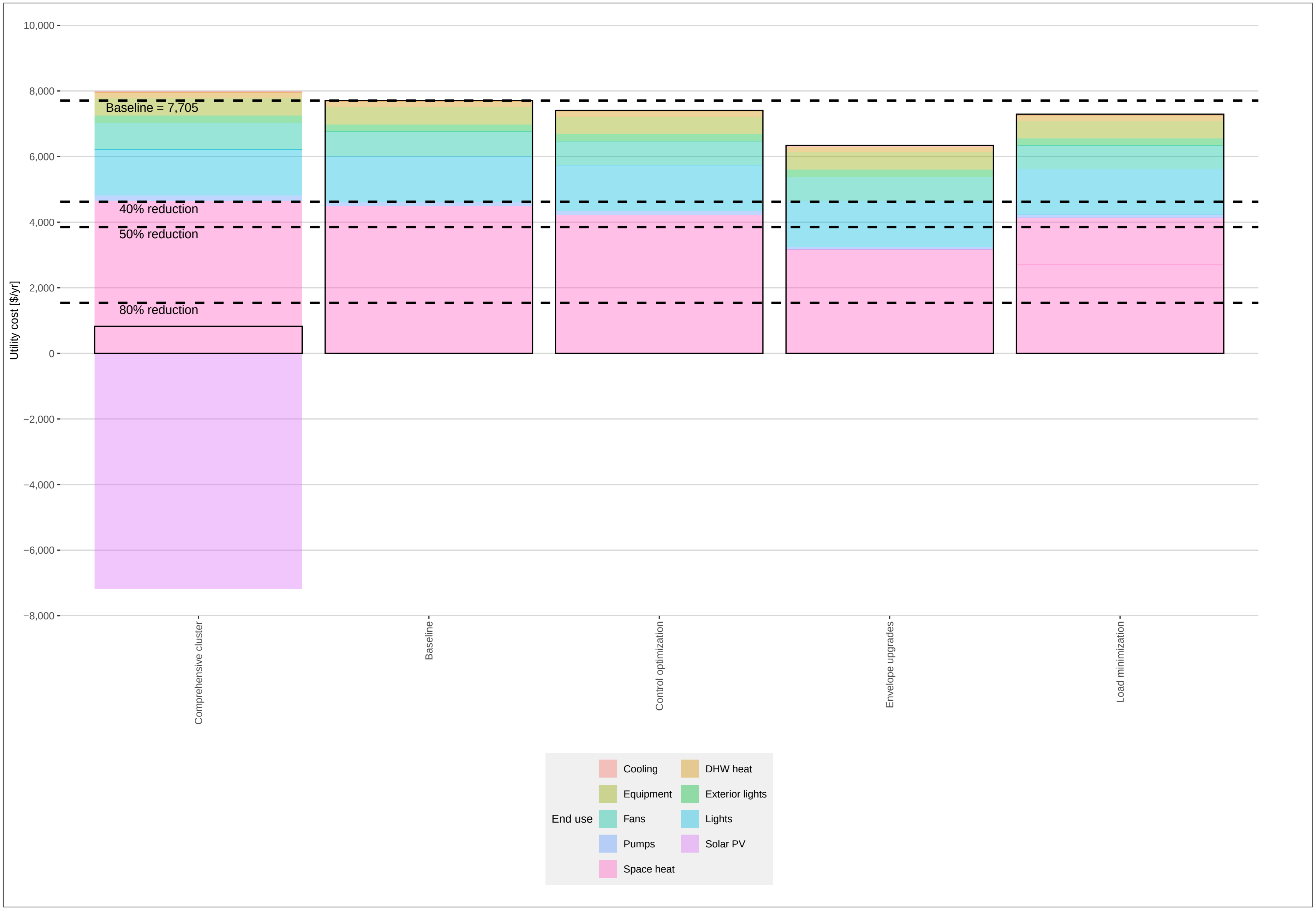


Figure 111: Utility costs expected yearly for each scenario by end use

Financial performance comparison

The following figures compare the financial performance between each scenario.

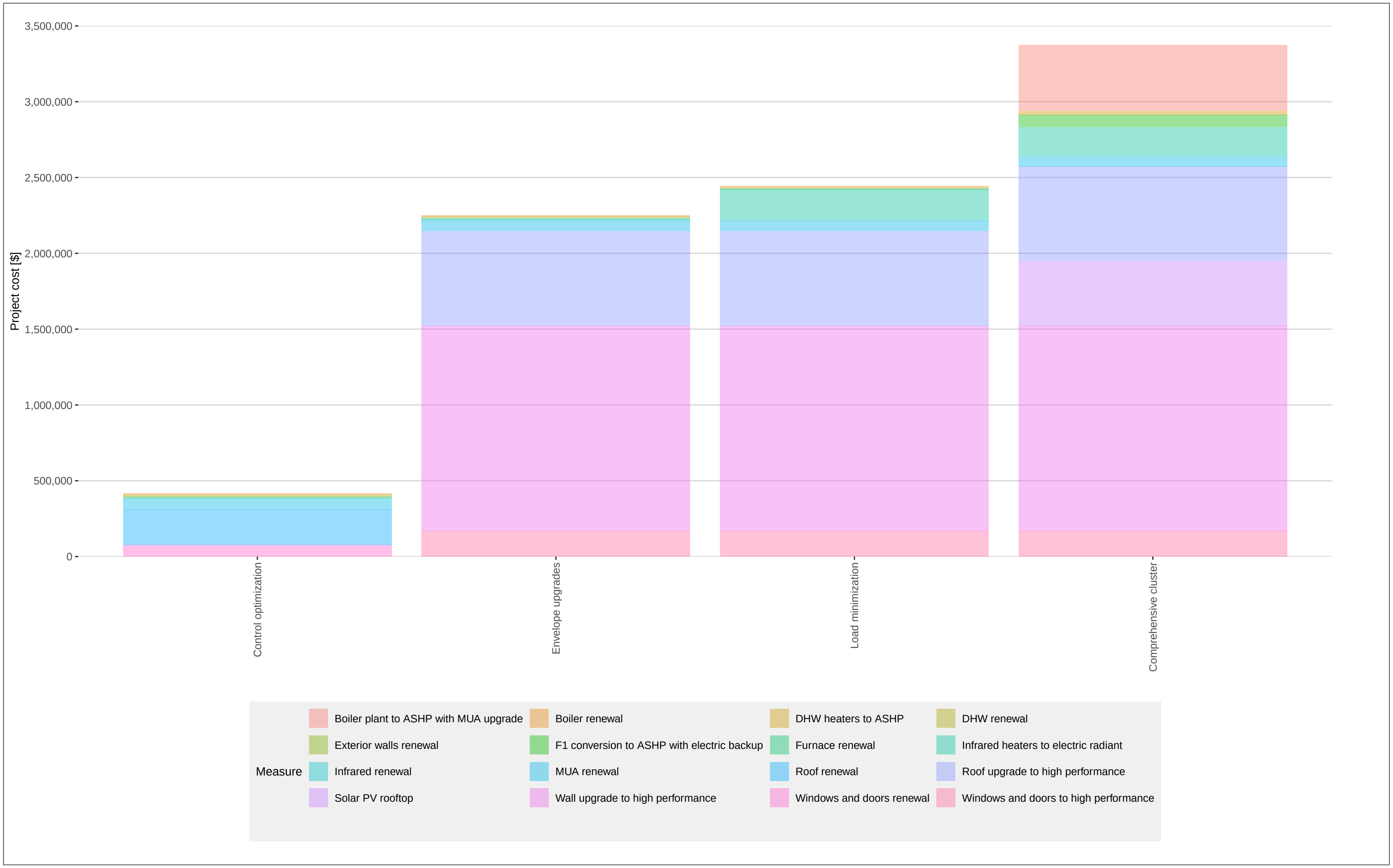


Figure 112: Project cost expected for each scenario by measure

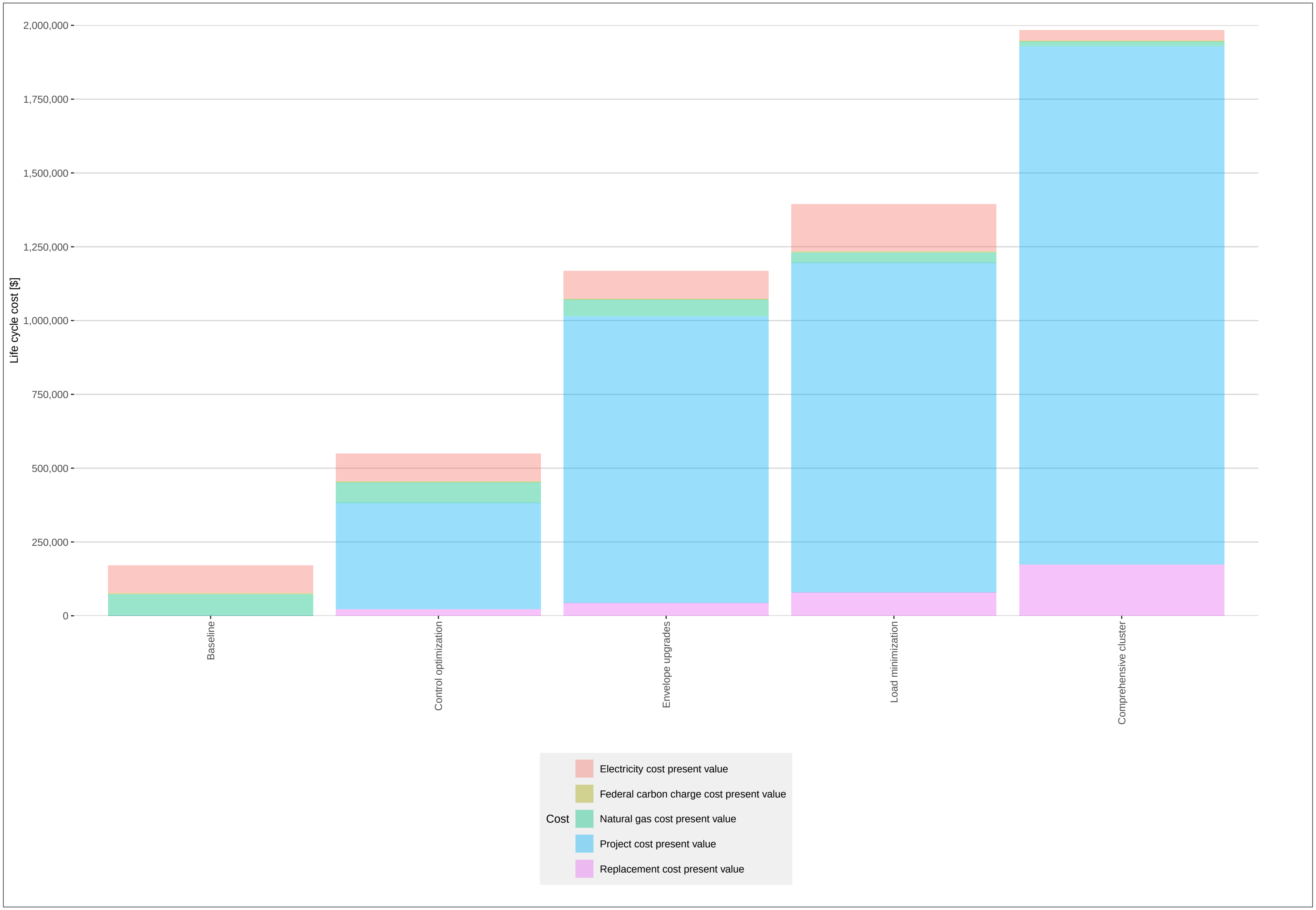


Figure 113: Life cycle cost expected for each scenario by cost item

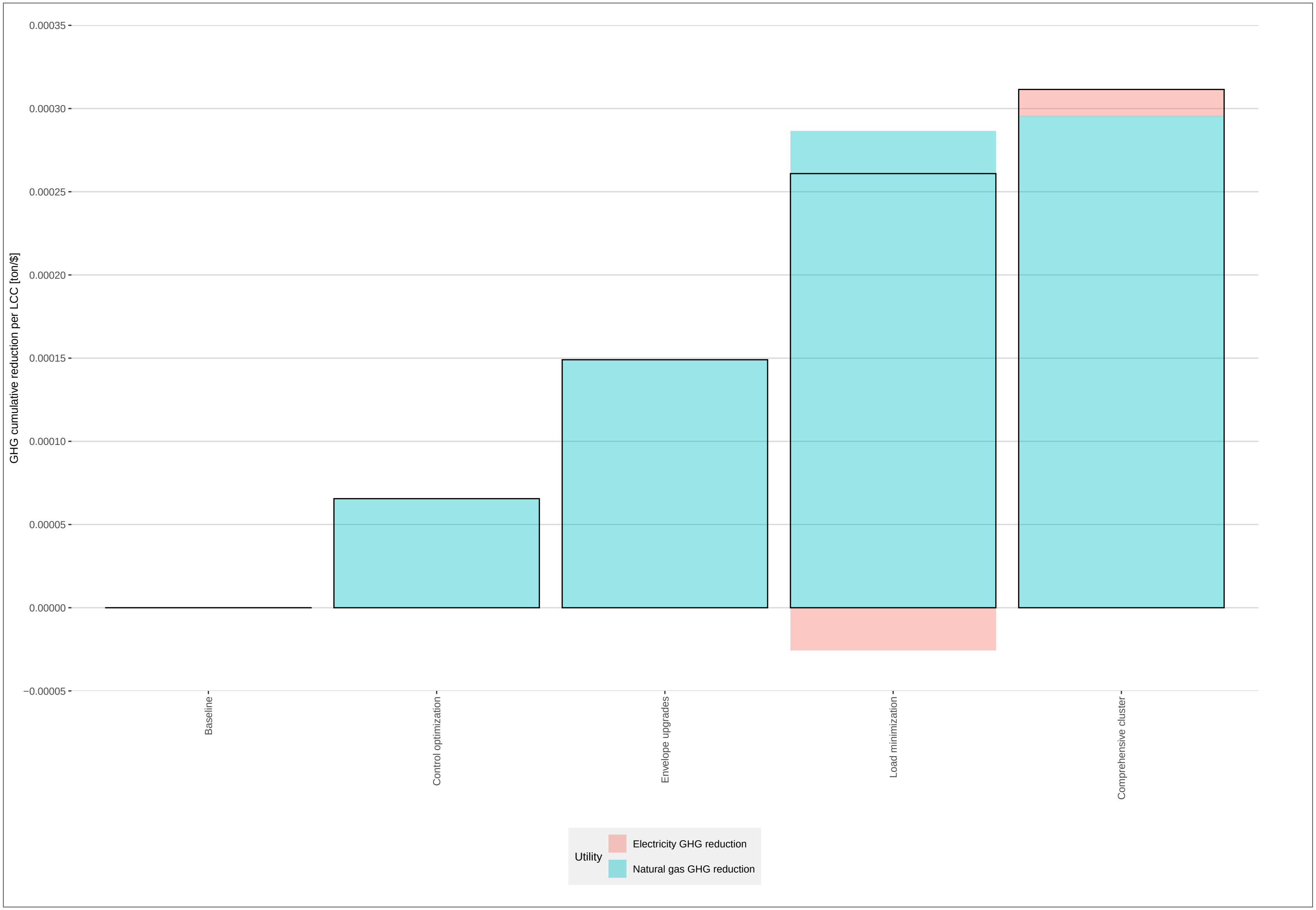


Figure 114: GHG cumulative reduction per life cycle cost (LCC) dollar expected for each scenario by utility

6.5 Plan scenario development

Plan scenario identification and objectives

The plan scenarios that were analyzed and their objectives are summarized in Table 49.

Table 49: 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 49. Results of the plan scenario composition are presented in Figure 115, 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 50 to 55.

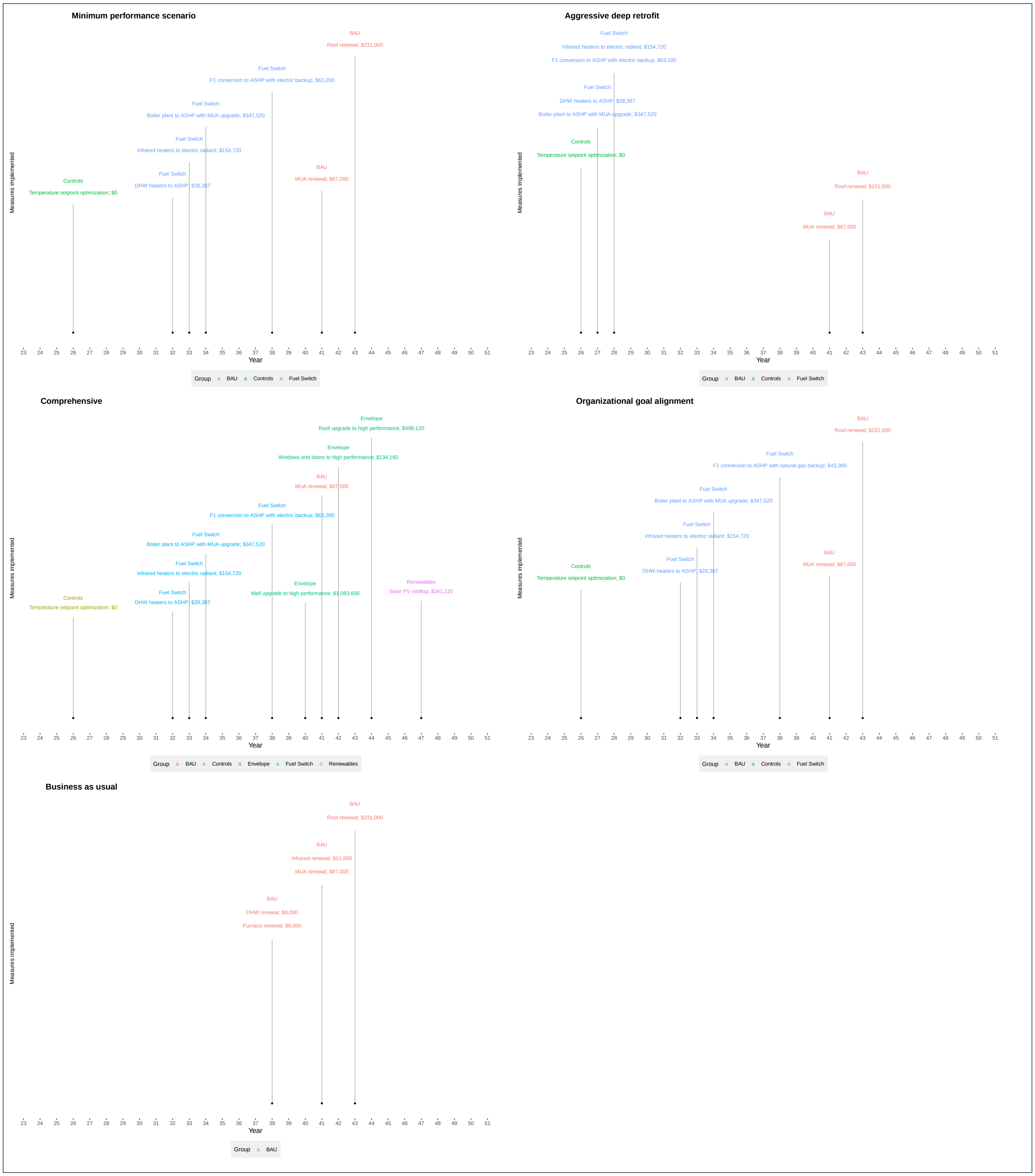


Figure 115: Plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

Table 50: Scenario composition summary

Measure	Minimum performance scenario	Aggressive deep retrofit	Comprehensive	Organizational goal alignment
Boiler plant to ASHP with MUA upgrade	✔	✔	✔	✔
Carbon offsets 20	✖	✖	✖	✖
DHW heaters to ASHP	✔	✔	✔	✔
F1 conversion to ASHP with electric backup	✔	✔	✔	✖
F1 conversion to ASHP with natural gas backup	✖	✖	✖	✔
Infrared heaters to electric radiant	✔	✔	✔	✔
Roof upgrade to high performance	✖	✖	✔	✖
Solar PV rooftop	✖	✖	✔	✖
Temperature setpoint optimization	✔	✔	✔	✔
Wall upgrade to high performance	✖	✖	✔	✖
Windows and doors to high performance	✖	✖	✔	✖
Boiler renewal	✖	✖	✖	✖
DHW renewal	✖	✖	✖	✖
Exterior walls renewal	✔	✔	✖	✔
Furnace renewal	✖	✖	✖	✖
Infrared renewal	✖	✖	✖	✖
MUA renewal	✔	✔	✔	✔
Roof renewal	✔	✔	✖	✔
Windows and doors renewal	✔	✔	✖	✔

Table 51: Minimum performance scenario measure implementation timeline

Measure	Year
Temperature setpoint optimization	2026
DHW heaters to ASHP	2032
Infrared heaters to electric radiant	2033
Boiler plant to ASHP with MUA upgrade	2034
F1 conversion to ASHP with electric backup	2038
MUA renewal	2041
Roof renewal	2043
Windows and doors renewal	2063
Exterior walls renewal	2098

Table 52: Aggressive deep retrofit measure implementation timeline

Measure	Year
Temperature setpoint optimization	2026
Boiler plant to ASHP with MUA upgrade	2027
DHW heaters to ASHP	2027
F1 conversion to ASHP with electric backup	2028
Infrared heaters to electric radiant	2028
MUA renewal	2041
Roof renewal	2043
Windows and doors renewal	2063
Exterior walls renewal	2098

Table 53: Comprehensive measure implementation timeline

Measure	Year
Temperature setpoint optimization	2026
DHW heaters to ASHP	2032
Infrared heaters to electric radiant	2033
Boiler plant to ASHP with MUA upgrade	2034
F1 conversion to ASHP with electric backup	2038
Wall upgrade to high performance	2040
MUA renewal	2041
Windows and doors to high performance	2042
Roof upgrade to high performance	2044
Solar PV rooftop	2047

Table 54: Organizational goal alignment measure implementation timeline

Measure	Year
Temperature setpoint optimization	2026
DHW heaters to ASHP	2032
Infrared heaters to electric radiant	2033
Boiler plant to ASHP with MUA upgrade	2034
F1 conversion to ASHP with natural gas backup	2038
MUA renewal	2041
Roof renewal	2043
Windows and doors renewal	2063
Exterior walls renewal	2098

Table 55: Business as usual measure implementation timeline

Measure	Year
DHW renewal	2038
Furnace renewal	2038
Infrared renewal	2041
MUA renewal	2041
Roof renewal	2043
Boiler renewal	2053
Windows and doors renewal	2063
Exterior walls renewal	2098

6.6 Plan performance analysis

Figures 116 through 119 present the projected yearly electricity use, natural gas use, GHG emissions and life cycle costs associated with each plan scenario.

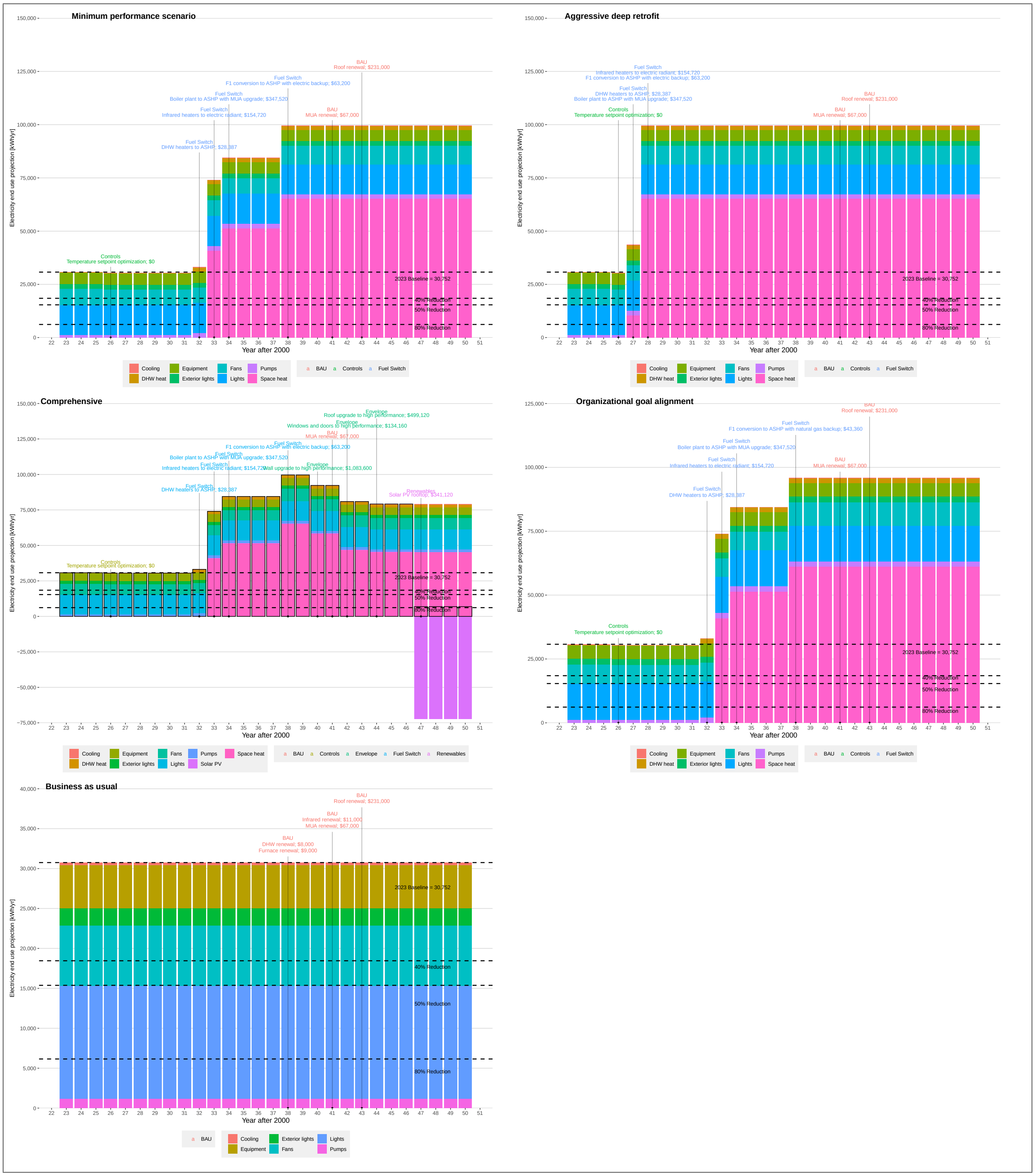


Figure 116: Electricity yearly utility use projection for each scenario

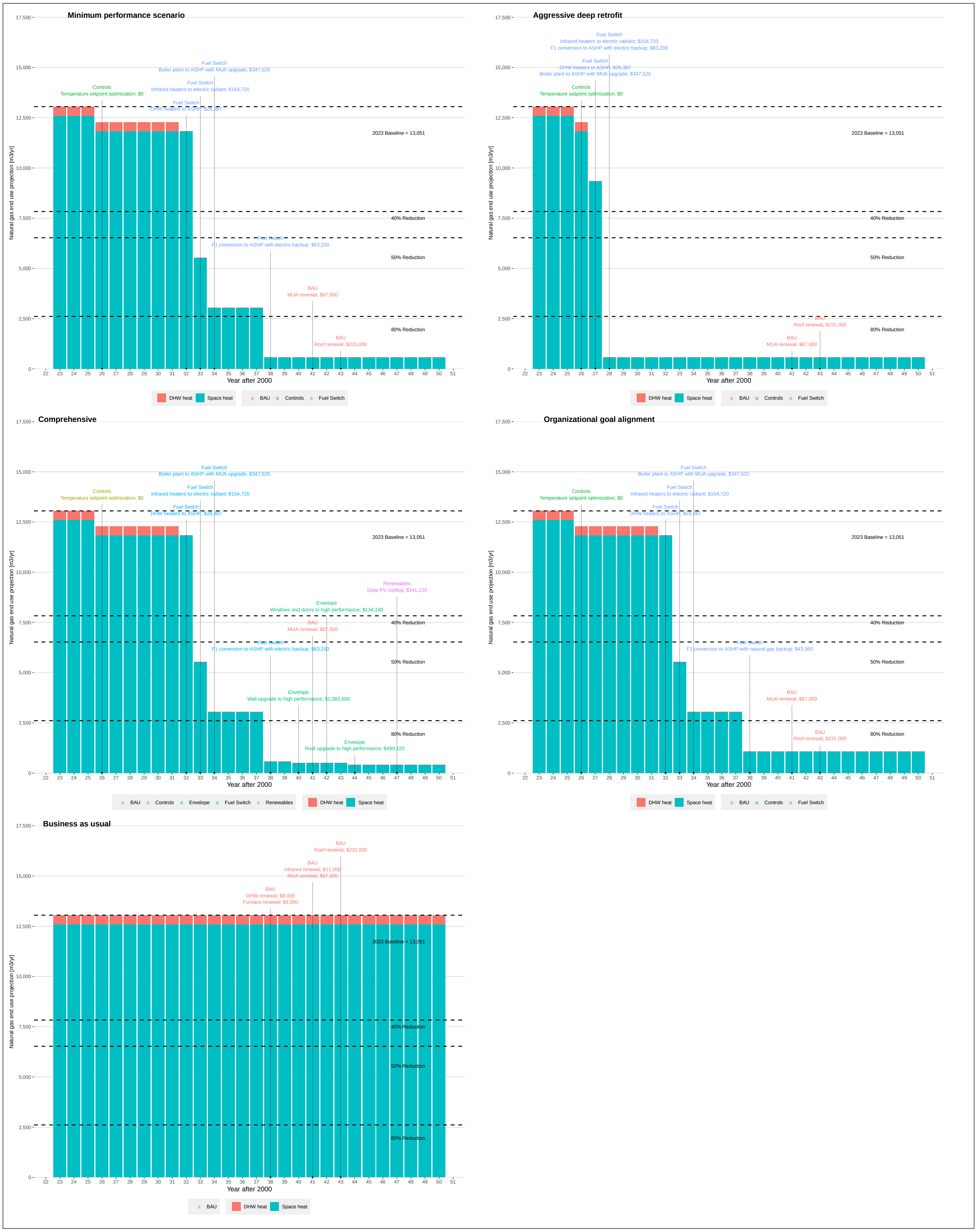


Figure 117: Natural gas yearly utility use projection for each scenario

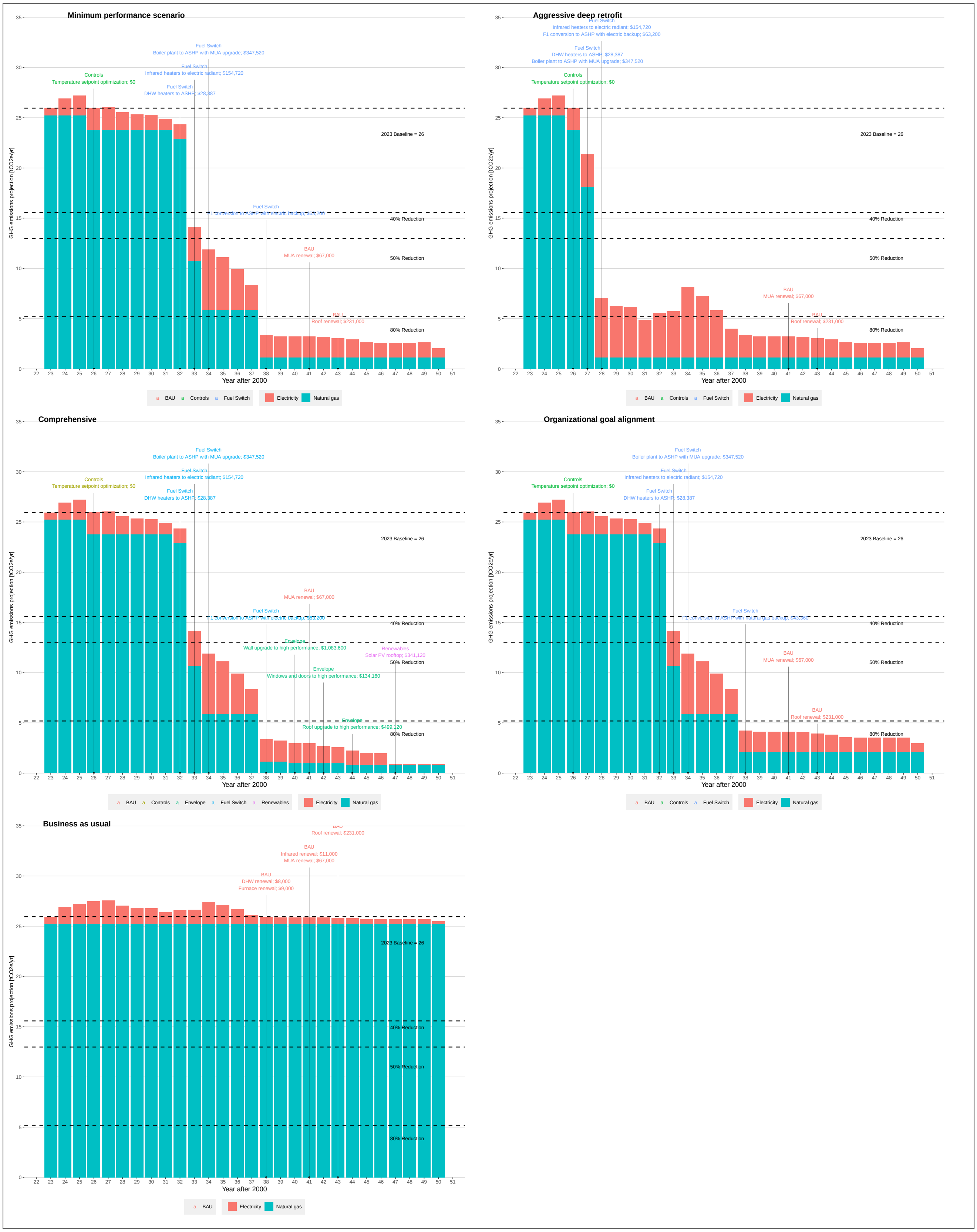


Figure 118: GHG yearly emissions projection for each scenario

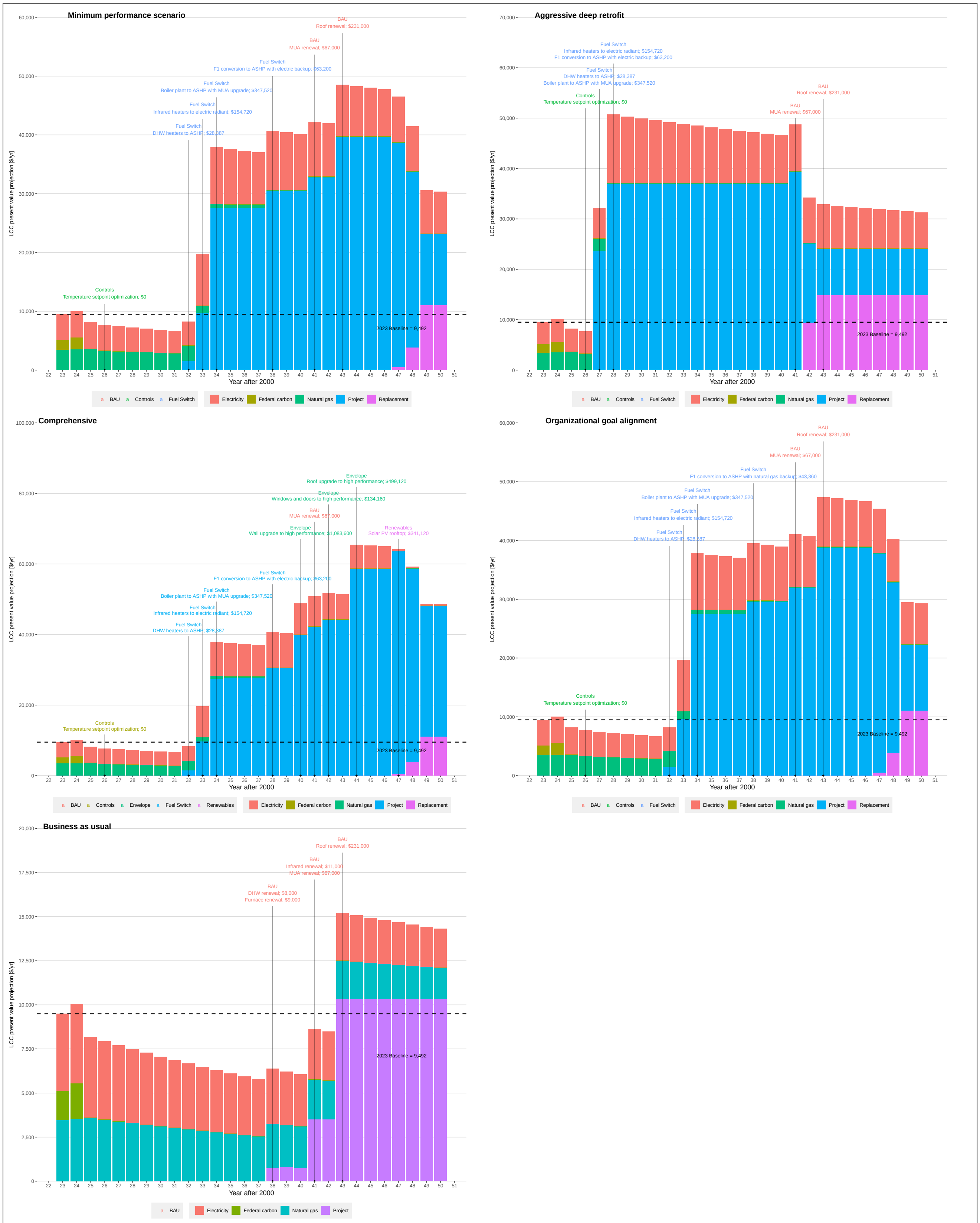


Figure 119: Life cycle yearly cost (after discounting to present value) projection for each scenario

6.7 Plan performance summary

Plan performance summary

Table 56 summarizes the performance of each plan scenario with respect to utility use, GHG emissions, utility cost, and financial metrics. The first half of Table 56 represents the estimated performance in the final year (2050) of the evaluation period. The second half of Table 56 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 56 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 119).

Table 56: 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]	99,629	99,629	6,845	95,898	30,752
	Electricity monthly peak (av)	[kW]	42.4	42.4	37.4	40.0	6.9
	Electricity yearly peak (max)	[kW]	61.7	61.7	58.7	56.0	7.4
	Natural gas use	[m3/yr]	575	575	414	1,072	13,051
GHG emissions final	Electricity GHGs	[tCO2e/yr]	0.95	0.95	0.07	0.91	0.29
	Natural gas GHGs	[tCO2e/yr]	1.1	1.1	0.8	2.1	25.2
	Carbon offsets GHGs	[tCO2e/yr]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e/yr]	2.1	2.1	0.9	3.0	25.5
Utility cost final	Electricity utility cost	[$/yr]	24,290	24,290	1,669	23,380	7,497
	Natural gas utility cost	[$/yr]	260	260	187	485	5,907
	Carbon offsets utility cost	[$/yr]	0.00	0.00	0.00	0.00	0.00
	Federal carbon charge	[$/yr]	0.00	0.00	0.00	0.00	0.00
	Total utility cost	[$/yr]	24,550	24,550	1,856	23,865	13,405
Utility use cumulative	Electricity use	[kWh]	2,015,366	2,457,785	1,530,712	1,966,860	861,069
	Natural gas use	[m3]	149,869	74,000	148,490	156,329	365,440
GHG emissions cumulative	Electricity GHGs	[tCO2e]	60.7	82.9	53.6	59.9	31.6
	Natural gas GHGs	[tCO2e]	290	143	287	302	706
	Carbon offsets GHGs	[tCO2e]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e]	350	226	341	362	738
Utility cost cumulative	Electricity utility cost	[$]	404,138	478,023	291,896	393,608	162,754
	Natural gas utility cost	[$]	45,082	21,584	44,504	47,685	128,224
	Carbon offsets utility cost	[$]	0.00	0.00	0.00	0.00	0.00
	Federal carbon charge	[$]	3,657	3,657	3,657	3,657	3,657
	Total utility cost	[$]	452,876	503,263	340,057	444,950	294,635
Financial cumulative	Project cost	[$]	1,302,581	1,192,576	4,598,566	1,270,500	458,994
	Replacement cost	[$]	523,869	518,613	523,869	523,869	0
	Life cycle cost	[$]	795,433	1,038,268	948,694	780,491	263,103

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 Haileybury Fire Hall could achieve, based on the measures that were analyzed under this Pathway to Decarbonization Feasibility Study.

7 END