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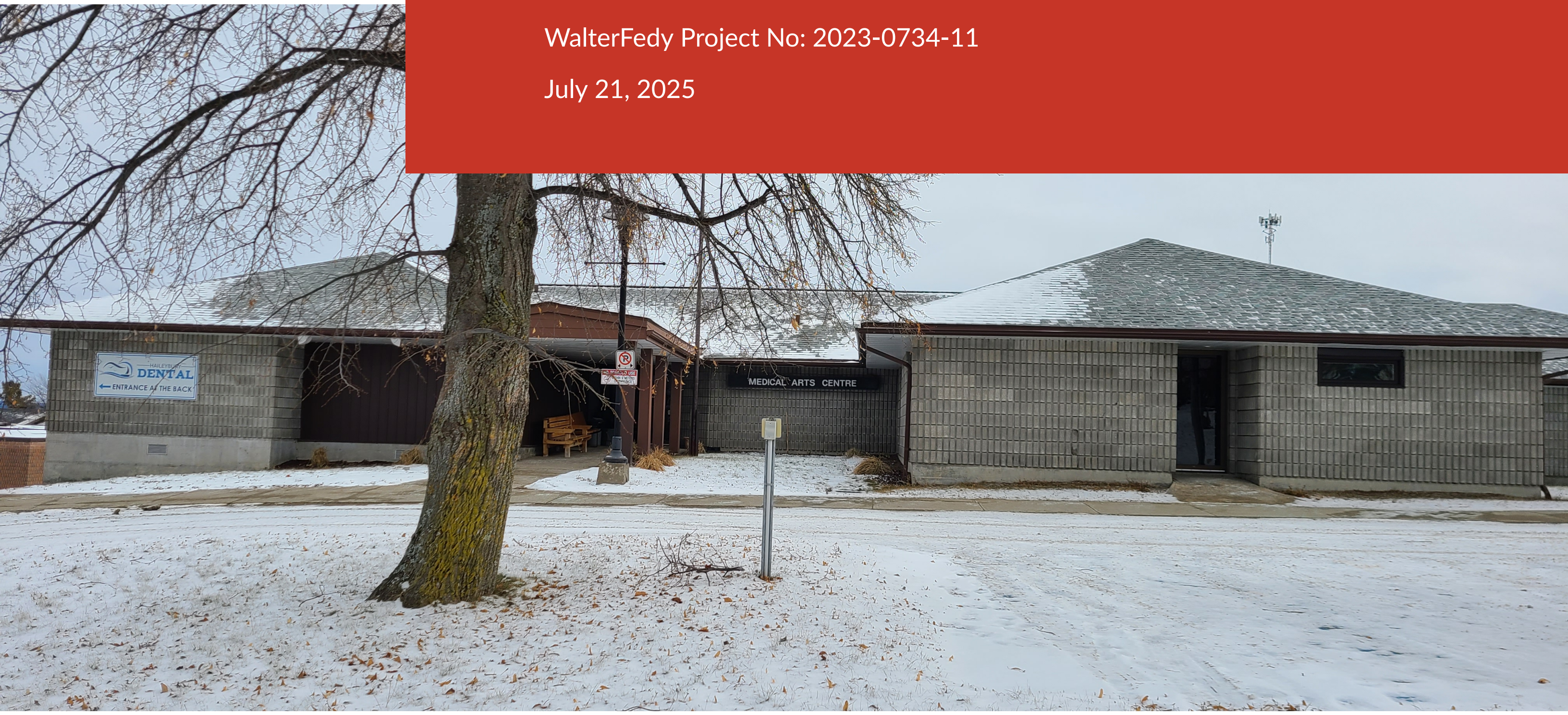
# PATHWAY TO DECARBONIZATION FEASIBILITY STUDY

## CITY OF TEMISKAMING SHORES

HAILEYBURY MEDICAL CENTRE
95 Meridian 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 Medical Centre, which is located at 95 Meridian 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 Medical Centre. The objective of this engagement is to identify and analyze measures that reduce utility use, GHG emissions, and utility costs at the Haileybury Medical Centre, 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 2024-04-17 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 Medical Centre. 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 Medical Centre 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.

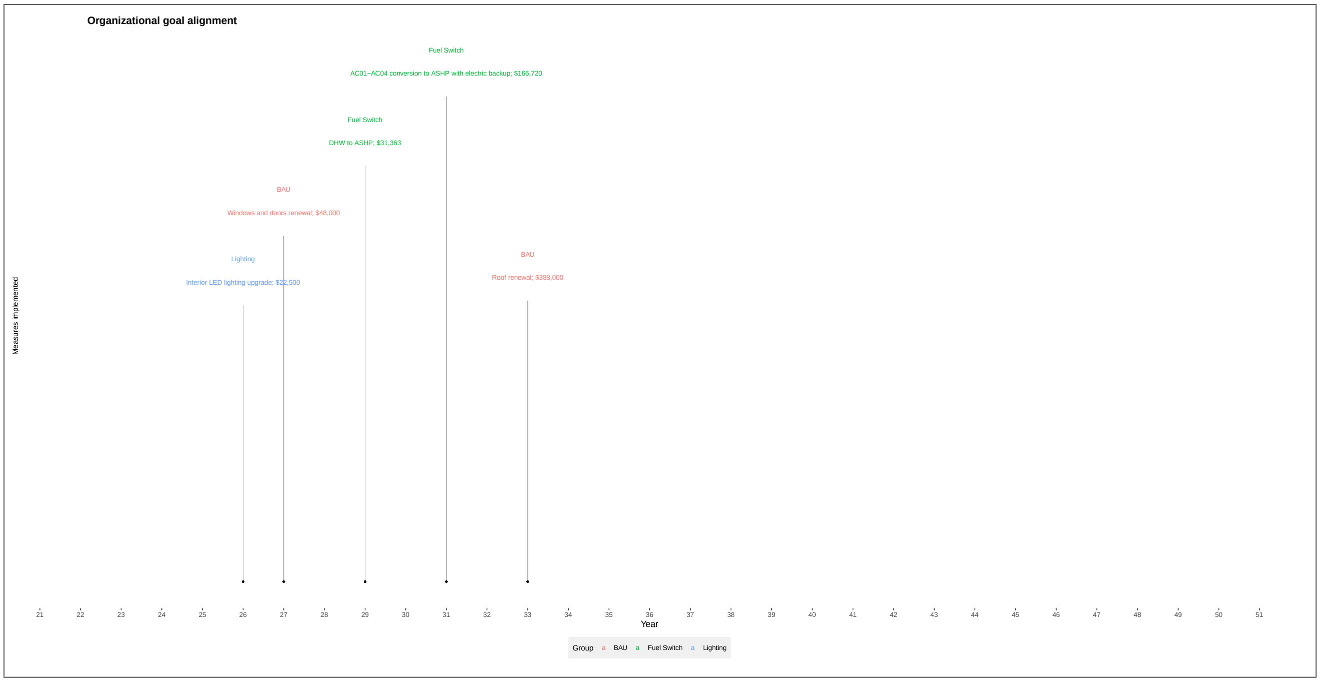


Figure 1: Recommended plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

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

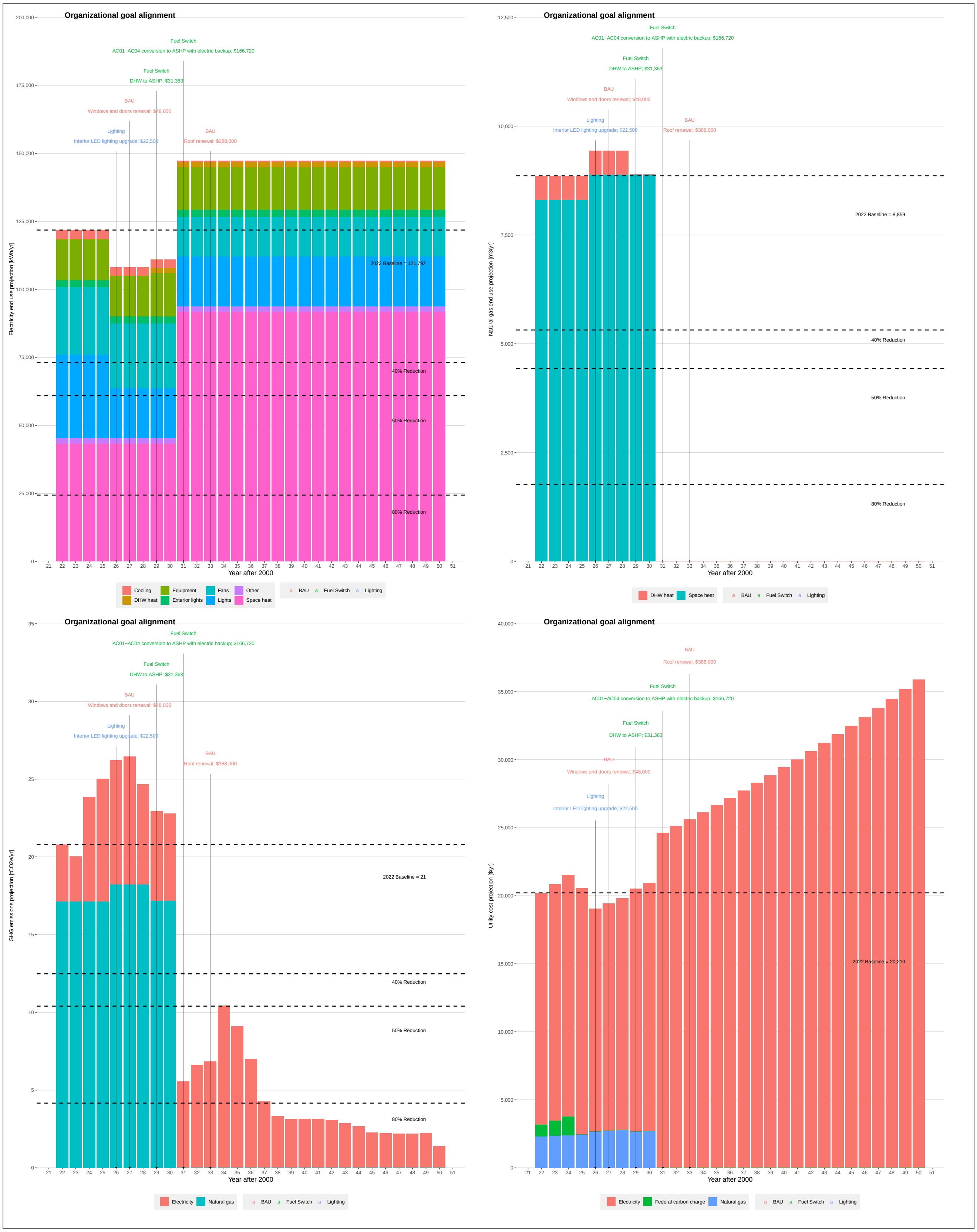


Figure 2: Recommended scenario performance

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] | 147,188 | 147,188 | 102,552 | **147,188** | 121,792 |
| | Electricity monthly peak (av) | [kW] | 39.8 | 39.8 | 34.4 | **39.8** | 33.6 |
| | Electricity yearly peak (max) | [kW] | 62.5 | 62.5 | 56.8 | **62.5** | 46.2 |
| | Natural gas use | [m3/yr] | 0 | 0 | 0 | **0** | 8,859 |
| GHG emissions final | Electricity GHGs | [tCO2e/yr] | 1.4 | 1.4 | 1.0 | **1.4** | 1.2 |
| | Natural gas GHGs | [tCO2e/yr] | 0.0 | 0.0 | 0.0 | **0.0** | 17.1 |
| | Carbon offsets GHGs | [tCO2e/yr] | 0.00 | 0.00 | 0.00 | **0.00** | 0.00 |
| | Total GHGs | [tCO2e/yr] | 1.4 | 1.4 | 1.0 | **1.4** | 18.3 |
| Utility cost final | Electricity utility cost | [$/yr] | 35,884 | 35,884 | 25,002 | **35,884** | 29,693 |
| | Natural gas utility cost | [$/yr] | 0 | 0 | 0 | **0** | 4,010 |
| | 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 | [$/yr] | 35,884 | 35,884 | 25,002 | **35,884** | 33,703 |
| Utility use cumulative | Electricity use | [kWh] | 3,977,014 | 4,127,743 | 3,438,315 | **3,977,014** | 3,531,960 |
| | Natural gas use | [m3] | 81,513 | 44,873 | 81,513 | **81,513** | 256,920 |
| GHG emissions cumulative | Electricity GHGs | [tCO2e] | 139 | 148 | 127 | **139** | 129 |
| | Natural gas GHGs | [tCO2e] | 158 | 87 | 158 | **158** | 496 |
| | Carbon offsets GHGs | [tCO2e] | 0.00 | 0.00 | 0.00 | **0.00** | 0.00 |
| | Total GHGs | [tCO2e] | 297 | 235 | 285 | **297** | 625 |
| Utility cost cumulative | Electricity utility cost | [$] | 755,000 | 778,996 | 638,915 | **755,000** | 661,621 |
| | Natural gas utility cost | [$] | 22,978 | 12,149 | 22,978 | **22,978** | 89,342 |
| | Carbon offsets utility cost | [$] | 0.00 | 0.00 | 0.00 | **0.00** | 0.00 |
| | Federal carbon charge | [$] | 3,338 | 3,338 | 3,338 | **3,338** | 3,338 |
| | Total utility cost | [$] | 781,316 | 794,484 | 665,231 | **781,316** | 754,301 |
| Financial cumulative | Project cost | [$] | 796,282 | 777,085 | 2,302,668 | **796,282** | 568,626 |
| | Replacement cost | [$] | 197,928 | 185,010 | 197,928 | **197,928** | 44,508 |
| | Life cycle cost | [$] | 970,940 | 1,021,793 | 899,230 | **970,940** | 812,288 |

# 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 Medical Centre. 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 $tCO_2e$, 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 Medical Centre 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 Medical Centre represented 19 $tCO_2e$ in 2019, or 0.96% 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 Medical Centre.

Table 2: Asset management summary for this facility

| Group | Metric | Unit | Value |
|---|---|---|---|
| Financial | Content Value Estimated | [$] | 39,383 |
| | Building Land Tank | [$] | 2,423,954 |
| | Replacement Cost | [$] | 2,463,337 |
| Information | Install Date | [yr] | 1981 |
| | Age | [yrs] | 44 |
| Condition Rating | Structure Condition Score | [-] | 4 |
| | Final Condition Score | [-] | 4 |
| 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 2024-04-17 to review the energy systems applicable to the desired retrofit scenario.

## 2.2 Facility overview

An overview of the Haileybury Medical Centre is provided in Table 4.

Table 4: Facility overview

| Description | Unit | Value |
|---|---|---|
| Name | [-] | Haileybury Medical Centre |
| Address | [-] | 95 Meridian Avenue |
| Location | [-] | Haileybury, ON |
| Type | [-] | Medical services |
| Construction year | [-] | 1981 |
| Gross floor area | [m2] | 1,369 |
| Gross floor area | [ft2] | 14,740 |

An aerial view of the Haileybury Medical Centre is provided in Figure 3.

Figure 3: Haileybury Medical Centre aerial view

## 2.3 Building information

### Renovations

The following renovations are known:

- **HVAC spot audit (2009)**: a detailed report outlining the HVAC system at this facility. The report indicated that there was a minimum of 14 inches of blown-in insulation. Furthermore, the report provided the cost of upgrading the system and performed heating and cooling load calculations. However, the renovation did not proceed.
- **Roof replacement (2013)**: the asphalt shingles were replaced. No additional insulation added at this time.
- **Partial window installation (2023)**: five thermally broken aluminum awning windows were installed at the facility.

### 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

### 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: one report focused on the HVAC system that was conducted in 2009.
- 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:

- Architectural drawings were not made available. The overall R-value of building envelope assemblies and area take-offs (e.g., window area) will be estimated.
- Mechanical drawings, ME01-ME03; M01-M02, dated July 1976.
- Electrical drawings, E01-E02, dated July 1976.
- Floor plans.
- Schematic drawings of HVAC system, July 2010.

## 2.4 Space use

### Type summary

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

- Examination rooms
- Imaging room
- Lunch room
- Laundry
- Medical supply room
- Storage
- Janitorial
- Electrical/Mechanical room
- Office, enclosed and open
- Washroom
- Computer/Server room
- Meeting room
- Lobby

All spaces appear to be used as originally intended.

### Occupancy scheduling

The facility operation hours are as follows:

- **Family Health team hours**: 09:00-16:00 Monday to Thursday; 09:00-12:00 Friday.
- **Dentist hours**: 08:00-17:00 Monday and Thurday; 08:00-18:00 Tuesday and Wednesday; 08:00-16:00 Friday.

Based on the GFA, it is assumed that this building has a peak occupancy of 35 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] | - | - |
| North basement area | 180.6 | AC1 | Assumption. |
| Dentist office | 204.3 | AC2 | Assumption. |
| Central core, south, east, and west wings | 437.9 | AC3 | Assumption. |
| North wing | 198.9 | AC4 | Assumption. |
| Washrooms | 35.3 | - | Assumption. |
| Storage | 203.4 | - | Assumption. |
| Corridor and stairwells | 72.1 | - | Assumption. |
| Mechanical | 37.0 | - | Assumption. |

## 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] |
| 727 | 938 | 734 | 188 | 16.7 |

### Overview

No architectural drawings were available, and therefore no detailed information on building assemblies. All overall R-Values are based on observations at the site.

### Roof

- The roof exterior layer consisted of asphalt shingles. The HVAC audit report indicated a minimum of 14 inches of blown-in insulation in the attic space.
- The overall R-Value is assumed to be R47.
- The roof condition was good.

### Opaque Walls (above ground)

- The exterior walls comprised an outer layer of concrete block.
- The overall R-Value is assumed to be R20.
- The wall condition was excellent.

### Fenestration

**Windows**

- The facility has aluminum-framed, double-pane windows. Five windows were installed in 2023, which were aluminum-framed, thermally broken.
- Windows appeared to be in good condition, including sealant around windows.
- The overall U-Value is assumed to be 3.18 W/m2K for the window system with a SHGC of 0.35.

**Doors**

- The facility has eight swing doors, 6 with glazing, and 2 hollow metal.
- The overall fenestration-to-wall ratio is estimated to be 20%, as elevation drawings were not made available.

### 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 4: Asphalt shingled roof


Figure 5: Concrete block exterior walls


Figure 6: Door sweeps are in good condition


Figure 7: Entrance to the old literacy entrance


Figure 8: Hollow metal door


Figure 9: Main entrance


Figure 10: No insulation on foundation wall

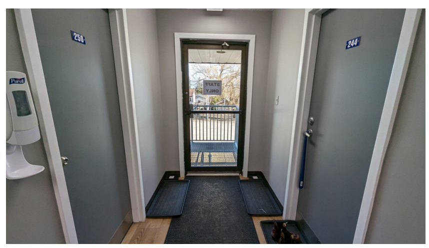
Figure 11: North exit


Figure 12: Northeast elevation


Figure 13: One of the five awning windows added in 2023


Figure 14: Skylight in core wing


Figure 15: Swinging door with glazing


Figure 16: Typical window

## 2.6 HVAC

### HVAC equipment summary

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

Table 7: Air distribution systems summary

| Tag | Make | Model | Serves | Design flow | Motor output | Data source |
|---|---|---|---|---|---|---|
| - | - | - | - | [cfm] | [hp] | - |
| AC1 | Heil | NTG-M075EGA3 | North basement area | 1,300 | 1.50 | Assumption. |
| AC2 | Heil | NTG-M075EGA3 | Dentist office | 1,300 | 1.50 | Assumption. |
| AC3 | Heil | NTG-M125EKA3 | Central core, south, east, and west wings | 2,000 | 1.50 | Assumption. |
| AC4 | Heil | NTG-M100EHA3 | North wing | 1,700 | 1.50 | Assumption. |
| HRV1 | LifeBreath | 195DCS | Serves AC1 | 210 | 0.25 | Assumption. |
| HRV2 | LifeBreath | 195DCS | Serves AC2 | 210 | 0.25 | Assumption. |
| HRV3 | LifeBreath | 195DCS | Serves AC3 | 210 | 0.25 | Assumption. |
| HRV4 | LifeBreath | 195DCS | Serves AC4 | 210 | 0.25 | Assumption. |

Table 8: Heating systems summary

| Tag | Serves | Utility | Efficiency | Output | Data source |
|---|---|---|---|---|---|
| - | - | - | [decimal] | [btuh] | - |
| AC1_HEAT | AC1 | Natural gas | 0.90 | 67,500 | Nameplate. |
| AC2_HEAT | AC2 | Natural gas | 0.90 | 67,500 | Nameplate. |
| AC3_HEAT | AC3 | Natural gas | 0.90 | 112,500 | Nameplate. |
| AC4_HEAT | AC4 | Natural gas | 0.90 | 90,000 | Nameplate. |
| DHW1 | DHW | Natural gas | 0.95 | 34,200 | Nameplate. |
| ELECT_HT | - | Electricity | 1.00 | 332,684 | Drawings. |

Table 9: Cooling systems summary

| Tag | Serves | Efficiency | Output | Data source |
|---|---|---|---|---|
| - | - | [decimal] | [ton] | - |
| CU1 | Serves AC1 | 4 | 2.0 | Report. |
| CU2 | Serves AC2 | 4 | 2.5 | Report. |
| CU3 | Serves AC3 | 4 | 5.0 | Report. |
| CU4 | Serves AC4 | 4 | 3.0 | Report. |

### System type

The facility utilizes four furnaces, each with an outdoor condensing unit, and a heat recovery ventilator. Supplementary heat is delivered via electric basboard. A summary of this system is as follows:

- All furnaces are natural gas-fired burners complete with DX cooling.
- There are four HRVs with sensible effectiveness ranging from 68% to 81%.
- Most HRVs had dirty filters that require maintenance.
- The four air-cooled condensers range in size from 2 tons to 5 tons.

- CU3 was replaced and relocated to the opposite side of the building. The old CU3 is still present.

A take-off of the electrical drawings suggests a total heating capacity of 97.5 kW. This amount does not include additional electric baseboard heaters installed in the literacy and dentist office. Electric baseboards are controlled either by an integrated thermostat or a wall-mounted thermostat. These thermostats are non-programmable.

### Central Plant

- There is no centralized plant at this facility.

### Distribution system

The air distribution throughout the building uses a single-duct approach to registers. A central return is used.

There are no pumps present at this site.

### Controls

#### AC1 to AC4

The following summarizes the controls for all the furnaces:

- AC1 is controlled by a programmable thermostat. However, its temperature setpoint was in a hold at 20C. There was no schedule present, and the fan was set to ON.
- AC2 is controlled by a programmable thermostat. However, its temperature setpoint was in a hold at 67F. There was no schedule present, and the fan was set to ON.
- AC3 is controlled by a non-programmable thermostat. The temperature setpoint was 72F and the fan was set to auto.
- AC4 is controlled by a programmable thermostat. However, its temperature setpoint was in a hold at 71F. There was no schedule present and the fan was set to auto.

#### HRV1 to HRV4

The following summarizes the controls for all the HRVs:

- HRV1 was set to continuous ventilation at the lowest fan speed. There was no RH setpoint, and the space was registering 24%. The controller was calling for maintenance.
- HRV2 controller was not observed during the site visit.
- HRV3 was set to operate for 10 minutes every hour and was at the lowest fan speed. The RH setpoint was 40%, and the space was registering 26%.
- HRV4 was set to continuous ventilation at the highest fan speed. The RH setpoint was 41%, and the space was registering 27%. The controller was calling for maintenance.

#### Electric baseboard heaters

All electric baseboard heaters were controlled by a built-in or wall-mounted thermostat. Most thermostats observed had their temperature setpoint turned down, suggesting minimal use of electricity at this facility for space heat.

### HVAC system documentation

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


Figure 17: 5 kW electric heater with built-in thermostat


Figure 18: AC1

Figure 19: AC1 thermostat


Figure 20: AC2

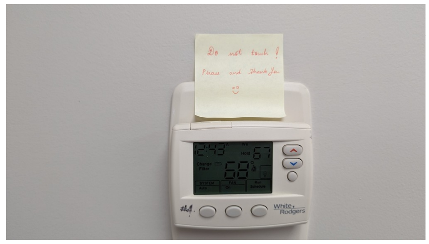
Figure 21: AC2 thermostat


Figure 22: AC3


Figure 23: AC3 dirty filter

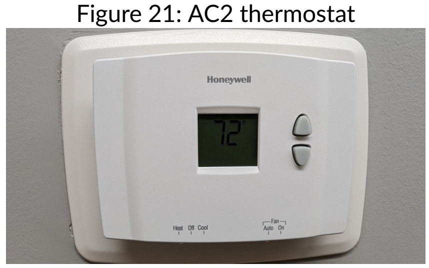

Figure 24: AC3 thermostat

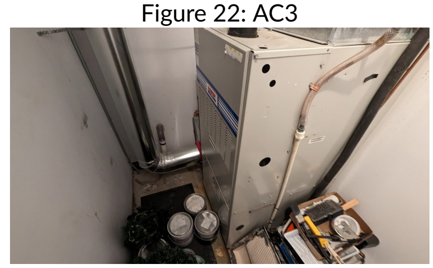
Figure 25: AC4

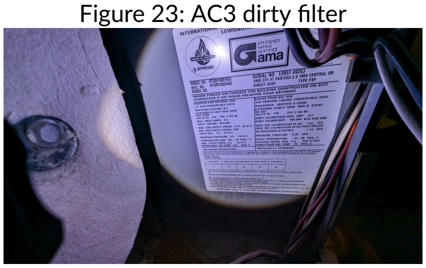
Figure 26: AC4 nameplate

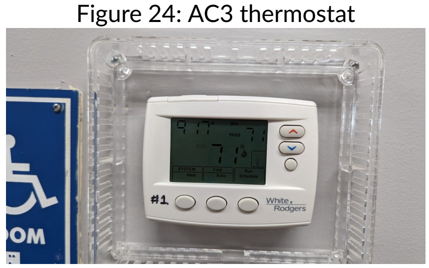

Figure 27: AC4 thermostat control


Figure 28: Additional HRV being installed in the old literacy area


Figure 29: CU1 protected by wood enclosure


Figure 30: CU2


Figure 31: CU3 - no longer in use

Figure 32: CU3


Figure 33: CU4 protected by wood enclosure


Figure 34: Dirty filter on HRV4


Figure 35: Electric heater at entrance to dentist office


Figure 36: Electric heater in room 240


Figure 37: Exhaust fan


Figure 38: Exhaust fan in dentist area washroom


Figure 39: HRV1

Figure 40: HRV1 dirty filter

Figure 41: HRV1 control


Figure 42: HRV2


Figure 43: HRV3

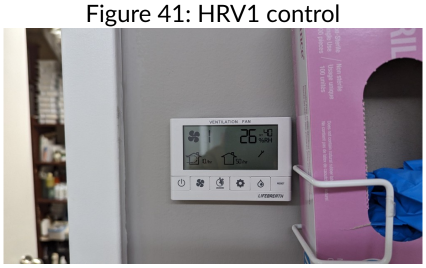

Figure 44: HRV3 control

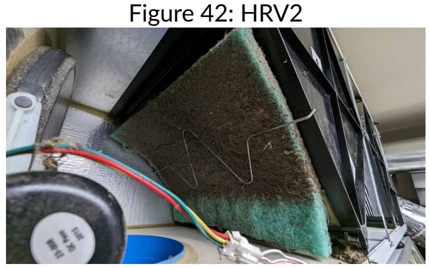
Figure 45: HRV3 dirty filter

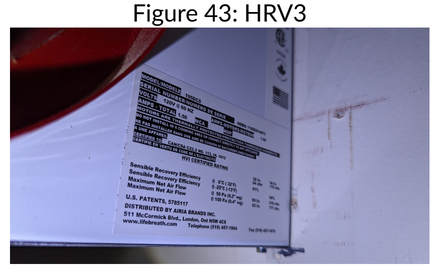
Figure 46: HRV3 nameplate

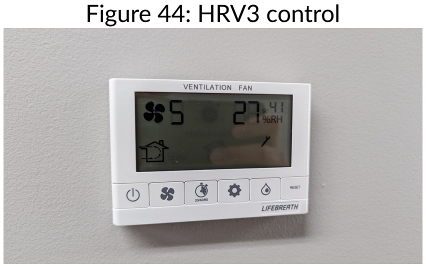

Figure 47: HRV4 control


Figure 48: HRV4 serving AC4

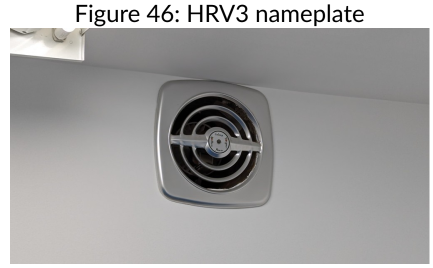
Figure 49: Men's washroom exhaust


Figure 50: Men's washroom baseboard heater with integrated thermostat

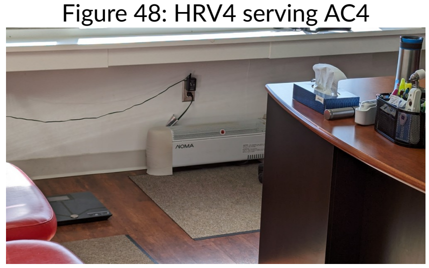
Figure 51: Plug in electric heater in an office

Figure 52: Portable dehumidifier in storage room

Figure 53: Portable dehumidifier in storage room-2

Figure 54: Portable heater in the dentist area

Figure 55: Supply and exhaust for HRV

Figure 56: Supply and exhaust for HRV - 2

Figure 57: Thermostat for an electric heater in the waiting room

## 2.7 Domestic hot water

### Overview

One natural gas DHW heater serves this building, and is located in the basement mechanical room. It has a capacity of 50 USG.

### Domestic Hot Water documentation

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

Figure 58: DHW1

## 2.8 Lighting

### Lighting system summary

Lighting systems are summarized in Table 10.

Table 10: Lighting systems summary

| Space name | Floor area of space | Light power density | Light power input | Data source |
|---|---|---|---|---|
| - | [m2] | [W/m2] | [W] | - |
| North basement area | 180.6 | 9.5 | 1,716 | Assumption. |
| Dentist office | 204.3 | 9.5 | 1,941 | Assumption. |
| Central core, south, east, and west wings | 437.9 | 9.5 | 4,160 | Assumption. |
| North wing | 198.9 | 9.5 | 1,889 | Assumption. |
| Washrooms | 35.3 | 9.5 | 335 | Assumption. |
| Storage | 203.4 | 9.5 | 1,932 | Assumption. |
| Corridor and stairwells | 72.1 | 9.5 | 684 | Assumption. |
| Mechanical | 37.0 | 9.5 | 351 | Assumption. |

### Interior lighting

**Fixtures**

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

- Type A1: 2’x4’ surface-mounted, 4 lamp, 120V, assumed T8
- Type A2: 2’x4’ surface-mounted, 4 lamp, 120V, T12, magnetic ballast
- Type A3: 2’x4’ surface-mounted, 4 lamp, 120V, LED lamp retrofitted
- Type A4: 2’x4’ recessed, 4 lamp, 120V, T12, magnetic ballast
- Type A5: 2’x4’ recessed, 120V, LED integrated panel
- Type B: 1’x4’ surface-mounted, 2 lamp, 120V, T8 lamp
- Type B1: 1’x4’ surface-mounted, 2 lamp, 120V, LED lamp retrofitted
- Type C1: Recessed 6" downlight, 1 lamp, 120V, LED lamp
- Type C2: 1’x4’ surface-mounted, 2 lamp, 120V, LED lamp retrofitted
- Type C3: Recessed 6" downlight, 1 lamp, 120V, LED
- Type F: sconce, 1 lamp, 120V, LED lamp

**Controls**

Interior lighting control is done through manual switches. The lights are assumed to be on one hour before typical hours of operation and three hours after hours of operation.

### Exterior lighting

**Fixtures**

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

- Type C: Recessed 6" downlight, 1 lamp, 120V, LED lamp
- Type H: Pole, LED fixture

**Controls**

A timer controls the exterior lighting. The schedule runs from 17:00 to 07:00 each day.

## Lighting system documentation

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

Figure 59: 100 W incadescent lamp in the AC4 mechanical room


Figure 60: Exterior light fixture on


Figure 61: Exterior light on in front of dental office

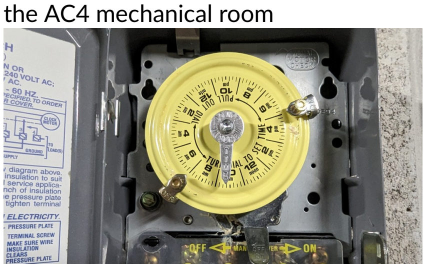
Figure 62: Exterior lights control

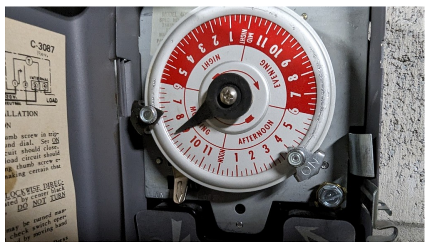
Figure 63: Exterior sign light control

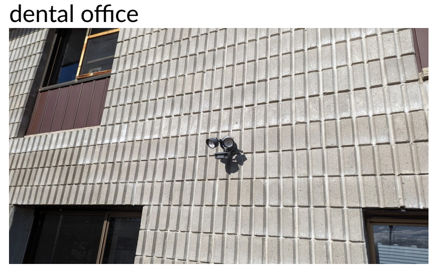
Figure 64: Flood lights with integrated motion sensor

Figure 65: Manual switch in room 243


Figure 66: Type A1 in administration


Figure 67: Type A1 - surface mounted fixtures assumed to have T8 lamps


Figure 68: Type A2 - T12 lamps


Figure 69: Type A3 - retrofitted with LED lamps


Figure 70: Type A4 - T12 lamps with a magnetic ballast

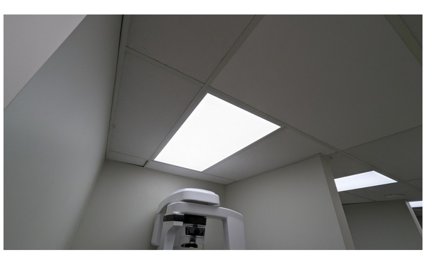
Figure 71: Type A5 - Integrated LED panel

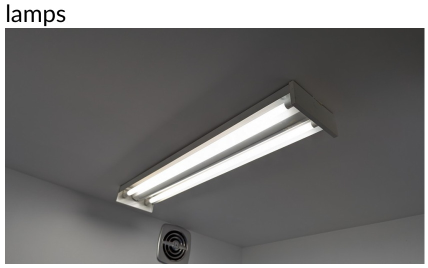
Figure 72: Type B1 - LED lamps


Figure 73: Type B - Washroom lighting with T8 lamps

Figure 74: Type C1 - Vestibule lighting with LED lamp

Figure 75: Type C2 - replaced 1x4 surface mounted fixtures with LED lamps

Figure 76: Type C3 - waiting room LED pot lights

Figure 77: Type C - Soffit LED light

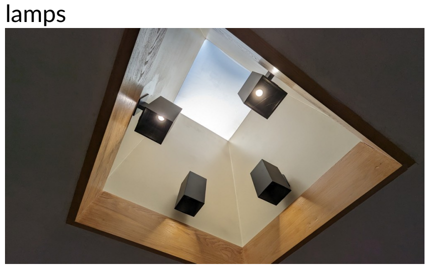

Figure 78: Type F - sconce fixtures with LED lamps

Figure 79: Type H - LED pole

## 2.9 Process and plug loads

### Process

Various process loads are present at the facility, including:

- IT equipment
- Autoclaves
- Central vacuum
- Dental air compressor
- Dental dry vacuum
- Dental lubrication
- Pharmaceutical refrigerator
- X-ray machine
- Washer and dryer

### Plug loads

Various plug loads are present at the facility, including:

- Office equipment (e.g., photocopier)
- Personal computers
- Appliances (e.g., dishwasher, kettle, stove, refrigerator, 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.

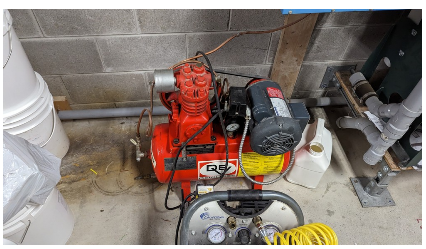

Figure 80: Air compressor

Figure 81: Autoclave in family medicine

Figure 82: Autoclaves in dentist area

Figure 83: Central vacuum

Figure 84: Coffee maker and kettle

Figure 85: Dental air compressor


Figure 86: Dental dry vacuum


Figure 87: Dental lubrication


Figure 88: Dentist chair

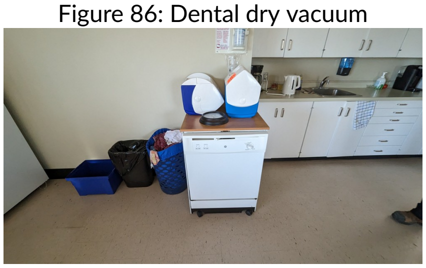
Figure 89: Dishwasher

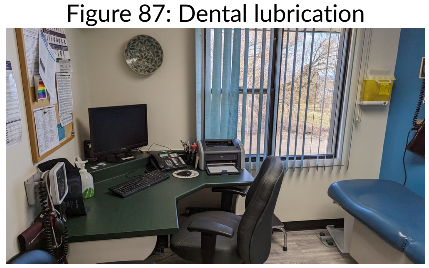
Figure 90: Examination room equipment

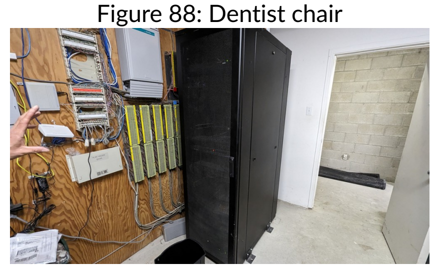
Figure 91: IT equipment

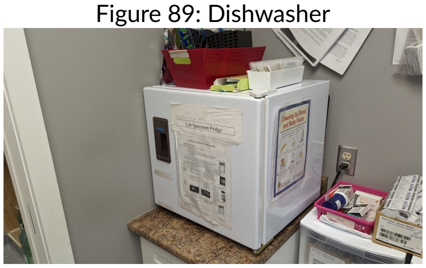
Figure 92: Lab specimen refrigerator


Figure 93: Microwaves in the lunch room


Figure 94: Pharmaceutical refrigerator


Figure 95: Photo copier


Figure 96: Portable air compressor


Figure 97: Refrigerator


Figure 98: Refrigerator in the basement


Figure 99: Sound equipment in doctor's office


Figure 100: Stove and rangehood in the basmeent


Figure 101: Television in dentist area

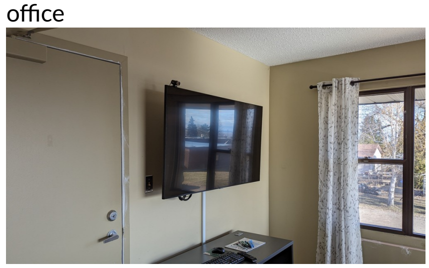
Figure 102: Television in the lunchroom

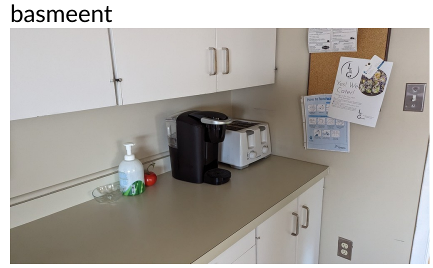
Figure 103: Toaster and single serve coffee


Figure 104: Washer and dryer


Figure 105: X-ray machine

## 2.10 Water fixtures

### Water fixture summary

Water fixtures at Haileybury Medical Centre are summarized in Table 11.

Table 11: Water fixture summary

| Serves | Unit count | Flow | Volume | Data source |
|---|---|---|---|---|
| - | - | [gpm] | [gpc] | - |
| Kitchen faucets | 3 | 2.2 | - | Assumption. |
| Washroom faucets | 8 | 1.0 | - | Assumption. |
| Toilets | 7 | - | 1.6 | Assumption. |
| Urinals | 1 | - | 1.0 | Assumption. |
| Washroom faucets | 1 | 2.5 | - | Assumption. |

### Overview

A summary of water fixtures is as follows:

- Eight handwashing faucets.
- Three kitchen sinks.
- Two slop sinks.
- Seven toilets.
- One urinal.
- One shower.

### Water fixture documentation

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

Figure 106: 1.6 gpf toilet

Figure 107: Central vacuum

Figure 108: Examination room sink

Figure 109: Hand faucet in the basement

Figure 110: Handwashing faucet

Figure 111: Handwashing faucet in rm 105


Figure 112: Handwashing faucet in dentist area


Figure 113: Janitorial sink


Figure 114: Kitchen faucet in the basement


Figure 115: Kitchen sink


Figure 116: Lab sink


Figure 117: Men's washroom faucets


Figure 118: Shower in the basement

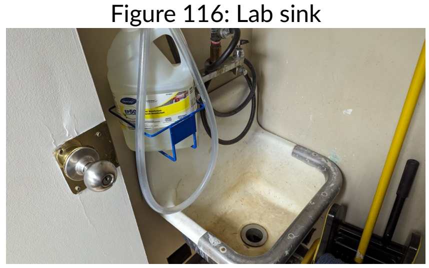
Figure 119: Sob sink in the basement


Figure 120: Toilet in the basmeent


Figure 121: Urinal


Figure 122: Water fountain

## 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 123: Electricity meter

Figure 124: Natural gas meter

Figure 125: Water meter

## 2.12 Onsite energy sources

### Overview

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

## 2.13 Electrical infrastructure

### Overview

The existing systems is 600A at 208V -3P service running at a maximum load of 34.2 kW, which is approximately 20% of the full load of 173 kW of the building. The main switchboard and house panel (Panel A) are both physically full. The building is fed from a pole-mounted transformer bank across the road. The feed travels underground to the mechanical room via 4-500 MCM into the main 120/208V switchgear, with a 600A main disconnect. There are an estimated ten panels throughout the building.

### Panel summary

The ten panels at this site are summarized below:

- Panel A, 120/208V, 200A, three ph, 4W. Serves receptacles, lights, heating, vacuum, ac units, and outside lights.
- Panel B, 120/208V, 100A, three ph, 4W. Serves receptacles, lights, and heaters. This panel does not meet code as it is blocked by bookshelves.
- Panel C, 120/208V, 100A, three ph, 4W. This panel was not observed during the site visit.
- Panel D, 120/208V, 100A, three ph, 4W. Serves AC1 fan, receptacles, AC units, electric heating, and sub-panel D.
- Panel E, 120/208V, 100A, three ph, 4W. Serves receptacles, lights, and heating (turned off).
- Panel F, 120/208V, 100A, three ph, 4W. This panel was not observed during the site visit.
- Panel G, 120/208V, 100A, three ph, 4W. Serves receptacles, lights, heaters, and air conditioners. The circuits labelled as heater and air conditioner are turned off.
- Panel unknown, 120/208V, 100A, three ph, 4W. Serves washer, dryer, stove, refrigerator, range hood, and receptacles.
- Dentist panel-1. Serves x-ray machines, dentist lighting, receptacles, vacuum pump, air compressor, sterilization cabinet, and dentist chairs.
- Dentist panel-2. Serves AC2, receptacles, lighting, dentist chairs, x-ray machines, and car receptacles.

### Electrical infrastructure documentation

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


Figure 126: Dentist panel-1


Figure 127: Dentist panel-2

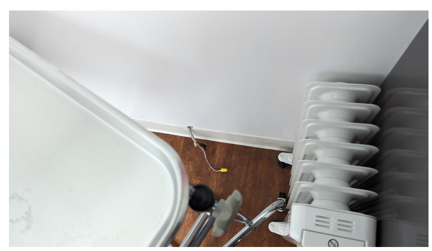
Figure 128: Exposed electrical wiring


Figure 129: Main switch - 600A

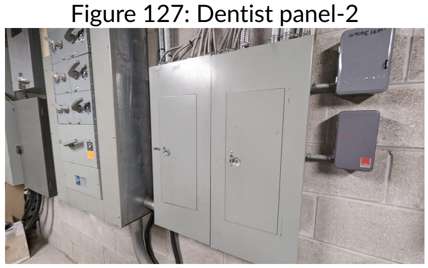
Figure 130: Panel A (2 tub)


Figure 131: Panel B

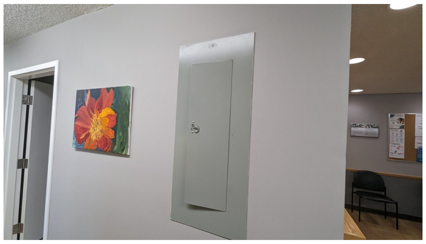
Figure 132: Panel C

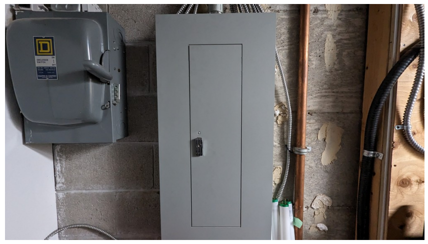
Figure 133: Panel D


Figure 134: Panel E

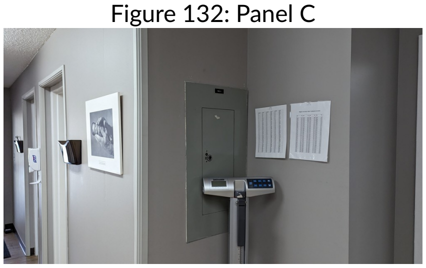
Figure 135: Panel G

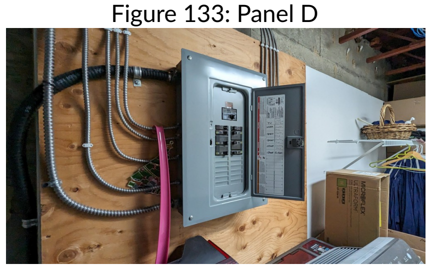
Figure 136: Panel unknown

# 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 Medical Centre.
    - 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 12 summarizes the data source of the baseline performance for each utility.

Table 12: 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 Medical Centre 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 Medical Centre.
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 13.

Table 13: GHG emissions factor assumptions

| Utility | Unit | Value | Source |
|---|---|---|---|
| Electricity | [tCO2e/kWh] | 0.0000302 | 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 2022 were assumed as per Table 14. 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 14: Utility cost rate assumptions for the baseline year (2022)

| 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 137.

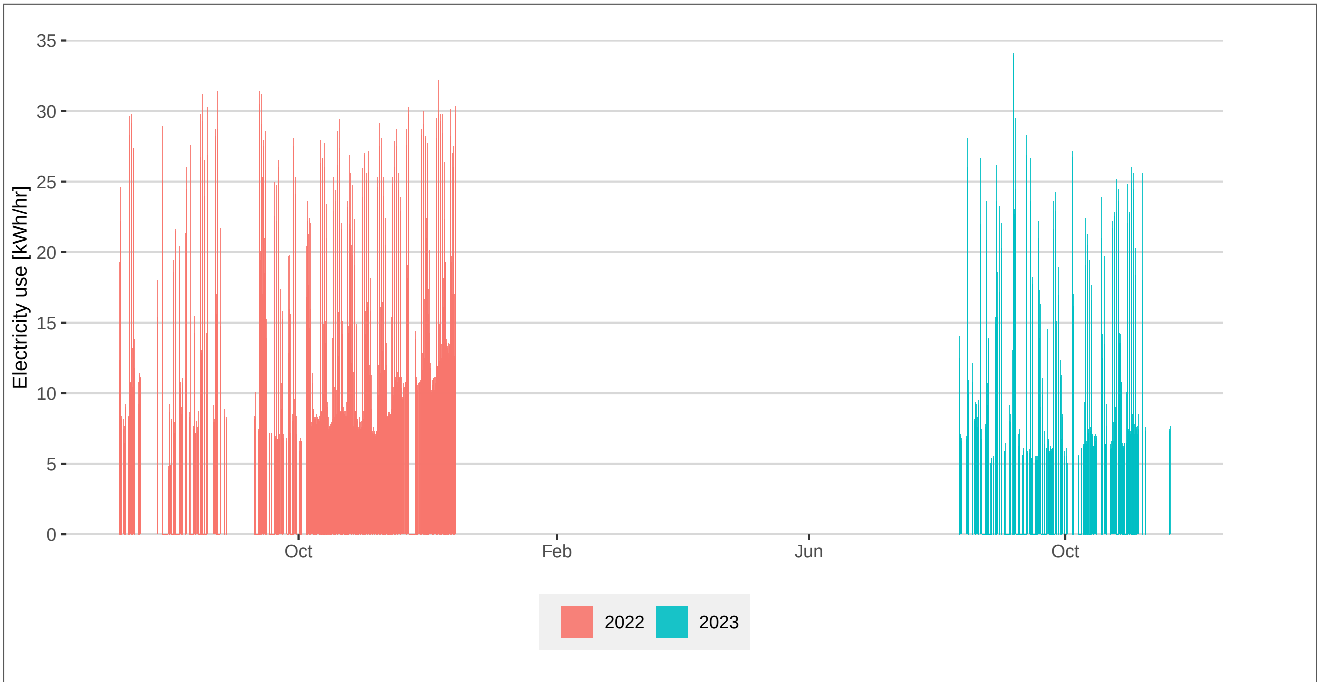


Figure 137: Hourly electricity use

The same hourly electricity use data is plotted in Figure 138, which highlights how electricity use is influenced by year, season, day of week and hour of day. The vertical axis on Figure 138 may be rescaled relative to in Figure 137 for greater resolution.

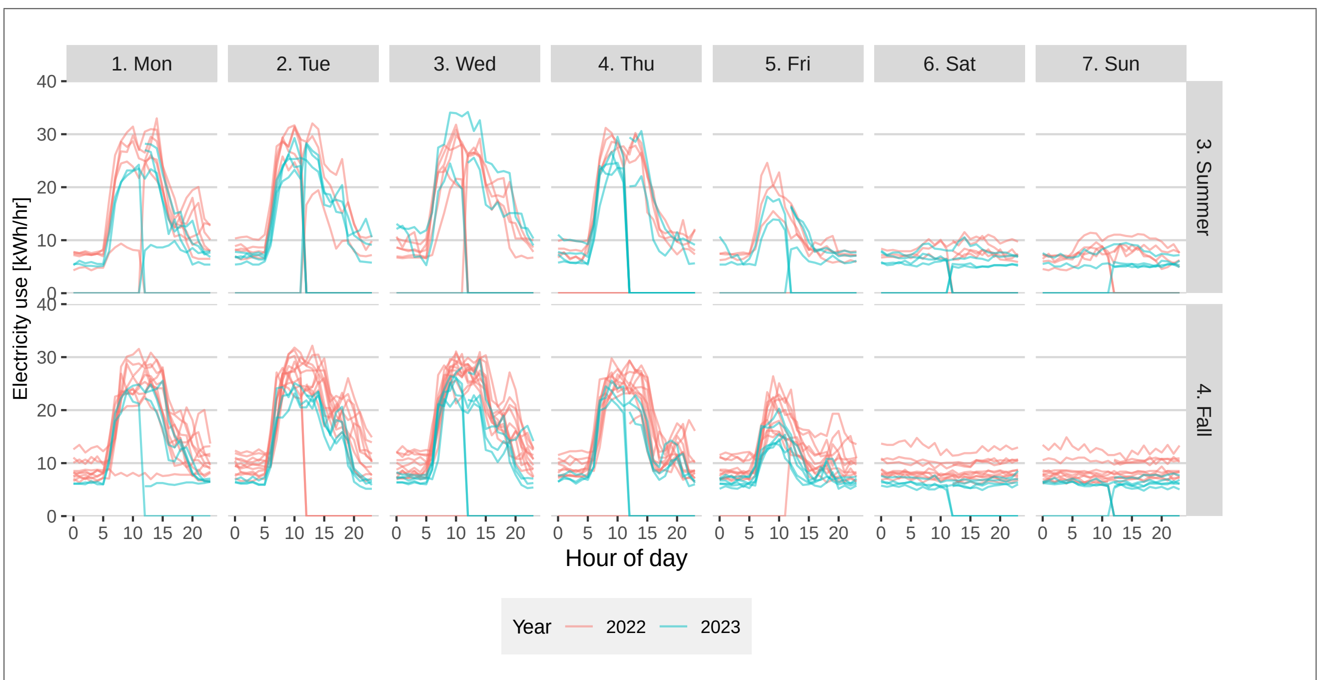


Figure 138: Hourly electricity use hairball plot

Monthly electricity use is plotted in Figure 139.

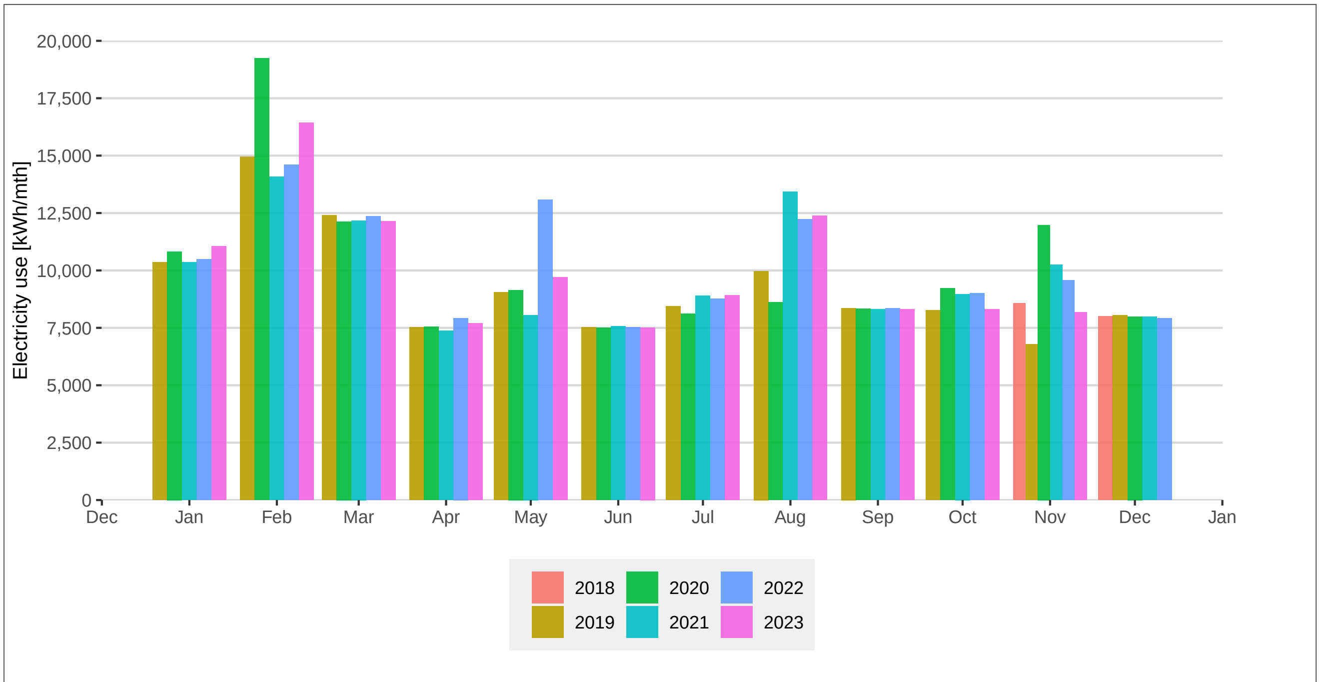


Figure 139: Monthly electricity use

## 3.4 Natural gas metered utility use

Monthly natural gas use is plotted in Figure 140.

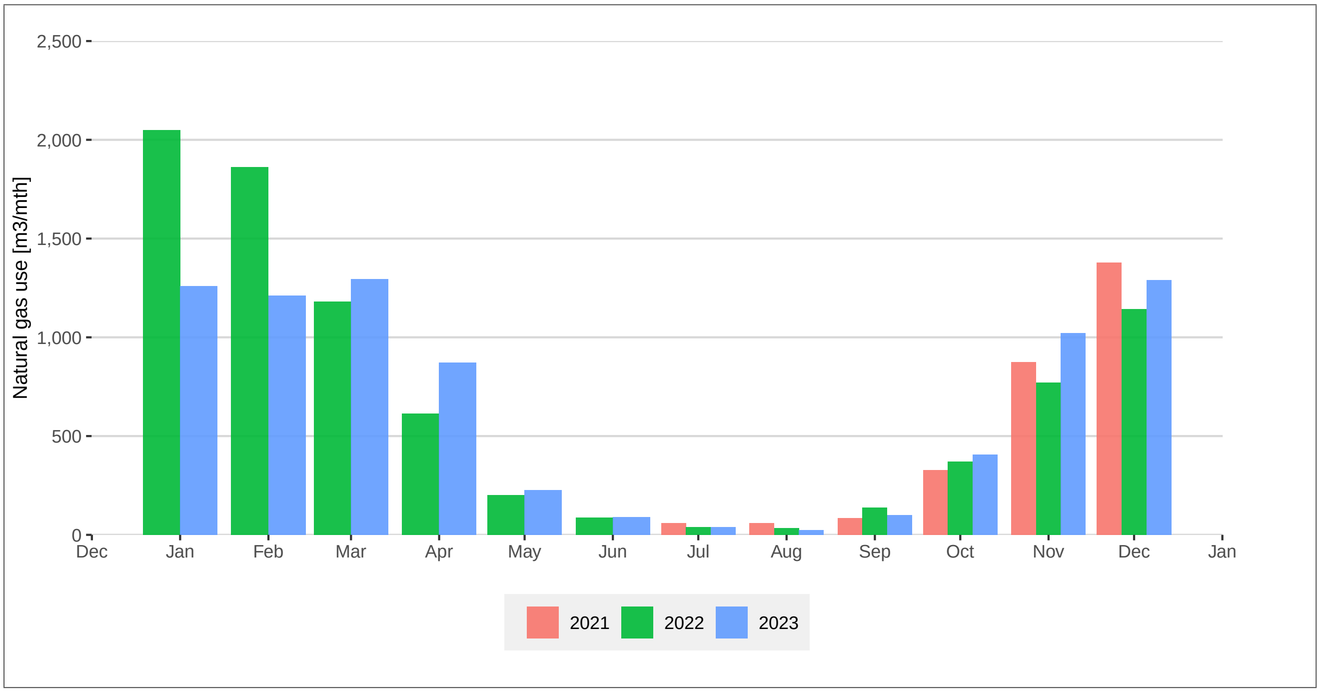


Figure 140: Monthly natural gas use

## 3.5 Utility use baseline

### Baseline year

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

- **Baseline year**: 2022.

### Baseline performance

Baseline utility use performance for the baseline year of 2022 is summarized in Table 15.

Table 15: Baseline utility use performace

| Category | Utility | Unit | Value |
|---|---|---|---|
| Utility use | Electricity use | [kWh/yr] | 121,792 |
| | Natural gas use | [m3/yr] | 8,859 |
| | Carbon offset use | [tCO2e/yr] | 0 |
| Equivalent energy use | Electricity energy | [kWh/yr] | 121,792 |
| | Natural gas energy | [kWh/yr] | 93,525 |
| | Total energy | [kWh/yr] | 215,317 |
| GHG emissions | Electricity GHGs | [tCO2e/yr] | 4 |
| | Natural gas GHGs | [tCO2e/yr] | 17 |
| | Carbon offsets GHGs | [tCO2e/yr] | 0 |
| | Total GHGs | [tCO2e/yr] | 21 |
| Utility cost | Electricity utility cost | [$/yr] | 12,082 |
| | Natural gas utility cost | [$/yr] | 2,303 |
| | Carbon offsets utility cost | [$/yr] | 0 |
| | Federal carbon charge | [$/yr] | 856 |
| | Total utility cost | [$/yr] | 15,241 |

## 3.6 Benchmarking analysis

Benchmarking analysis results are presented in the following figures.

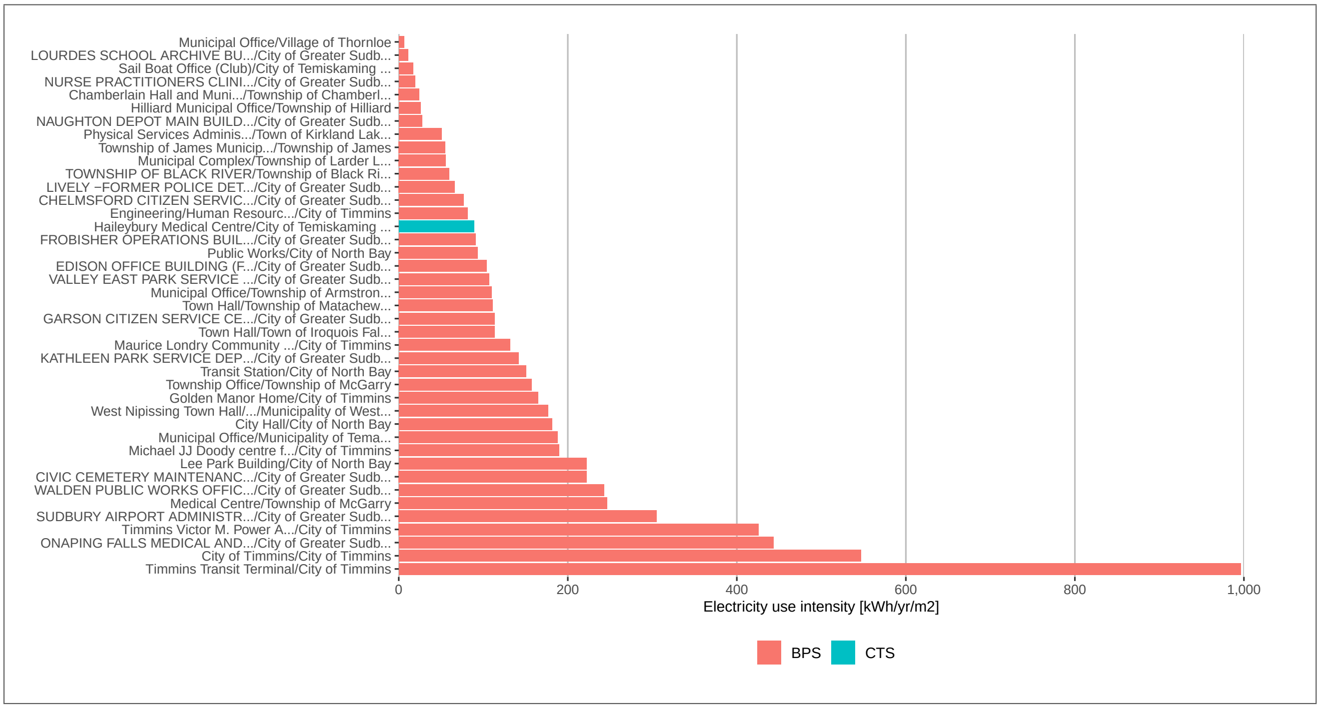


Figure 141: Electricity use intensity benchmarking analysis comparison

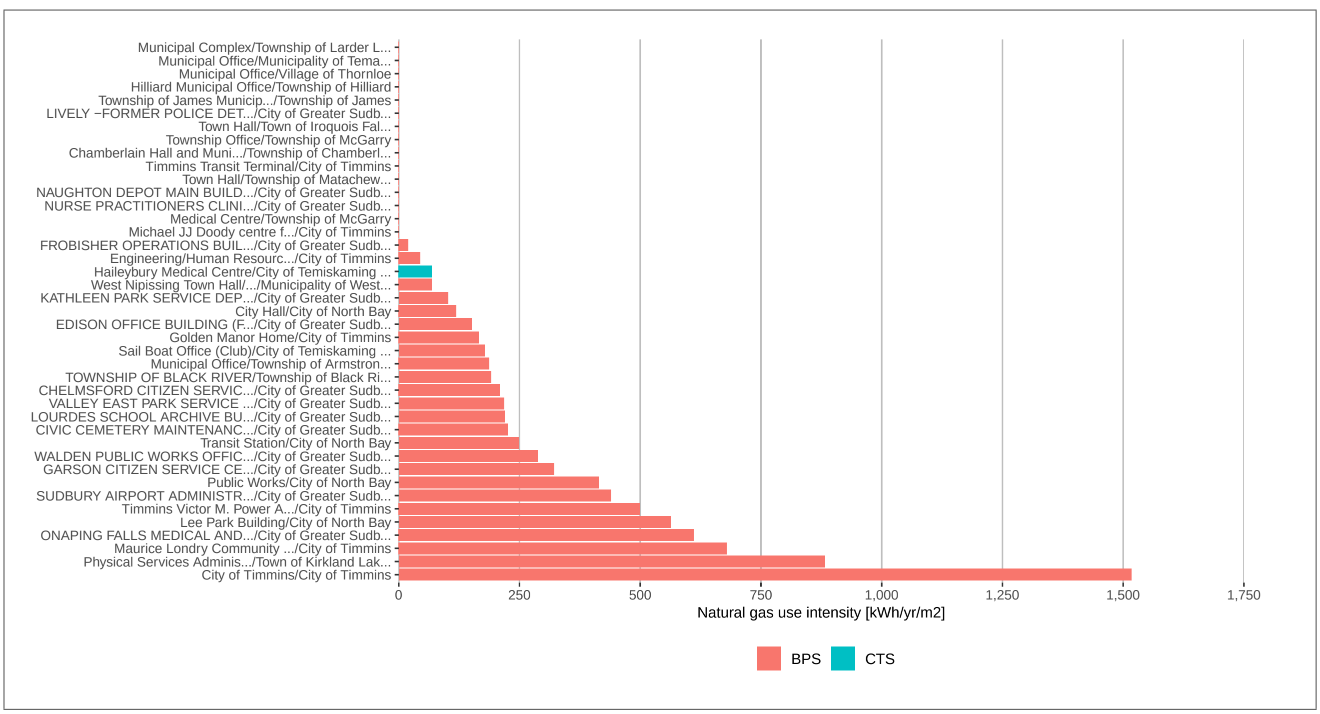


Figure 142: Natural gas use intensity benchmarking analysis comparison

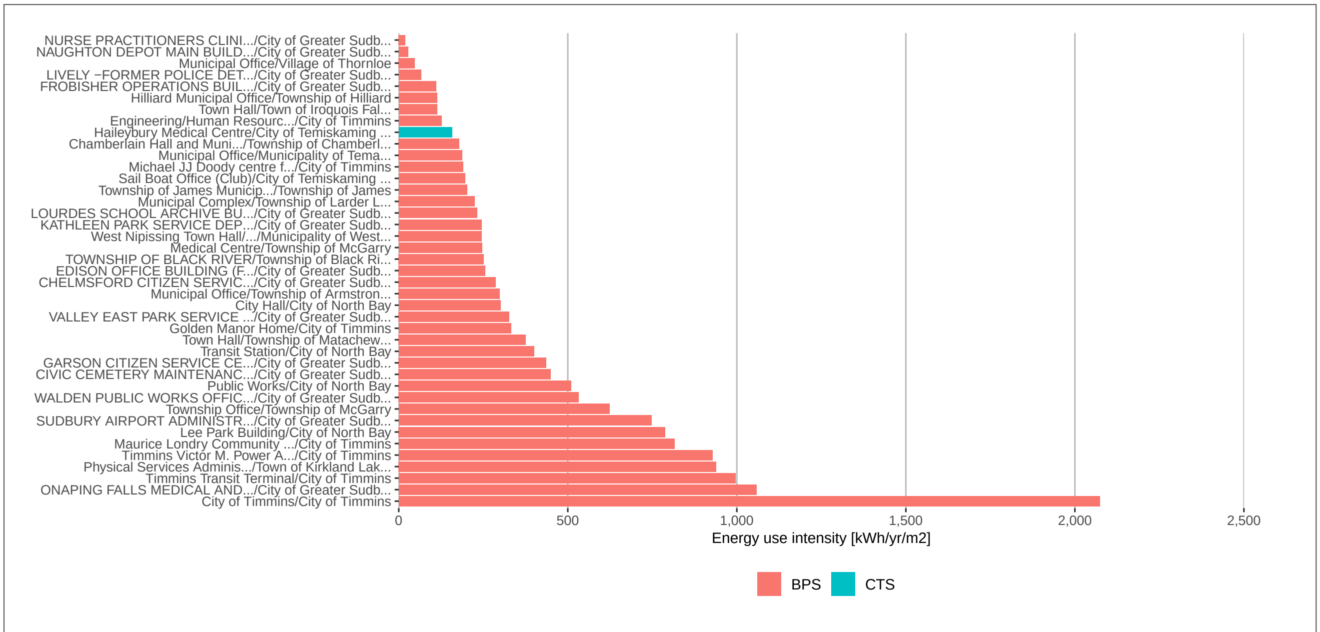


Figure 143: Total energy use intensity benchmarking analysis comparison

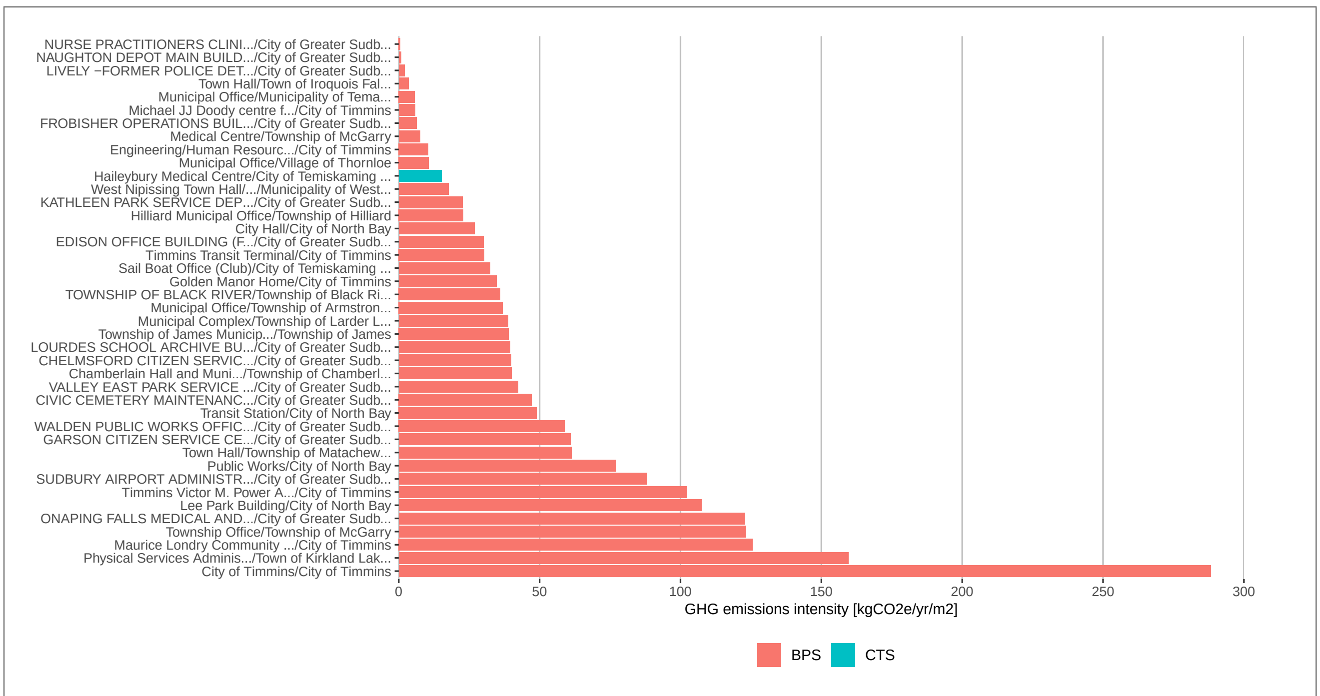


Figure 144: GHG emissions intensity benchmarking analysis comparison

## 3.7 ENERGY STAR Portfolio Manager benchmarking analysis

The scorecard is shown in Figure 145.

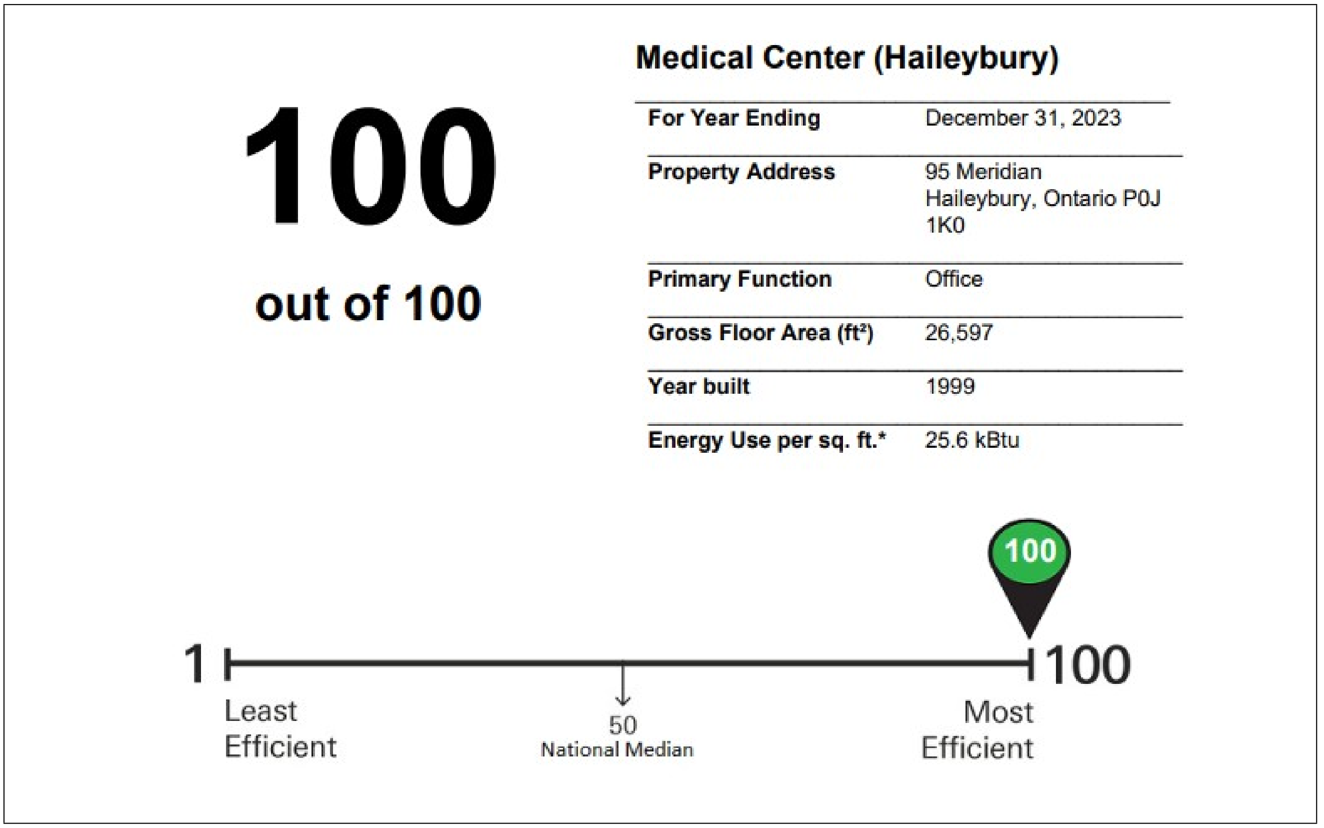


Figure 145: Energy Star energy performance scorecard.

## 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.

### Electricity - Hourly

- There is limited hourly metered electricity data.
- From the available hourly data, it appears that the electricity consumption is typically around 5-10 kWh during unoccupied hours, and 20-30 kWh during occupied hours.

### Electricity - Monthly

- **2018**: The dataset provided started in November 2018 and did not allow for a full year of comparison. November and December for this year exhibited similar consumption to November and December in other years.
- **2019**: Peak consumption in February and March, with spikes in consumption in May and August. This is consistent with other years, although the cause of these peaks is unknown. Electricity use in most other months (e.g. April, June, September, and December) is fairly constant at around 7,500 kWh/month, and the consumption in February is roughly double that value at about 15,000 kWh/month.
- **2020**: Monthly consumption is similar to other years. February 2020 has the highest electrical consumption of the dataset.
- **2021**: Monthly consumption is similar to other years.
- **2022**: Monthly consumption is similar to other years, with consumption in May higher than the seasonal average.
- **2023**: Monthly consumption is similar to other years.

### Natural gas

- Natural gas consumption has maintained a consistent profile year over year. It is highest during the heating season and very low during the cooling season.
- This building has two end uses: space heating and domestic hot water heating.
- Natural gas consumption in the summer is due to domestic hot water heating.
- Of the 31 data points available for monthly natural gas consumption, only 13 were actual readings, not estimates. This observation can lead to calibration issues, as the model may not pass ASHRAE Guideline 14.

### Energy Star Benchmarking

The score of 100 out of 100 is misleading, and is believed to be the result of the building being grouped with hospitals.

# 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 16.

Table 16: 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. |
| | Other | Metered use less modelled use. |
| | Space heat | Space heating 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 146. See Table 16 for end use definitions.

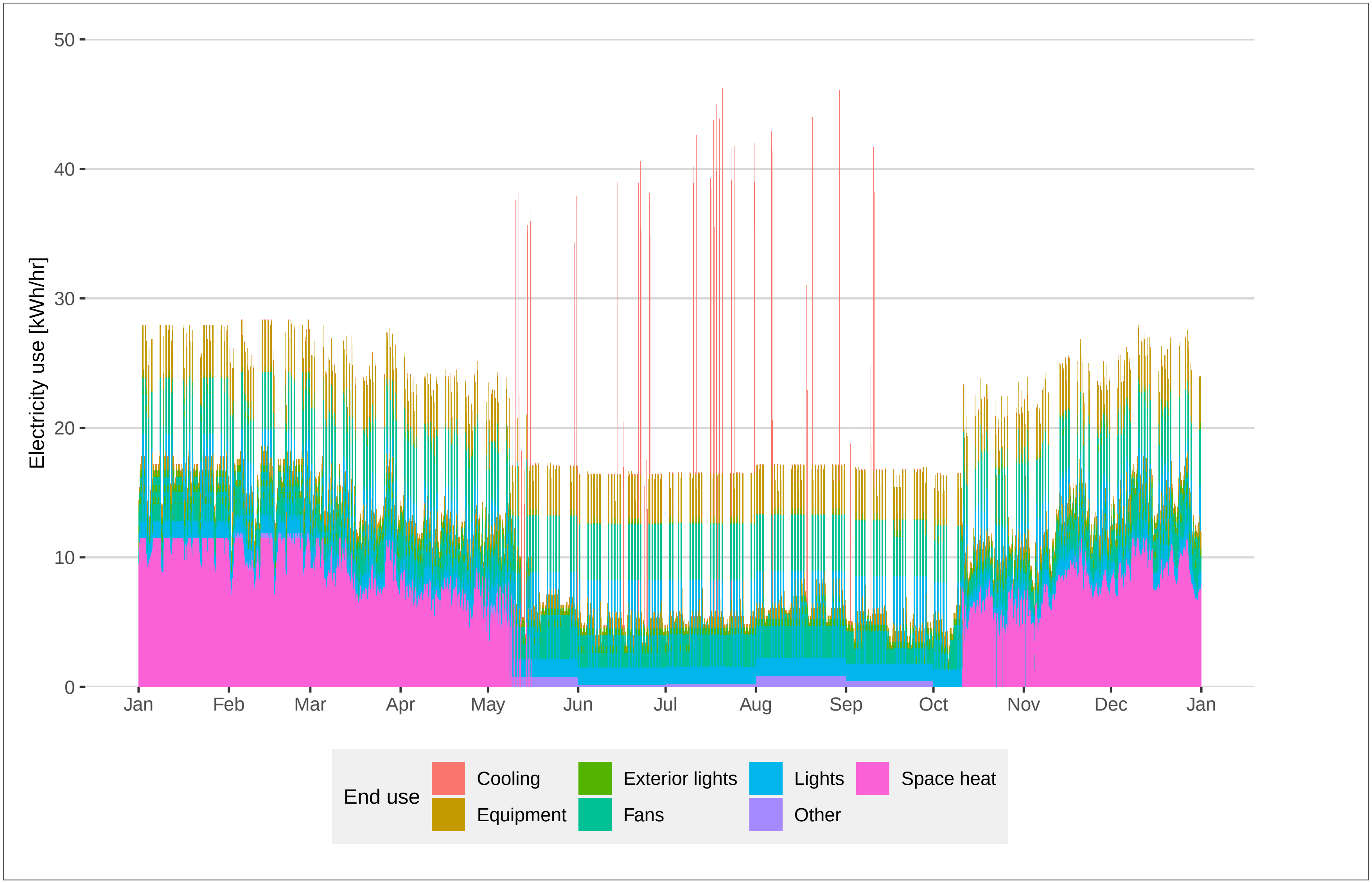


Figure 146: Hourly electricity utility use by end use (made by calibrated energy model)

## Natural gas

The hourly natural gas utility use profile by end use made by the energy model is plotted in Figure 147. See Table 16 for end use definitions.

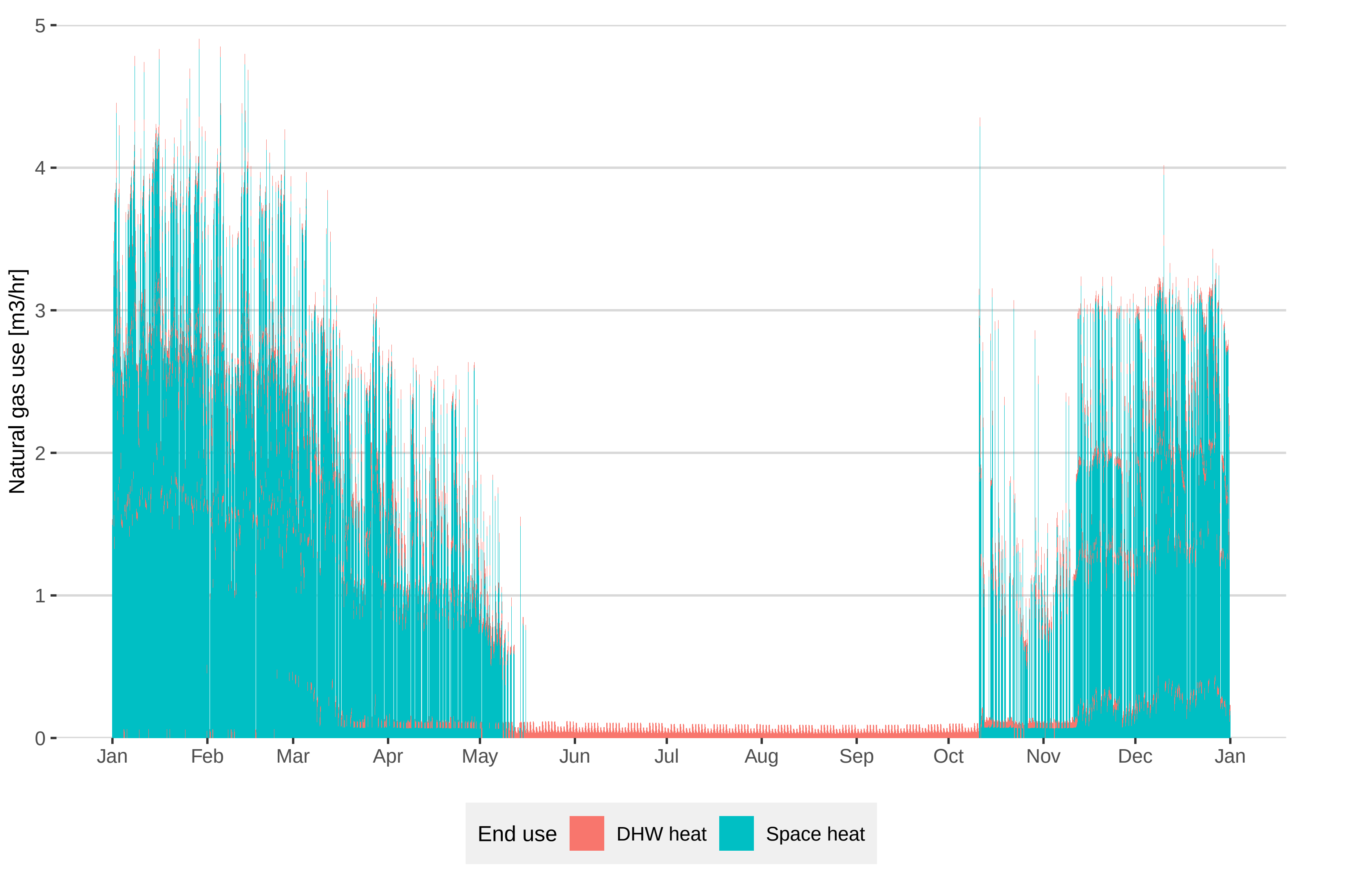


Figure 147: Hourly natural gas utility use by end use (made by calibrated energy model)

## 4.3 Monthly utility use profiles

Monthly utility use profiles for each modelled utility are presented in Figure 148.

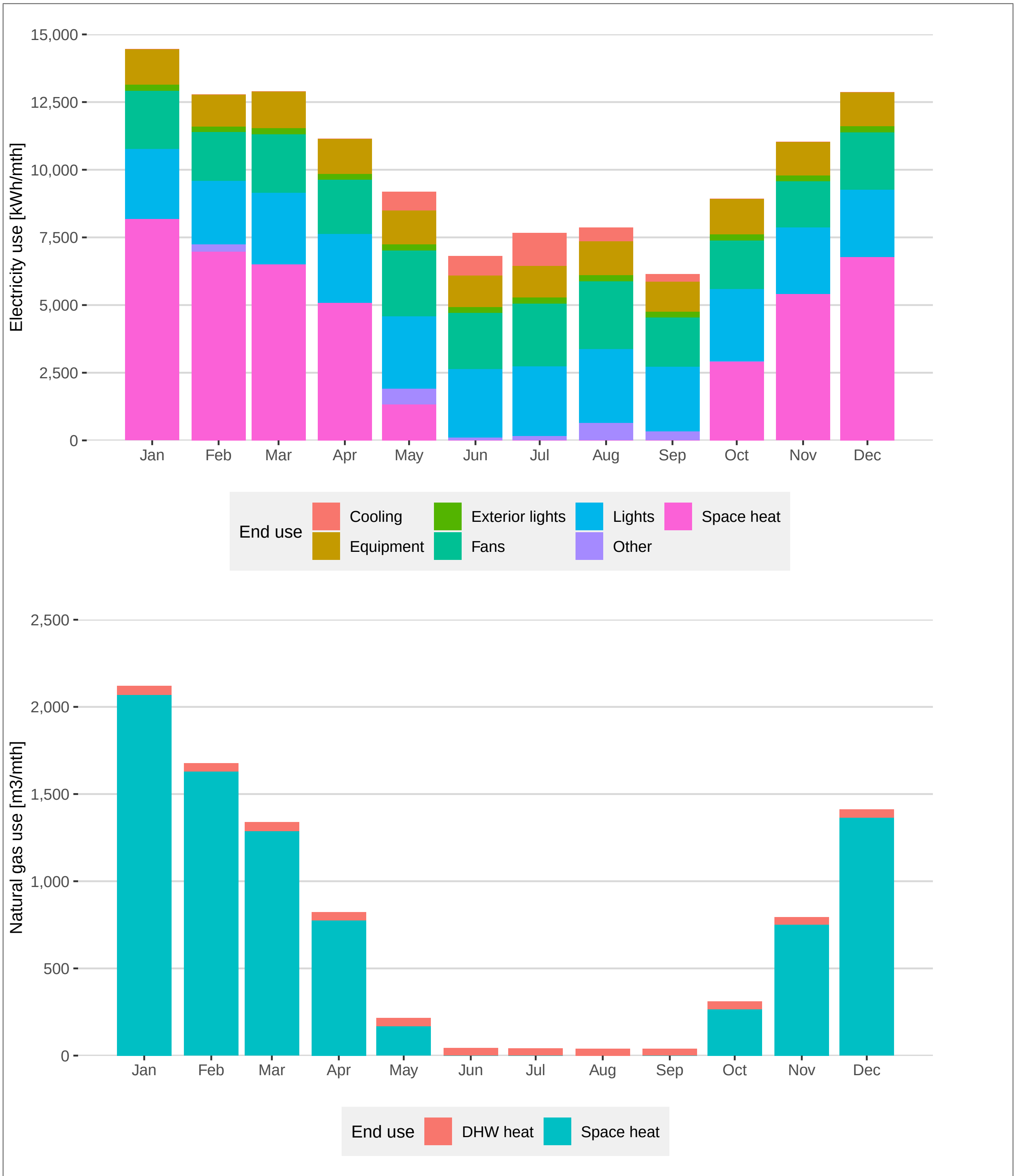


Figure 148: Monthly utility use profiles for each modelled utility

## 4.4 Calibration analysis

### Electricity

Figure 149 compares the metered utility use with the modelled use to check how well the model is calibrated.


Figure 149: Electricity calibration analysis (metered vs modelled utility use)

### Natural gas

Figure 150 compares the metered utility use with the modelled use to check how well the model is calibrated.

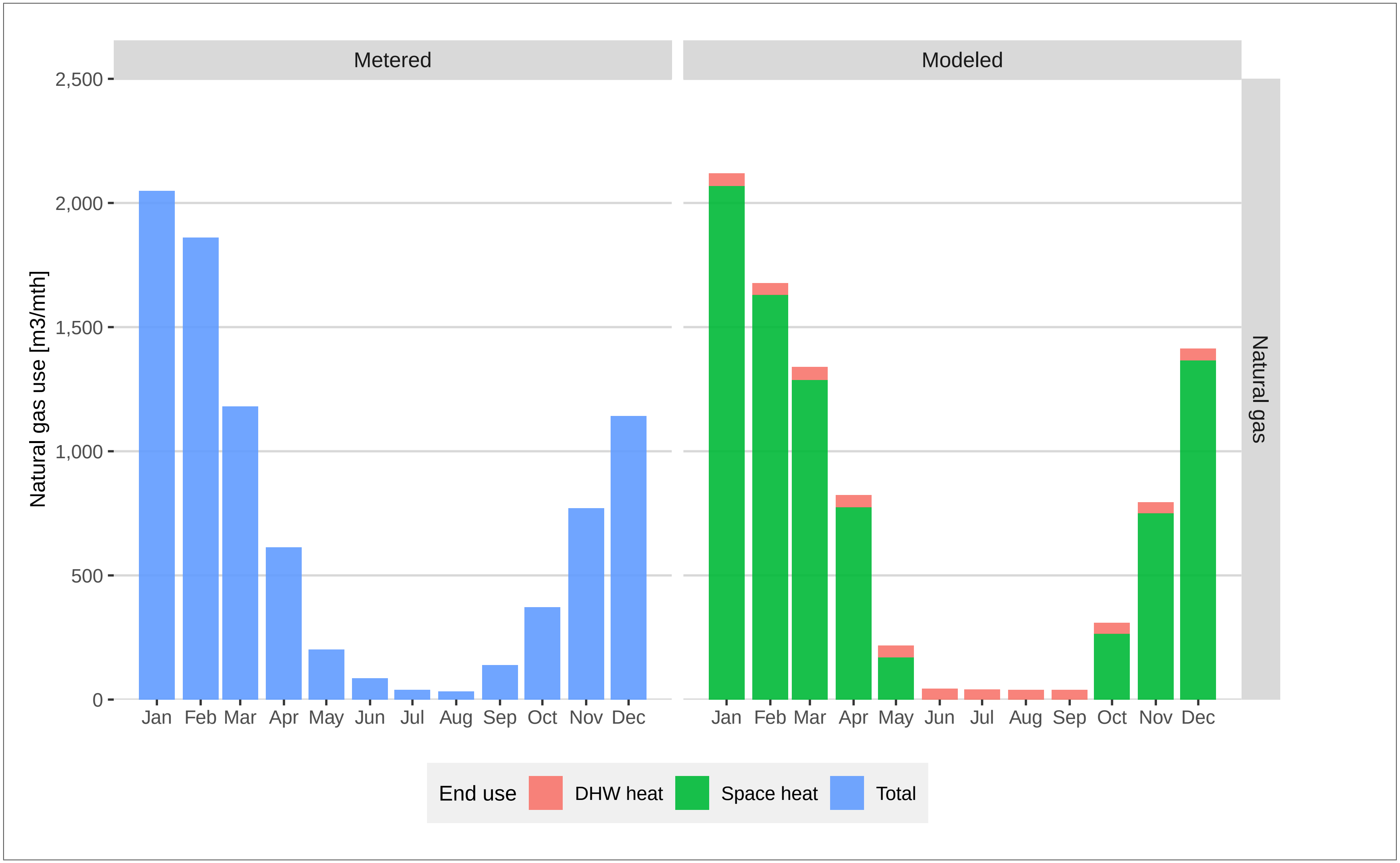


Figure 150: Natural gas calibration analysis (metered vs modelled utility use)

## 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 17.

Table 17: Statistical calibration analysis summary

| Utility | Description | Unit | ASHRAE 14 | Model | Pass/Fail |
|---|---|---|---|---|---|
| Electricity | Mean bias error | [%] | < +/- 5 | -0.0 | Pass |
| | Root mean square error | [%] | < 15 | 29.2 | Fail |
| Natural gas | Mean bias error | [%] | < +/- 5 | -4.8 | Pass |
| | Root mean square error | [%] | < 15 | 18.9 | 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 149 and 150 both demonstrate a reasonable agreement between monthly trends observed in the metered utility use data and the monthly utility use predicted by the calibrated energy model.
- Electricity use fails to follow ASHRAE Guideline 14 on the root mean square error. Note that the mean bias error is zero for electricity because the Other end-use ensures that the yearly modelled utility use matches the yearly metered utility use. Some notable issues are the peaks with unknown cause in February, March, May, and August.
- Natural gas consumption fails to follow ASHRAE Guideline 14 on the root mean square error. Some notable issues are that consumption is higher in the model in May and October. There is also a discrepancy in the summer months. Another note is that only 6 of 12 natural gas readings are actual readings. This issue makes it difficult to calibrate the model, especially against estimated data that the LDC typically underestimates.
- The successful energy model calibration is largely due to the methodology used in developing the calibrated energy model. Under this methodology, the major systems affecting utility use were studied in detail (see Section 2), so that these systems could be explicitly modelled one-to-one, precisely reflecting the unique operations associated with each system. Examples of such major systems include all air handling systems (AC1-AC4). The methodology also integrates the Other end-use category, which reflects the exact difference between metered and modelled utility use in a top-down calculation after all systems have been modelled from the bottom-up.

- Therefore, there can be confidence that the utility use impacts quantified in the various measure and scenario analyses under this report are reasonable.
- To achieve better alignment between the modelled and metered heating load, a relatively low infiltration rate was assumed for the building (0.25 lps/m2 envelope). In addition, although the fans for AC1 and AC2 were observed to be ON, it was assumed that they were set to Auto overnight. It was also assumed that the temperatures were setback overnight by an average of 4 degrees F.

### Electricity

- Figure 149 indicates reasonable agreement between modelled and metered data.
- The peak and trough hourly consumption align with the metered interval data.
- The model does not capture the unexpected peaks in electrical consumption in February, March, May, and October.

### Natural gas

- Figure 150 indicates good agreement between modelled and metered data.
- The annual amount of natural gas consumption in the model is very close to the annual amount of the metered data. However, there are variances within several months. That being said, there are several estimated readings for this particular dataset.

## 4.5 End use analysis

### Electricity

The yearly electricity end use breakdown calculated by the energy model is plotted in Figure 151. See Table 16 for end use definitions.

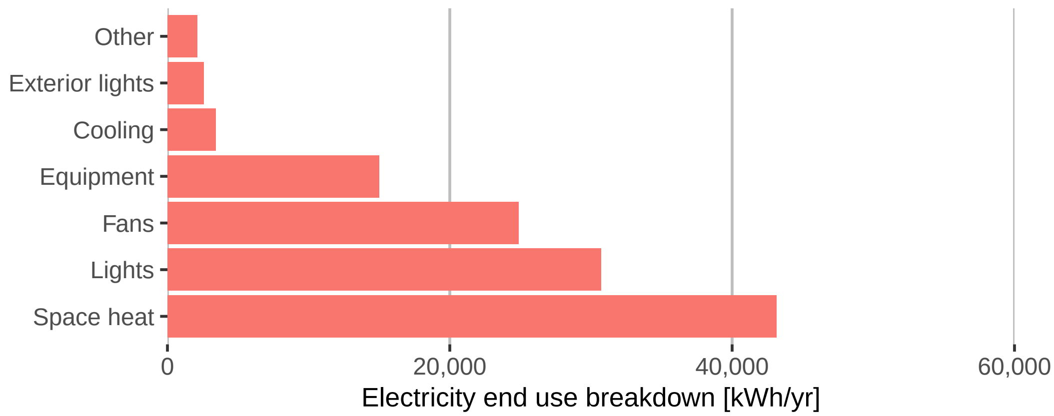


Figure 151: Electricity end use breakdown (calculated by calibrated energy model)

### Natural gas

The yearly natural gas end use breakdown calculated by the energy model is plotted in Figure 152. See Table 16 for end use definitions.

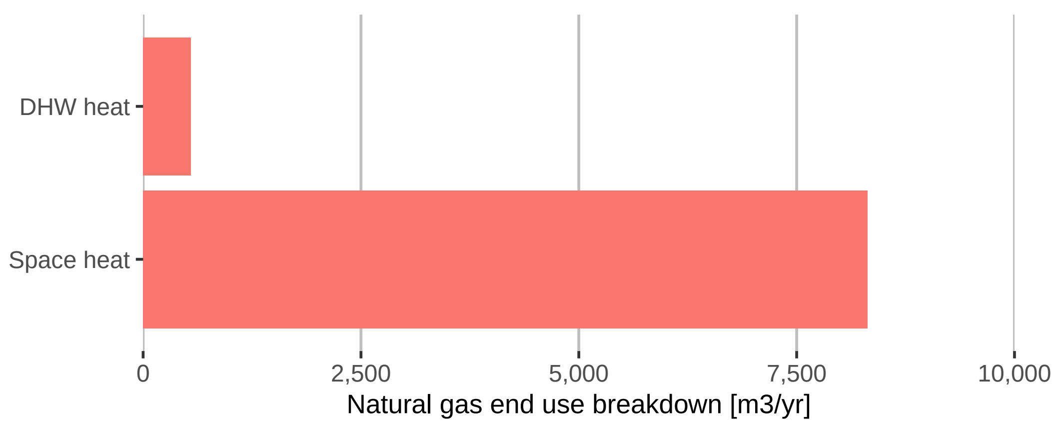


Figure 152: Natural gas end use breakdown (calculated by calibrated energy model)

# 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 5.12). 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 14 and 20 according to the following methodology.
        (a) The life cycle cost for each measure was calculated based on the assumed implementation year of 2026 for each measure. The life cycle cost for each measure was calculated as the sum of the following future financial cost expenditures, discounted back to present value using the discount rate from Table 20, 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 20. 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 20. 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 18 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 21 was tested under each risk case also defined in Table 21 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 5.13.

4. **Measure analysis summary**. Measure analysis results for all measures were summarized in table format in Section 5.14.

## 5.2 Measure analysis assumptions

Assumptions general to all measures are as follows.

- GHG emissions factor assumptions are summarized in Table 13, in Section 3.2.
- Utility cost rate assumptions applied to quantify yearly utility cost impacts relative to the baseline are summarized in Table 14, in Section 3.2. Utility cost rate future assumptions applied in the life cycle analysis for each measure are summarized in Table 18. 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 18: 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] |
| 2022 | 0.26 | 50 | 30 | 0.02 | 0.0735 | 0.0057 |
| 2023 | 0.2652 | 65 | 30 | 0.0204 | 0.075 | 0.0058 |
| 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 19.

Table 19: 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<br>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)<br>Up to 25% of funding can be grant |

- Life cycle cost analysis assumptions are summarized in Table 20.

Table 20: 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 21.

Table 21: 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 22.

Table 22: Measure identification and triaging summary

| Measure name | Triage for analysis |
|---|---|
| Baseline | |
| AC01-AC04 conversion to ASHP with electric backup | Analyzed. |
| AC01-AC04 conversion to ASHP with natural gas backup | Analyzed. |
| Carbon offsets 20 | Analyzed. |
| DHW to ASHP | Analyzed. |
| Interior LED lighting upgrade | Analyzed. |
| Roof upgrade to high performance | Analyzed. |
| Solar PV rooftop | Analyzed. |
| Wall upgrade to high performance | Analyzed. |
| Windows and doors to high performance | Analyzed. |
| AC01-AC04 renewal | Business as usual. |
| DHW renewal | Business as usual. |
| Exterior walls renewal | Business as usual. |
| Interior lighting renewal | Business as usual. |
| Roof renewal | Business as usual. |
| Windows and doors renewal | Business as usual. |
| Exterior LED lighting upgrade | Not analyzed: already LED. |

## 5.4 AC01-AC04 conversion to ASHP with electric backup

### Measure description

**Existing condition**

AC01 to AC04 are natural gas-fired furnaces complete with DX cooling.

**Opportunity**

Replace the AC units 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 pair of Cold Climate ASHPs with backup electric resistance. The following units shall be supplied:

- Moovair - Central-Moov 5T Capacity with 20kW backup electric
- Moovair - Central-Moov 2.5T Capacity with 10kW backup electric
- 2 x Moovair - Central-Moov 2T Capacity with 10kW backup electric

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

Condensing units installed at grade outside must be raised to account for snow cover and drifting.

#### Electrical

The ASHP with the electric backup will add approximately 67.25 kW of power to the existing system, which will put the system at 101.45 kW, which is approximately 59% of the full load of the electrical capacity of the building. A new 200 A panel will need to be installed off a new bus tap from the main switchboard. The fuse in the main switchboard will need to be replaced.

#### Project cost estimate

Table 23: Project cost estimate (AC01-AC04 conversion to ASHP with electric backup)

| Category | Line item | Unit | Value |
|---|---|---|---|
| Construction | Supply | [$] | 28,500 |
| | Install | [$] | 24,000 |
| | Electrical contingency | [$] | 53,000 |
| | General requirements (25%) | [$] | 26,400 |
| Contingency | Subtotal after Construction | [$] | 131,900 |
| | Design Contingency (25%) | [$] | 33,000 |
| | Construction Contingency (10%) | [$] | 13,200 |
| Design, Contractors, PM | Subtotal after Contingency | [$] | 178,100 |
| | Engineering Design and Field Review (10%) | [$] | 17,800 |
| | Contractor Fee (7%) | [$] | 12,500 |
| Total | Total | [$] | 208,400 |

### Utility analysis

#### Utility analysis methodology

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

- **Baseline**: AC1-4 provide space heating and cooling through natural gas-fired burners and DX, respectively. The existing heat efficiency and cooling COP are 90% and 4, respectively.
- **Proposed**: AC1-4 provide space heating and cooling through air-source heat pumps. The proposed average heating and cooling COPs are 3 and 4.1 (14 EER), respectively. Backup heating is provided through electric resistance when the outdoor air temperature is below -15 C.

#### Utility analysis results

Table 24: AC01-AC04 conversion to ASHP with electric backup analysis results summary

| Category | Description | Unit | Baseline | Proposed | Reduction | Reduction [%] |
|---|---|---|---|---|---|---|
| Utility use | Electricity use | [kWh/yr] | 121,792 | 152,205 | -30,413 | -25.0 |
| | Natural gas use | [m3/yr] | 8,859 | 563 | 8,297 | 93.7 |
| | Carbon offset use | [tCO2e/yr] | 0 | 0 | 0 | — |
| Equivalent energy use | Electricity energy | [kWh/yr] | 121,792 | 152,205 | -30,413 | -25.0 |
| | Natural gas energy | [kWh/yr] | 93,525 | 5,938 | 87,587 | 93.7 |
| | Total energy | [kWh/yr] | 215,317 | 158,143 | 57,174 | 26.6 |
| GHG emissions | Electricity GHGs | [tCO2e/yr] | 3.7 | 4.6 | -0.92 | -25.0 |
| | Natural gas GHGs | [tCO2e/yr] | 17.1 | 1.1 | 16.0 | 93.7 |
| | Carbon offsets GHGs | [tCO2e/yr] | 0 | 0 | 0 | — |
| | Total GHGs | [tCO2e/yr] | 20.8 | 5.7 | 15.1 | 72.7 |
| Utility cost | Electricity utility cost | [$/yr] | 12,082 | 15,099 | -3,017 | -25.0 |
| | Natural gas utility cost | [$/yr] | 2,303 | 146 | 2,157 | 93.7 |
| | Carbon offsets utility cost | [$/yr] | 0 | 0 | 0 | — |
| | Federal carbon charge | [$/yr] | 856 | 54.3 | 802 | 93.7 |
| | Total utility cost | [$/yr] | 15,241 | 15,299 | -58.2 | -0.38 |
| Financial | Assumed life | [yrs] | 15 | 15 | — | — |
| | Project cost | [$] | 0 | 208,400 | — | — |
| | Incentive amount | [$] | 0 | 41,680 | — | — |
| | Incremental project cost | [$] | 0 | 166,720 | — | — |
| | Life cycle cost | [$] | 443,213 | 687,962 | — | — |
| | Net present value | [$] | 0 | -244,749 | — | — |
| | Project cost per GHG reduction | [$yr/tCO2e] | — | 11,031 | — | — |
| | Simple payback period | [yr] | — | — | — | — |

## 5.5 AC01-AC04 conversion to ASHP with natural gas backup

### Measure description

#### Existing condition

AC01 to AC04 are natural gas-fired furnaces complete with DX cooling.

#### Opportunity

Replace the AC units 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 each of the gas-fired furnaces 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
- Moovair indoor unit model CUB30 and outdoor unit model DMA30
- 2 x Moovair indoor unit model CUB24 and outdoor unit model DMA24

Condensing units installed at grade outside must be raised to account for snow cover and drifting.

#### Electrical

The ASHP with the electric backup will add approximately 25.8 kW of power to the existing system, which will put the system at 60 kW, which is approximately 35% of the full load of the electrical capacity of the building. A new 200 A panel will need to be installed off a new bus tap from the main switchboard. The fuse in the main switchboard will need to be replaced.

### Project cost estimate

Table 25: Project cost estimate (AC01-AC04 conversion to ASHP with natural gas backup)

| Category | Line item | Unit | Value |
|---|---|---|---|
| Construction | Equipment | [$] | 19,000 |
| | Installation | [$] | 16,000 |
| | Electrical contingency | [$] | 24,000 |
| | General requirements (25%) | [$] | 14,800 |
| Contingency | Subtotal after Construction | [$] | 73,800 |
| | Design Contingency (25%) | [$] | 18,400 |
| | Construction Contingency (10%) | [$] | 7,400 |
| Design, Contractors, PM | Subtotal after Contingency | [$] | 99,600 |
| | Engineering Design and Field Review (10%) | [$] | 10,000 |
| | Contractor Fee (7%) | [$] | 7,000 |
| Total | Total | [$] | 116,600 |

## Utility analysis

### Utility analysis methodology

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

- **Baseline**: AC1-4 provide space heating and cooling through natural gas-fired burners and DX, respectively. The existing heat efficiency and cooling COP are 90% and 4, respectively.
- **Proposed**: AC1-4 provide space heating and cooling through air-source heat pumps. The proposed average heating and cooling COPs are 3 and 4.1 (14 EER), respectively. Backup heating is provided from the existing gas-fired furnaces when the outdoor air temperature is below -15 C.

### Utility analysis results

Table 26: AC01-AC04 conversion to ASHP with natural gas backup analysis results summary

| Category | Description | Unit | Baseline | Proposed | Reduction | Reduction [%] |
|---|---|---|---|---|---|---|
| Utility use | Electricity use | [kWh/yr] | 121,792 | 132,787 | -10,995 | -9.0 |
| | Natural gas use | [m3/yr] | 8,859 | 2,786 | 6,073 | 68.6 |
| | Carbon offset use | [tCO2e/yr] | 0 | 0 | 0 | — |
| Equivalent energy use | Electricity energy | [kWh/yr] | 121,792 | 132,787 | -10,995 | -9.0 |
| | Natural gas energy | [kWh/yr] | 93,525 | 29,410 | 64,116 | 68.6 |
| | Total energy | [kWh/yr] | 215,317 | 162,196 | 53,121 | 24.7 |
| GHG emissions | Electricity GHGs | [tCO2e/yr] | 3.7 | 4.0 | -0.33 | -9.0 |
| | Natural gas GHGs | [tCO2e/yr] | 17.1 | 5.4 | 11.7 | 68.6 |
| | Carbon offsets GHGs | [tCO2e/yr] | 0 | 0 | 0 | — |
| | Total GHGs | [tCO2e/yr] | 20.8 | 9.4 | 11.4 | 54.8 |
| Utility cost | Electricity utility cost | [$/yr] | 12,082 | 13,172 | -1,091 | -9.0 |
| | Natural gas utility cost | [$/yr] | 2,303 | 724 | 1,579 | 68.6 |
| | Carbon offsets utility cost | [$/yr] | 0 | 0 | 0 | — |
| | Federal carbon charge | [$/yr] | 856 | 269 | 587 | 68.6 |
| | Total utility cost | [$/yr] | 15,241 | 14,166 | 1,075 | 7.1 |
| Financial | Assumed life | [yrs] | 15 | 15 | — | — |
| | Project cost | [$] | 0 | 116,600 | — | — |
| | Incentive amount | [$] | 0 | 23,320 | — | — |
| | Incremental project cost | [$] | 0 | 93,280 | — | — |
| | Life cycle cost | [$] | 443,213 | 557,544 | — | — |
| | Net present value | [$] | 0 | -114,331 | — | — |
| | Project cost per GHG reduction | [$yr/tCO2e] | — | 8,180 | — | — |
| | Simple payback period | [yr] | — | >20 | — | — |

## 5.6 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 27: Carbon offsets 20 analysis results summary

| Category | Description | Unit | Baseline | Proposed | Reduction | Reduction [%] |
|---|---|---|---|---|---|---|
| Utility use | Electricity use | [kWh/yr] | 121,792 | 121,792 | 0 | 0 |
| | Natural gas use | [m3/yr] | 8,859 | 8,859 | 0 | 0 |
| | Carbon offset use | [tCO2e/yr] | 0 | 4.2 | -4.2 | – |
| Equivalent energy use | Electricity energy | [kWh/yr] | 121,792 | 121,792 | 0 | 0 |
| | Natural gas energy | [kWh/yr] | 93,525 | 93,525 | 0 | 0 |
| | Total energy | [kWh/yr] | 215,317 | 215,317 | 0 | 0 |
| GHG emissions | Electricity GHGs | [tCO2e/yr] | 3.7 | 3.7 | 0 | 0 |
| | Natural gas GHGs | [tCO2e/yr] | 17.1 | 17.1 | 0 | 0 |
| | Carbon offsets GHGs | [tCO2e/yr] | 0 | -4.2 | 4.2 | – |
| | Total GHGs | [tCO2e/yr] | 20.8 | 16.6 | 4.2 | 20.0 |
| Utility cost | Electricity utility cost | [$/yr] | 12,082 | 12,082 | 0 | 0 |
| | Natural gas utility cost | [$/yr] | 2,303 | 2,303 | 0 | 0 |
| | Carbon offsets utility cost | [$/yr] | 0 | 125 | -125 | – |
| | Federal carbon charge | [$/yr] | 856 | 856 | 0 | 0 |
| | Total utility cost | [$/yr] | 15,241 | 15,366 | -125 | -0.82 |
| Financial | Assumed life | [yrs] | 15 | 20 | – | – |
| | Project cost | [$] | 0 | – | – | – |
| | Incentive amount | [$] | 0 | 0 | – | – |
| | Incremental project cost | [$] | 0 | – | – | – |
| | Life cycle cost | [$] | 443,213 | 445,489 | – | – |
| | Net present value | [$] | 0 | -2,276 | – | – |
| | Project cost per GHG reduction | [$yr/tCO2e] | – | – | – | – |
| | Simple payback period | [yr] | – | – | – | – |

## 5.7 DHW to ASHP

### Measure description

**Existing condition**

One natural gas DHW heater serves this building, and is located in the basement mechanical room. It has a capacity of 50 USG.

**Opportunity**

Replace the gas-fired DHW heater with ASHP (air source heat pump) equivalent.

**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 the gas-fired hot water be replaced with a hybrid heat pump hot water heater that extracts heat from the space for hot water.

The following units are to be installed to match the existing capacity:

- Rheem Proterra 80 USG

**Electrical**

The ASHP will add approximately 5 kW of power to the existing system, which will put the system at 39.2 kW, which is approximately 23% of the full load of the electrical capacity of the building.

### Project cost estimate

Table 28: Project cost estimate (DHW to ASHP)

| Category | Line item | Unit | Value |
|---|---|---|---|
| Materials and labour | Supply | [$] | 5,000 |
| | Installation | [$] | 4,000 |
| | Electrical work | [$] | 12,000 |
| Contingency | Subtotal after Materials and labour | [$] | 21,000 |
| | General Contingency (50%) | [$] | 10,500 |
| Total | Total | [$] | 31,500 |

## 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 29: DHW to ASHP analysis results summary

| Category | Description | Unit | Baseline | Proposed | Reduction | Reduction [%] |
|---|---|---|---|---|---|---|
| Utility use | Electricity use | [kWh/yr] | 121,792 | 124,651 | -2,860 | -2.3 |
| | Natural gas use | [m3/yr] | 8,859 | 8,313 | 547 | 6.2 |
| | Carbon offset use | [tCO2e/yr] | 0 | 0 | 0 | – |
| Equivalent energy use | Electricity energy | [kWh/yr] | 121,792 | 124,651 | -2,860 | -2.3 |
| | Natural gas energy | [kWh/yr] | 93,525 | 87,755 | 5,771 | 6.2 |
| | Total energy | [kWh/yr] | 215,317 | 212,406 | 2,911 | 1.4 |
| GHG emissions | Electricity GHGs | [tCO2e/yr] | 3.7 | 3.8 | -0.09 | -2.3 |
| | Natural gas GHGs | [tCO2e/yr] | 17.1 | 16.1 | 1.1 | 6.2 |
| | Carbon offsets GHGs | [tCO2e/yr] | 0 | 0 | 0 | – |
| | Total GHGs | [tCO2e/yr] | 20.8 | 19.8 | 0.97 | 4.7 |
| Utility cost | Electricity utility cost | [$/yr] | 12,082 | 12,365 | -284 | -2.3 |
| | Natural gas utility cost | [$/yr] | 2,303 | 2,161 | 142 | 6.2 |
| | Carbon offsets utility cost | [$/yr] | 0 | 0 | 0 | – |
| | Federal carbon charge | [$/yr] | 856 | 803 | 52.8 | 6.2 |
| | Total utility cost | [$/yr] | 15,241 | 15,330 | -88.7 | -0.58 |
| Financial | Assumed life | [yrs] | 15 | 15 | – | – |
| | Project cost | [$] | 0 | 31,500 | – | – |
| | Incentive amount | [$] | 0 | 137 | – | – |
| | Incremental project cost | [$] | 0 | 31,363 | – | – |
| | Life cycle cost | [$] | 443,213 | 485,090 | – | – |
| | Net present value | [$] | 0 | -41,877 | – | – |
| | Project cost per GHG reduction | [$yr/tCO2e] | – | 32,336 | – | – |
| | Simple payback period | [yr] | – | – | – | – |

## 5.8 Interior LED lighting upgrade

### Measure description

**Existing condition**

Some areas of the building currently operate with LED fixtures (e.g. corridors and waiting rooms). The remaining areas of the building primarily utilize T8 or T12 lamps.


**Opportunity**

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

**Utility-savings mechanism**

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

### Design description

**Overview**

The lighting system shall be designed to meet the latest ASHRAE 90.1 energy codes, IESNA standards, the Haileybury Medical Centre standards and other applicable regulations and standards.

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

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

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

Type A1, A2, A4, and B fixtures should be replaced.

### Project cost estimate

Table 30: Project cost estimate (Interior LED lighting upgrade)

| Category | Line item | Unit | Value |
|---|---|---|---|
| Materials and labour | Interior LED lighting upgrade | [$] | 15,000 |
| Contingency | Subtotal after Materials and labour | [$] | 15,000 |
| | General Contingency (50%) | [$] | 7,500 |
| Total | Total | [$] | 22,500 |

## Utility analysis

### Utility analysis methodology

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

- **Baseline**: It is assumed that there is an average LPD of 9.5 W/m2.
- **Proposed**: It is assumed that the average LPD is reduced to 5.7 W/m2. Operation schedules are maintained.

### Utility analysis results

Table 31: Interior LED lighting upgrade analysis results summary

| Category | Description | Unit | Baseline | Proposed | Reduction | Reduction [%] |
|---|---|---|---|---|---|---|
| Utility use | Electricity use | [kWh/yr] | 121,792 | 108,069 | 13,723 | 11.3 |
| | Natural gas use | [m3/yr] | 8,859 | 9,436 | -576 | -6.5 |
| | Carbon offset use | [tCO2e/yr] | 0 | 0 | 0 | – |
| Equivalent energy use | Electricity energy | [kWh/yr] | 121,792 | 108,069 | 13,723 | 11.3 |
| | Natural gas energy | [kWh/yr] | 93,525 | 99,610 | -6,084 | -6.5 |
| | Total energy | [kWh/yr] | 215,317 | 207,678 | 7,639 | 3.5 |
| GHG emissions | Electricity GHGs | [tCO2e/yr] | 3.7 | 3.3 | 0.41 | 11.3 |
| | Natural gas GHGs | [tCO2e/yr] | 17.1 | 18.2 | -1.1 | -6.5 |
| | Carbon offsets GHGs | [tCO2e/yr] | 0 | 0 | 0 | – |
| | Total GHGs | [tCO2e/yr] | 20.8 | 21.5 | -0.70 | -3.4 |
| Utility cost | Electricity utility cost | [$/yr] | 12,082 | 10,720 | 1,361 | 11.3 |
| | Natural gas utility cost | [$/yr] | 2,303 | 2,453 | -150 | -6.5 |
| | Carbon offsets utility cost | [$/yr] | 0 | 0 | 0 | – |
| | Federal carbon charge | [$/yr] | 856 | 912 | -55.7 | -6.5 |
| | Total utility cost | [$/yr] | 15,241 | 14,085 | 1,156 | 7.6 |
| Financial | Assumed life | [yrs] | 15 | 20 | – | – |
| | Project cost | [$] | 0 | 22,500 | – | – |
| | Incentive amount | [$] | 0 | 0 | – | – |
| | Incremental project cost | [$] | 0 | 22,500 | – | – |
| | Life cycle cost | [$] | 443,213 | 433,640 | – | – |
| | Net present value | [$] | 0 | 9,573 | – | – |
| | Project cost per GHG reduction | [$yr/tCO2e] | – | -32,177 | – | – |
| | Simple payback period | [yr] | – | 19 | – | – |

## 5.9 Roof upgrade to high performance

### Measure description

**Existing condition**

The building has a gable roof which is assumed to be on wood trusses, with some batt insulation in the attic space. The HVAC audit report indicated a minimum of 14 inches of blown-in insulation in the attic space.

**Opportunity**

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

**Utility-savings mechanism**

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

### Design description

**Overview**

The building has a gable roof, which we assume is on wood trusses, with some batt insulation in the attic space. The current code requires this type of insulation to have a thermal performance of R70 in this climatic zone, which would mean providing a minimum total of at least 12 inches of insulation in the attic. Spray foam could be applied where the attic trusses meet the exterior walls if the depth of the trusses does not allow a full 12 inches of batts.

**Project cost estimate**

Table 32: Project cost estimate (Roof upgrade to high performance)

| Category | Line item | Unit | Value |
|---|---|---|---|
| Construction | Roof replacement | [$] | 80,000 |
| | General requirements (25%) | [$] | 20,000 |
| Contingency | Subtotal after Construction | [$] | 100,000 |
| | Design Contingency (25%) | [$] | 25,000 |
| | Construction Contingency (10%) | [$] | 10,000 |
| Design, Contractors, PM | Subtotal after Contingency | [$] | 135,000 |
| | Engineering Design and Field Review (10%) | [$] | 13,500 |
| | Contractor Fee (7%) | [$] | 9,400 |
| Total | Total | [$] | 157,900 |

## 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 0.0213 BTU/hr.ft2.F (R47) was assumed.
- **Proposed**. An average roof U-value of 0.0143 BTU/hr.ft2.F (R70) was assumed.

### Utility analysis results

Table 33: Roof upgrade to high performance analysis results summary

| Category | Description | Unit | Baseline | Proposed | Reduction | Reduction [%] |
|---|---|---|---|---|---|---|
| Utility use | Electricity use | [kWh/yr] | 121,792 | 121,801 | -9.1 | -0.01 |
| | Natural gas use | [m3/yr] | 8,859 | 8,337 | 522 | 5.9 |
| | Carbon offset use | [tCO2e/yr] | 0 | 0 | 0 | – |
| Equivalent energy use | Electricity energy | [kWh/yr] | 121,792 | 121,801 | -9.1 | -0.01 |
| | Natural gas energy | [kWh/yr] | 93,525 | 88,014 | 5,512 | 5.9 |
| | Total energy | [kWh/yr] | 215,317 | 209,814 | 5,503 | 2.6 |
| GHG emissions | Electricity GHGs | [tCO2e/yr] | 3.7 | 3.7 | -0.00 | -0.01 |
| | Natural gas GHGs | [tCO2e/yr] | 17.1 | 16.1 | 1.0 | 5.9 |
| | Carbon offsets GHGs | [tCO2e/yr] | 0 | 0 | 0 | – |
| | Total GHGs | [tCO2e/yr] | 20.8 | 19.8 | 1.0 | 4.8 |
| Utility cost | Electricity utility cost | [$/yr] | 12,082 | 12,083 | -0.90 | -0.01 |
| | Natural gas utility cost | [$/yr] | 2,303 | 2,168 | 136 | 5.9 |
| | Carbon offsets utility cost | [$/yr] | 0 | 0 | 0 | – |
| | Federal carbon charge | [$/yr] | 856 | 806 | 50.4 | 5.9 |
| | Total utility cost | [$/yr] | 15,241 | 15,056 | 185 | 1.2 |
| Financial | Assumed life | [yrs] | 15 | 20 | – | – |
| | Project cost | [$] | 0 | 157,900 | – | – |
| | Incentive amount | [$] | 0 | 31,580 | – | – |
| | Incremental project cost | [$] | 0 | 126,320 | – | – |
| | Life cycle cost | [$] | 443,213 | 574,161 | – | – |
| | Net present value | [$] | 0 | -130,948 | – | – |
| | Project cost per GHG reduction | [$yr/tCO2e] | – | 125,241 | – | – |
| | Simple payback period | [yr] | – | >20 | – | – |

## 5.10 Solar PV rooftop

### Measure description

#### Existing condition

There is no solar PV on the roof. Some rooftop space is available.

#### 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) = 22 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 rated high enough to accommodate the additional incoming load of the solar. No additional upgrades outside of the solar equipment will be required.

**Project cost estimate**

Table 34: Project cost estimate (Solar PV rooftop)

| Category | Line item | Unit | Value |
|---|---|---|---|
| Materials and labour | Solar PV electricity system installed (assuming 22 kW at 2000 $/kW) | [$] | 44,000 |
| | Electrical | [$] | 5,000 |
| Contingency | Subtotal after Materials and labour | [$] | 49,000 |
| | General Contingency (20%) | [$] | 9,800 |
| | Design Contingency (10%) | [$] | 4,900 |
| Total | Total | [$] | 63,700 |

## Utility analysis

**Utility analysis methodology**

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

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

**Utility analysis results**

Table 35: Solar PV rooftop analysis results summary

| Category | Description | Unit | Baseline | Proposed | Reduction | Reduction [%] |
|---|---|---|---|---|---|---|
| Utility use | Electricity use | [kWh/yr] | 121,792 | 98,560 | 23,231 | 19.1 |
| | Natural gas use | [m3/yr] | 8,859 | 8,859 | 0 | 0 |
| | Carbon offset use | [tCO2e/yr] | 0 | 0 | 0 | – |
| Equivalent energy use | Electricity energy | [kWh/yr] | 121,792 | 98,560 | 23,231 | 19.1 |
| | Natural gas energy | [kWh/yr] | 93,525 | 93,525 | 0 | 0 |
| | Total energy | [kWh/yr] | 215,317 | 192,086 | 23,231 | 10.8 |
| GHG emissions | Electricity GHGs | [tCO2e/yr] | 3.7 | 3.0 | 0.70 | 19.1 |
| | Natural gas GHGs | [tCO2e/yr] | 17.1 | 17.1 | 0 | 0 |
| | Carbon offsets GHGs | [tCO2e/yr] | 0 | 0 | 0 | – |
| | Total GHGs | [tCO2e/yr] | 20.8 | 20.1 | 0.70 | 3.4 |
| Utility cost | Electricity utility cost | [$/yr] | 12,082 | 9,777 | 2,305 | 19.1 |
| | Natural gas utility cost | [$/yr] | 2,303 | 2,303 | 0 | 0 |
| | Carbon offsets utility cost | [$/yr] | 0 | 0 | 0 | – |
| | Federal carbon charge | [$/yr] | 856 | 856 | 0.00 | 0.00 |
| | Total utility cost | [$/yr] | 15,241 | 12,937 | 2,305 | 15.1 |
| Financial | Assumed life | [yrs] | 15 | 30 | – | – |
| | Project cost | [$] | 0 | 63,700 | – | – |
| | Incentive amount | [$] | 0 | 12,740 | – | – |
| | Incremental project cost | [$] | 0 | 50,960 | – | – |
| | Life cycle cost | [$] | 443,213 | 423,951 | – | – |
| | Net present value | [$] | 0 | 19,262 | – | – |
| | Project cost per GHG reduction | [$yr/tCO2e] | – | 72,635 | – | – |
| | Simple payback period | [yr] | – | >20 | – | – |

## 5.11 Wall upgrade to high performance

### Measure description

#### Existing condition

The building appears to have a concrete block exterior, which may be on wood stud framing or maybe a masonry cavity wall with concrete block backup.

#### 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

To avoid having to rework and remove interior finishes, we recommend adding an EIFS system to the exterior walls to a depth of 6 inches. This system comes with its own air barrier, which will help to reduce air leakage if the proper flashing is applied at all door and window openings. The new thermal performance value should be at least R20, if not more, and can be applied to the lower-level concrete walls as well as the masonry, as long as the concrete finish is in good repair.

#### Project cost estimate

Table 36: Project cost estimate (Wall upgrade to high performance)

| Category | Line item | Unit | Value |
|---|---|---|---|
| Construction | Wall upgrade | [$] | 561,000 |
| | General requirements (25%) | [$] | 140,200 |
| Contingency | Subtotal after Construction | [$] | 701,200 |
| | Design Contingency (25%) | [$] | 175,300 |
| | Construction Contingency (10%) | [$] | 70,100 |
| Design, Contractors, PM | Subtotal after Contingency | [$] | 946,600 |
| | Engineering Design and Field Review (10%) | [$] | 94,700 |
| | Contractor Fee (7%) | [$] | 66,300 |
| Total | Total | [$] | 1,107,600 |

## 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 0.05 BTU/hr.ft2.F (R20) was assumed.
- **Proposed**. An average wall U-value of 0.025 BTU/hr.ft2.F (R40) was assumed. Infiltration flow was assumed to be reduced by 10% in total relative to the Baseline for affected spaces.

### Utility analysis results

Table 37: Wall upgrade to high performance analysis results summary

| Category | Description | Unit | Baseline | Proposed | Reduction | Reduction [%] |
|---|---|---|---|---|---|---|
| Utility use | Electricity use | [kWh/yr] | 121,792 | 123,542 | -1,750 | -1.4 |
| | Natural gas use | [m3/yr] | 8,859 | 6,469 | 2,391 | 27.0 |
| | Carbon offset use | [tCO2e/yr] | 0 | 0 | 0 | — |
| Equivalent energy use | Electricity energy | [kWh/yr] | 121,792 | 123,542 | -1,750 | -1.4 |
| | Natural gas energy | [kWh/yr] | 93,525 | 68,288 | 25,238 | 27.0 |
| | Total energy | [kWh/yr] | 215,317 | 191,829 | 23,488 | 10.9 |
| GHG emissions | Electricity GHGs | [tCO2e/yr] | 3.7 | 3.7 | -0.05 | -1.4 |
| | Natural gas GHGs | [tCO2e/yr] | 17.1 | 12.5 | 4.6 | 27.0 |
| | Carbon offsets GHGs | [tCO2e/yr] | 0 | 0 | 0 | — |
| | Total GHGs | [tCO2e/yr] | 20.8 | 16.2 | 4.6 | 22.0 |
| Utility cost | Electricity utility cost | [$/yr] | 12,082 | 12,255 | -174 | -1.4 |
| | Natural gas utility cost | [$/yr] | 2,303 | 1,682 | 622 | 27.0 |
| | Carbon offsets utility cost | [$/yr] | 0 | 0 | 0 | — |
| | Federal carbon charge | [$/yr] | 856 | 625 | 231 | 27.0 |
| | Total utility cost | [$/yr] | 15,241 | 14,562 | 679 | 4.5 |
| Financial | Assumed life | [yrs] | 15 | 75 | — | — |
| | Project cost | [$] | 0 | 1,107,600 | — | — |
| | Incentive amount | [$] | 0 | 221,520 | — | — |
| | Incremental project cost | [$] | 0 | 886,080 | — | — |
| | Life cycle cost | [$] | 443,213 | 723,133 | — | — |
| | Net present value | [$] | 0 | -279,920 | — | — |
| | Project cost per GHG reduction | [$yr/tCO2e] | — | 194,028 | — | — |
| | Simple payback period | [yr] | — | >20 | — | — |

## 5.12 Windows and doors to high performance

### Measure description

#### Existing condition

The facility has aluminum-framed, double-pane windows. Five windows were installed in 2023, which were aluminum-framed, thermally broken. The facility has eight swing doors, 6 with glazing, and 2 hollow metal.


#### Opportunity

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

#### Utility-savings mechanism

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

### Design description

#### Windows

We recommend replacing all windows with Passive House Certified Triple-glazed, thermally broken windows. These could be framed in aluminum, vinyl or fiberglass. At the very least we would recommend double-glazed windows in thermally broken frames to bring them up to current code standards.

#### 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.

### Project cost estimate

Table 38: Project cost estimate (Windows and doors to high performance)

| Category | Line item | Unit | Value |
|---|---|---|---|
| Construction | Window and door replacement | [$] | 162,000 |
| | General requirements (25%) | [$] | 40,500 |
| Contingency | Subtotal after Construction | [$] | 202,500 |
| | Design Contingency (25%) | [$] | 50,600 |
| | Construction Contingency (10%) | [$] | 20,200 |
| Design, Contractors, PM | Subtotal after Contingency | [$] | 273,300 |
| | Engineering Design and Field Review (10%) | [$] | 27,300 |
| | Contractor Fee (7%) | [$] | 19,100 |
| Total | Total | [$] | 319,700 |

## 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 0.5601 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 39: Windows and doors to high performance analysis results summary

| Category | Description | Unit | Baseline | Proposed | Reduction | Reduction [%] |
|---|---|---|---|---|---|---|
| Utility use | Electricity use | [kWh/yr] | 121,792 | 121,740 | 51.5 | 0.04 |
| | Natural gas use | [m3/yr] | 8,859 | 8,684 | 175 | 2.0 |
| | Carbon offset use | [tCO2e/yr] | 0 | 0 | 0 | – |
| Equivalent energy use | Electricity energy | [kWh/yr] | 121,792 | 121,740 | 51.5 | 0.04 |
| | Natural gas energy | [kWh/yr] | 93,525 | 91,675 | 1,851 | 2.0 |
| | Total energy | [kWh/yr] | 215,317 | 213,415 | 1,902 | 0.88 |
| GHG emissions | Electricity GHGs | [tCO2e/yr] | 3.7 | 3.7 | 0.00 | 0.04 |
| | Natural gas GHGs | [tCO2e/yr] | 17.1 | 16.8 | 0.34 | 2.0 |
| | Carbon offsets GHGs | [tCO2e/yr] | 0 | 0 | 0 | – |
| | Total GHGs | [tCO2e/yr] | 20.8 | 20.5 | 0.34 | 1.6 |
| Utility cost | Electricity utility cost | [$/yr] | 12,082 | 12,077 | 5.1 | 0.04 |
| | Natural gas utility cost | [$/yr] | 2,303 | 2,258 | 45.6 | 2.0 |
| | Carbon offsets utility cost | [$/yr] | 0 | 0 | 0 | – |
| | Federal carbon charge | [$/yr] | 856 | 839 | 16.9 | 2.0 |
| | Total utility cost | [$/yr] | 15,241 | 15,174 | 67.6 | 0.44 |
| Financial | Assumed life | [yrs] | 15 | 40 | – | – |
| | Project cost | [$] | 0 | 319,700 | – | – |
| | Incentive amount | [$] | 0 | 63,940 | – | – |
| | Incremental project cost | [$] | 0 | 255,760 | – | – |
| | Life cycle cost | [$] | 443,213 | 597,514 | – | – |
| | Net present value | [$] | 0 | -154,301 | – | – |
| | Project cost per GHG reduction | [$yr/tCO2e] | – | 751,537 | – | – |
| | Simple payback period | [yr] | – | >20 | – | – |

## 5.13 Measure risk analysis

### Utility use sensitivity

Figure 153 indicates how sensitive cumulative electricity and natural gas use are to variations in each risk parameter.

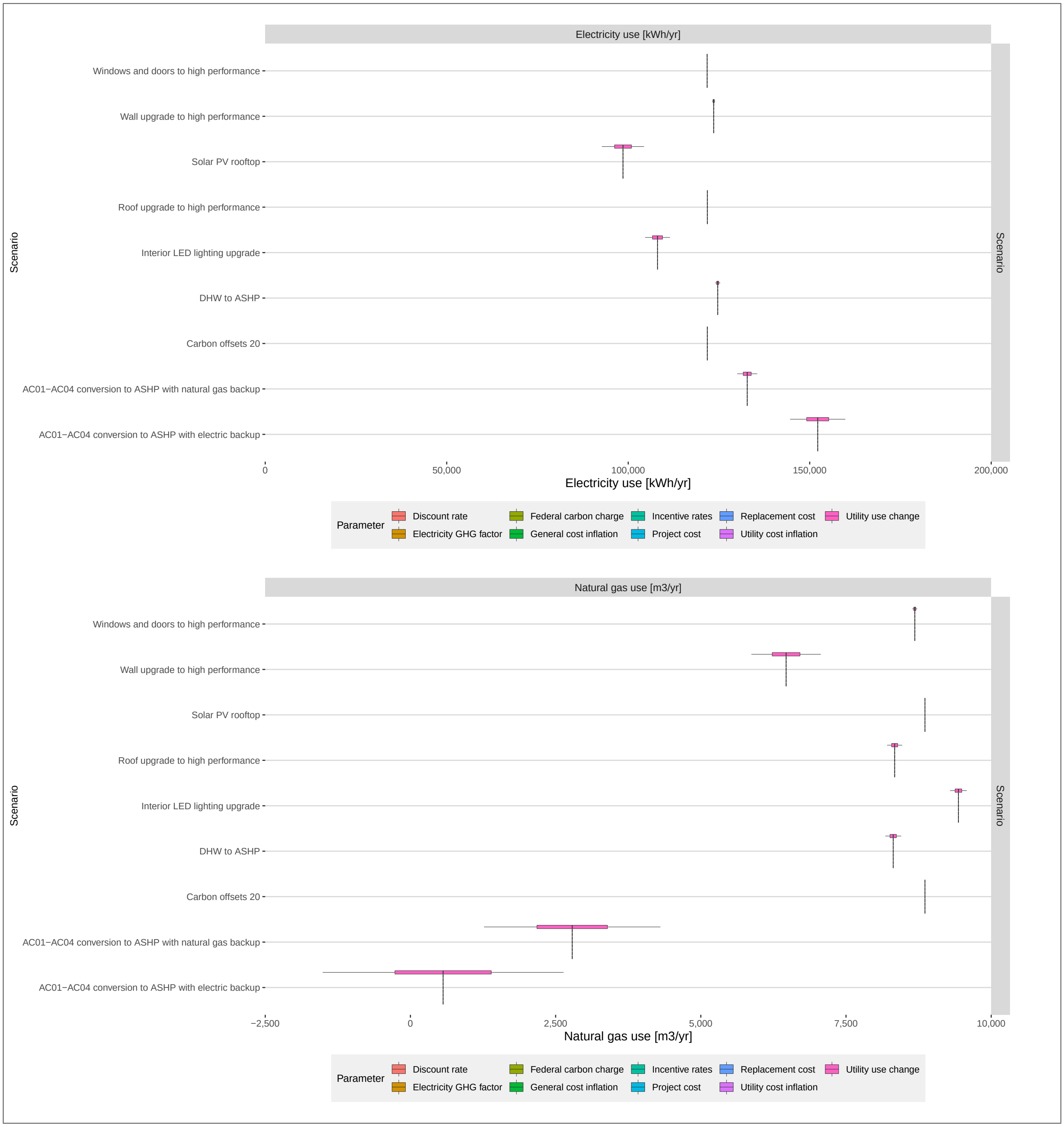


Figure 153: Utility cumulative use sensitivity analysis

## GHG emissions and life cycle cost sensitivity

Figure 154 indicates how sensitive cumulative GHG emissions and life cycle costs are to variations in each risk parameter.

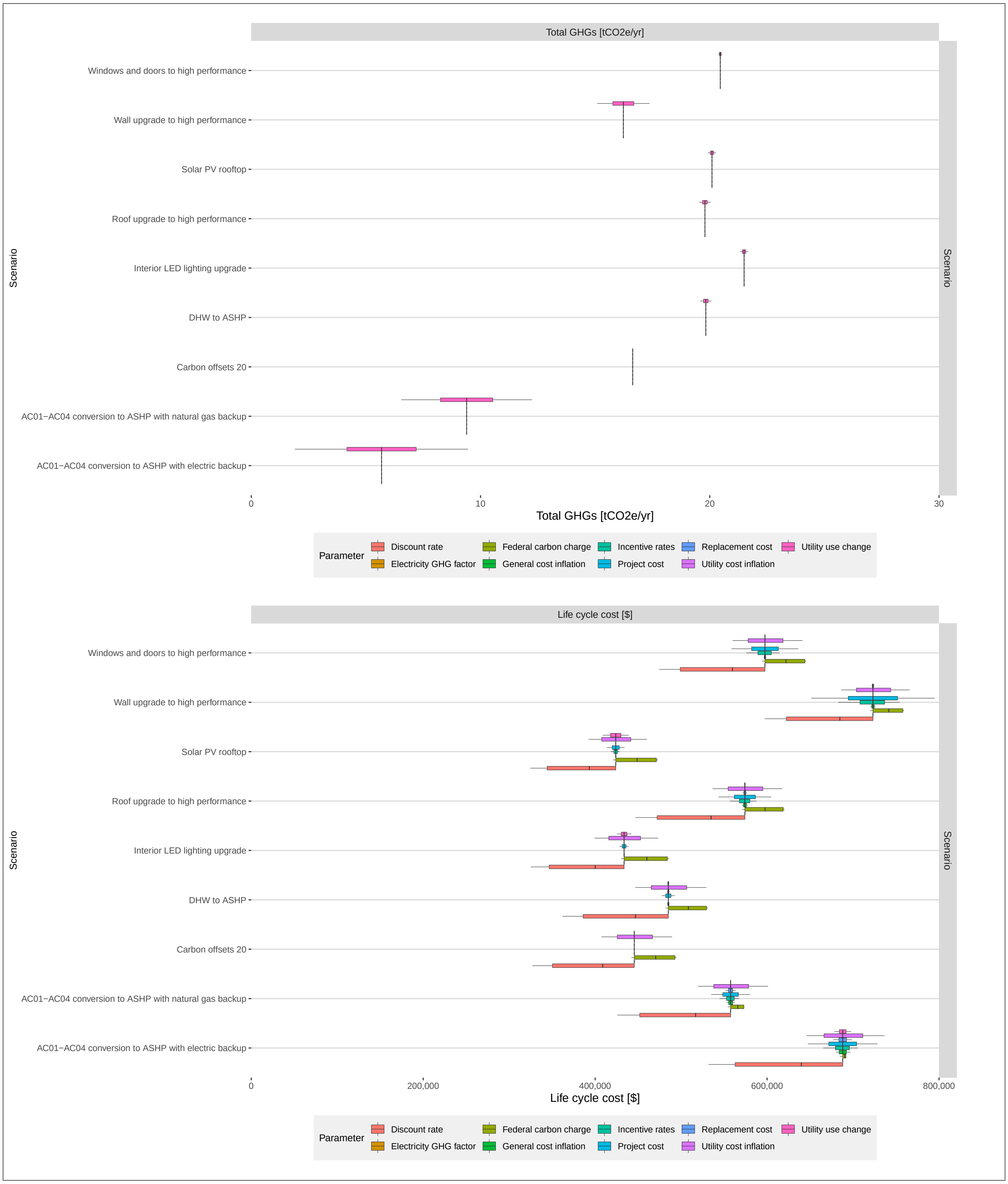


Figure 154: GHG cumulative emissions and life cycle cost sensitivity analysis

## 5.14 Measure analysis summary

For each analyzed measure, the analysis results are summarized in Table 40.

Table 40: 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 | 121,792 | 100.0 | 8,859 | 100.0 | 215,317 | 100.0 | 21 | 100.0 | 15,241 | 100.0 | 15 | 0 | 0 | 0 | 443,213 | 0 | - | - |
| AC01-AC04 conversion to ASHP with electric backup | -30,413 | -25.0 | 8,297 | 93.7 | 57,174 | 26.6 | 15 | 72.7 | -58 | -0.4 | 15 | 208,400 | 41,680 | 166,720 | 687,962 | -244,749 | 11,031 | -2,864 |
| AC01-AC04 conversion to ASHP with natural gas backup | -10,995 | -9.0 | 6,073 | 68.6 | 53,121 | 24.7 | 11 | 54.8 | 1,075 | 7.1 | 15 | 116,600 | 23,320 | 93,280 | 557,544 | -114,331 | 8,180 | 87 |
| Carbon offsets 20 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 4 | 20.0 | -125 | -0.8 | 20 | - | 0 | - | 445,488 | -2,276 | - | - |
| DHW to ASHP | -2,860 | -2.3 | 547 | 6.2 | 2,911 | 1.4 | 1 | 4.7 | -89 | -0.6 | 15 | 31,500 | 137 | 31,363 | 485,090 | -41,877 | 32,336 | -353 |
| Interior LED lighting upgrade | 13,723 | 11.3 | -576 | -6.5 | 7,639 | 3.5 | -1 | -3.4 | 1,156 | 7.6 | 20 | 22,500 | 0 | 22,500 | 433,640 | 9,573 | -32,177 | 19 |
| Roof upgrade to high performance | -9 | -0.0 | 522 | 5.9 | 5,503 | 2.6 | 1 | 4.8 | 185 | 1.2 | 20 | 157,900 | 31,580 | 126,320 | 574,161 | -130,948 | 125,241 | 682 |
| Solar PV rooftop | 23,231 | 19.1 | 0 | 0.0 | 23,231 | 10.8 | 1 | 3.4 | 2,305 | 15.1 | 30 | 63,700 | 12,740 | 50,960 | 423,951 | 19,262 | 72,635 | 22 |
| Wall upgrade to high performance | -1,750 | -1.4 | 2,391 | 27.0 | 23,488 | 10.9 | 5 | 22.0 | 679 | 4.5 | 75 | 1,107,600 | 221,520 | 886,080 | 723,133 | -279,920 | 194,028 | 1,305 |
| Windows and doors to high performance | 51 | 0.0 | 175 | 2.0 | 1,902 | 0.9 | 0 | 1.6 | 68 | 0.4 | 40 | 319,700 | 63,940 | 255,760 | 597,514 | -154,301 | 751,537 | 3,782 |
| Total project cost | - | - | - | - | - | - | - | - | - | - | - | 2,027,900 | - | - | - | - | - | - |
| AC01-AC04 renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 15 | 38,000 | 0 | 38,000 | 488,093 | -44,880 | - | - |
| DHW renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 15 | 4,000 | 0 | 4,000 | 447,937 | -4,724 | - | - |
| Exterior walls renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 75 | 8,000 | 0 | 8,000 | 445,803 | -2,590 | - | - |
| Interior lighting renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 20 | 19,000 | 0 | 19,000 | 462,962 | -19,749 | - | - |
| Roof renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 20 | 388,000 | 0 | 388,000 | 846,513 | -403,300 | - | - |
| Windows and doors renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 40 | 48,000 | 0 | 48,000 | 472,356 | -29,143 | - | - |
| BAU measure totals | - | - | - | - | - | - | - | - | - | - | - | 505,000 | - | - | - | - | - | - |

# 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 41.
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 41.

Table 41: 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 155 and Table 42 present the results of this exercise, indicating which measures were assigned to which scenario.

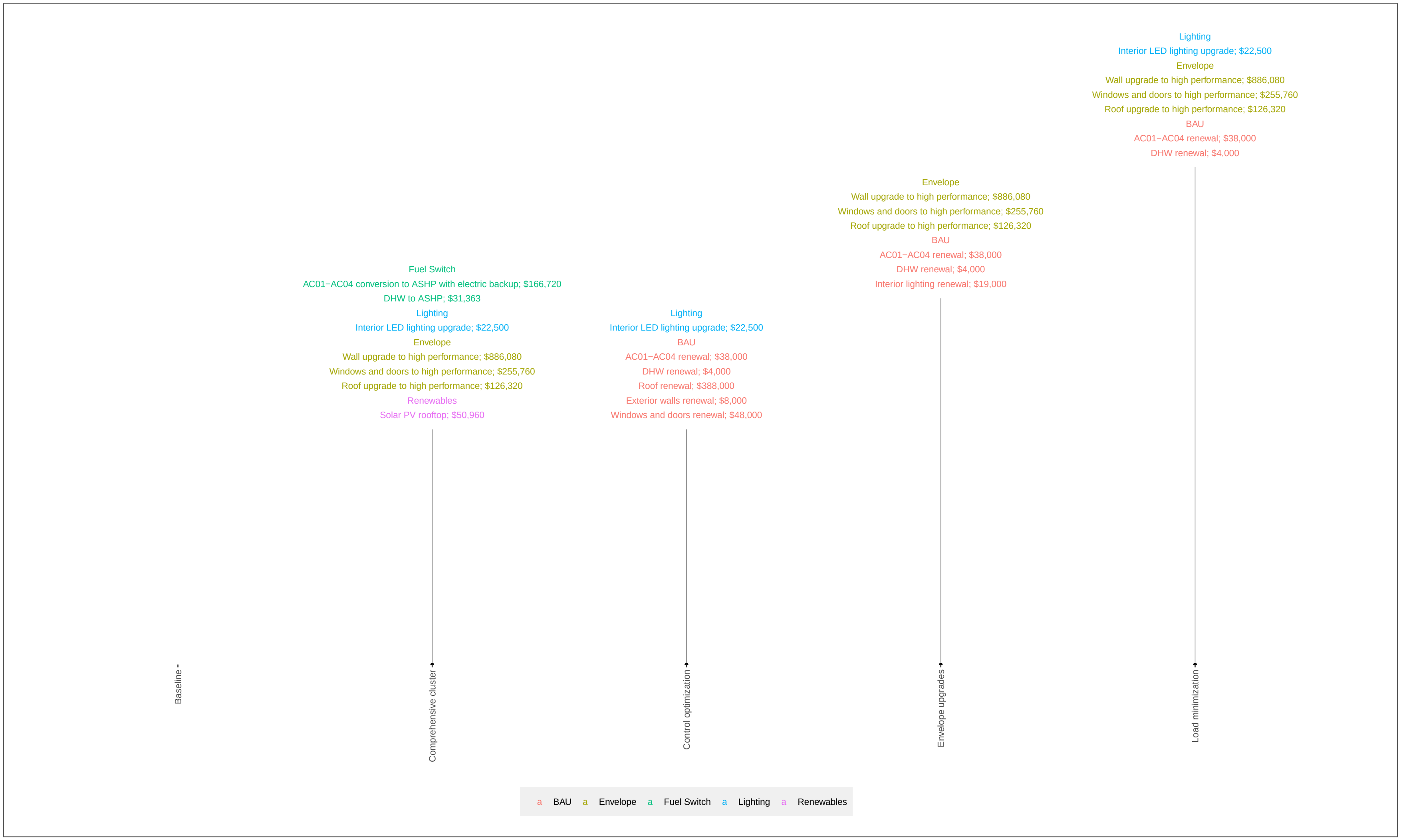


Figure 155: Scenario composition

Table 42: Cluster composition

| Measure | Control optimization | Envelope upgrades | Load minimization | Comprehensive cluster |
|---|---|---|---|---|
| AC01-AC04 conversion to ASHP with electric backup | ✖ | ✖ | ✖ | ✔ |
| AC01-AC04 conversion to ASHP with natural gas backup | ✖ | ✖ | ✖ | ✖ |
| Carbon offsets 20 | ✖ | ✖ | ✖ | ✖ |
| DHW to ASHP | ✖ | ✖ | ✖ | ✔ |
| Interior LED lighting upgrade | ✔ | ✖ | ✔ | ✔ |
| Roof upgrade to high performance | ✖ | ✔ | ✔ | ✔ |
| Solar PV rooftop | ✖ | ✖ | ✖ | ✔ |
| Wall upgrade to high performance | ✖ | ✔ | ✔ | ✔ |
| Windows and doors to high performance | ✖ | ✔ | ✔ | ✔ |
| AC01-AC04 renewal | ✔ | ✔ | ✔ | ✖ |
| DHW renewal | ✔ | ✔ | ✔ | ✖ |
| Exterior walls renewal | ✔ | ✖ | ✖ | ✖ |
| Interior lighting 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 43, 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 43: 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 | 19,240 | 15.8 | 8,859 | 100.0 | 112,765 | 52.4 | 18 | 85.1 | 5,068 | 33.3 | - | 1,911,300 | 371,597 | 1,539,703 | 1,187,133 | -743,920 | 86,987 | 304 |
| Comprehensive cluster | AC01-AC04 conversion to ASHP with electric backup | -30,413 | -25.0 | 8,297 | 93.7 | 57,174 | 26.6 | 15 | 72.7 | -58 | -0.4 | 15 | 208,400 | 41,680 | 166,720 | 687,962 | -244,749 | 11,031 | -2,864 |
| Comprehensive cluster | DHW to ASHP | -2,860 | -2.3 | 547 | 6.2 | 2,911 | 1.4 | 1 | 4.7 | -89 | -0.6 | 15 | 31,500 | 137 | 31,363 | 485,090 | -41,877 | 32,336 | -353 |
| Comprehensive cluster | Interior LED lighting upgrade | 13,723 | 11.3 | -576 | -6.5 | 7,639 | 3.5 | -1 | -3.4 | 1,156 | 7.6 | 20 | 22,500 | 0 | 22,500 | 433,640 | 9,573 | -32,177 | 19 |
| Comprehensive cluster | Wall upgrade to high performance | -1,750 | -1.4 | 2,391 | 27.0 | 23,488 | 10.9 | 5 | 22.0 | 679 | 4.5 | 75 | 1,107,600 | 221,520 | 886,080 | 723,133 | -279,920 | 194,028 | 1,305 |
| Comprehensive cluster | Windows and doors to high performance | 51 | 0.0 | 175 | 2.0 | 1,902 | 0.9 | 0 | 1.6 | 68 | 0.4 | 40 | 319,700 | 63,940 | 255,760 | 597,514 | -154,301 | 751,537 | 3,782 |
| Comprehensive cluster | Roof upgrade to high performance | -9 | -0.0 | 522 | 5.9 | 5,503 | 2.6 | 1 | 4.8 | 185 | 1.2 | 20 | 157,900 | 31,580 | 126,320 | 574,161 | -130,948 | 125,241 | 682 |
| Comprehensive cluster | Solar PV rooftop | 23,231 | 19.1 | 0 | 0.0 | 23,231 | 10.8 | 1 | 3.4 | 2,305 | 15.1 | 30 | 63,700 | 12,740 | 50,960 | 423,951 | 19,262 | 72,635 | 22 |
| Control optimization | Combined | 13,723 | 11.3 | -576 | -6.5 | 7,639 | 3.5 | -1 | -3.4 | 1,156 | 7.6 | - | 508,500 | 0 | 508,500 | 898,078 | -454,865 | -727,206 | 440 |
| Control optimization | Interior LED lighting upgrade | 13,723 | 11.3 | -576 | -6.5 | 7,639 | 3.5 | -1 | -3.4 | 1,156 | 7.6 | 20 | 22,500 | 0 | 22,500 | 433,640 | 9,573 | -32,177 | 19 |
| Control optimization | AC01-AC04 renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 15 | 38,000 | 0 | 38,000 | 488,093 | -44,880 | - | - |
| Control optimization | DHW renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 15 | 4,000 | 0 | 4,000 | 447,937 | -4,724 | - | - |
| Control optimization | Roof renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 20 | 388,000 | 0 | 388,000 | 846,513 | -403,300 | - | - |
| Control optimization | Exterior walls renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 75 | 8,000 | 0 | 8,000 | 445,803 | -2,590 | - | - |
| Control optimization | Windows and doors renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 40 | 48,000 | 0 | 48,000 | 472,356 | -29,143 | - | - |
| Envelope upgrades | Combined | -1,998 | -1.6 | 3,090 | 34.9 | 30,620 | 14.2 | 6 | 28.4 | 904 | 5.9 | - | 1,646,200 | 317,040 | 1,329,160 | 1,040,220 | -597,007 | 224,885 | 1,471 |
| Envelope upgrades | Wall upgrade to high performance | -1,750 | -1.4 | 2,391 | 27.0 | 23,488 | 10.9 | 5 | 22.0 | 679 | 4.5 | 75 | 1,107,600 | 221,520 | 886,080 | 723,133 | -279,920 | 194,028 | 1,305 |
| Envelope upgrades | Windows and doors to high performance | 51 | 0.0 | 175 | 2.0 | 1,902 | 0.9 | 0 | 1.6 | 68 | 0.4 | 40 | 319,700 | 63,940 | 255,760 | 597,514 | -154,301 | 751,537 | 3,782 |
| Envelope upgrades | Roof upgrade to high performance | -9 | -0.0 | 522 | 5.9 | 5,503 | 2.6 | 1 | 4.8 | 185 | 1.2 | 20 | 157,900 | 31,580 | 126,320 | 574,161 | -130,948 | 125,241 | 682 |
| Envelope upgrades | AC01-AC04 renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 15 | 38,000 | 0 | 38,000 | 488,093 | -44,880 | - | - |
| Envelope upgrades | DHW renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 15 | 4,000 | 0 | 4,000 | 447,937 | -4,724 | - | - |
| Envelope upgrades | Interior lighting renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 20 | 19,000 | 0 | 19,000 | 462,962 | -19,749 | - | - |
| Load minimization | Combined | 11,694 | 9.6 | 2,506 | 28.3 | 38,150 | 17.7 | 5 | 25.0 | 2,054 | 13.5 | - | 1,649,700 | 317,040 | 1,332,660 | 1,012,683 | -569,470 | 256,490 | 649 |
| Load minimization | Interior LED lighting upgrade | 13,723 | 11.3 | -576 | -6.5 | 7,639 | 3.5 | -1 | -3.4 | 1,156 | 7.6 | 20 | 22,500 | 0 | 22,500 | 433,640 | 9,573 | -32,177 | 19 |
| Load minimization | Wall upgrade to high performance | -1,750 | -1.4 | 2,391 | 27.0 | 23,488 | 10.9 | 5 | 22.0 | 679 | 4.5 | 75 | 1,107,600 | 221,520 | 886,080 | 723,133 | -279,920 | 194,028 | 1,305 |
| Load minimization | Windows and doors to high performance | 51 | 0.0 | 175 | 2.0 | 1,902 | 0.9 | 0 | 1.6 | 68 | 0.4 | 40 | 319,700 | 63,940 | 255,760 | 597,514 | -154,301 | 751,537 | 3,782 |
| Load minimization | Roof upgrade to high performance | -9 | -0.0 | 522 | 5.9 | 5,503 | 2.6 | 1 | 4.8 | 185 | 1.2 | 20 | 157,900 | 31,580 | 126,320 | 574,161 | -130,948 | 125,241 | 682 |
| Load minimization | AC01-AC04 renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 15 | 38,000 | 0 | 38,000 | 488,093 | -44,880 | - | - |
| Load minimization | DHW renewal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 15 | 4,000 | 0 | 4,000 | 447,937 | -4,724 | - | - |

## Utility use comparison

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

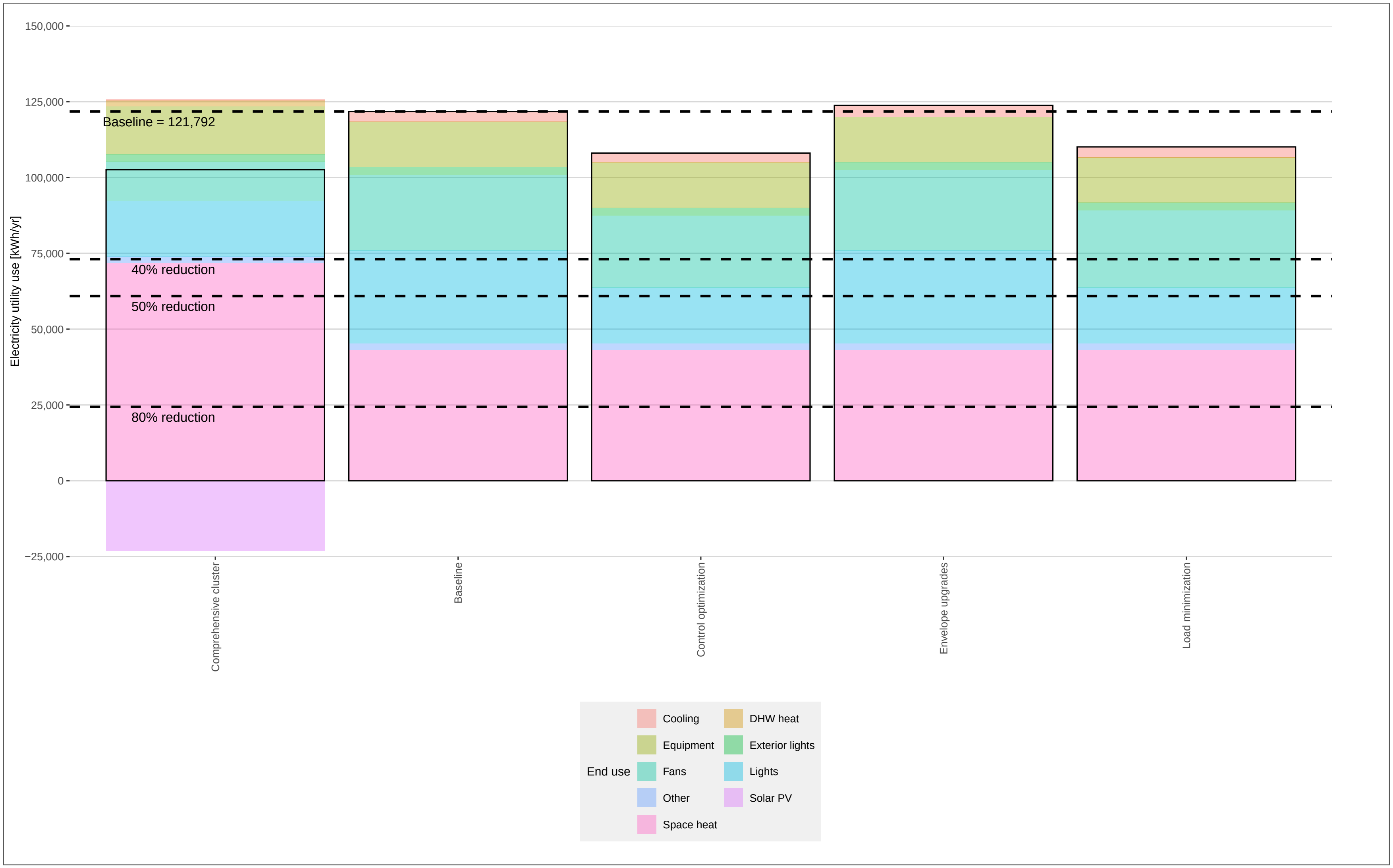


Figure 156: Electricity utility use expected yearly for each scenario by end use

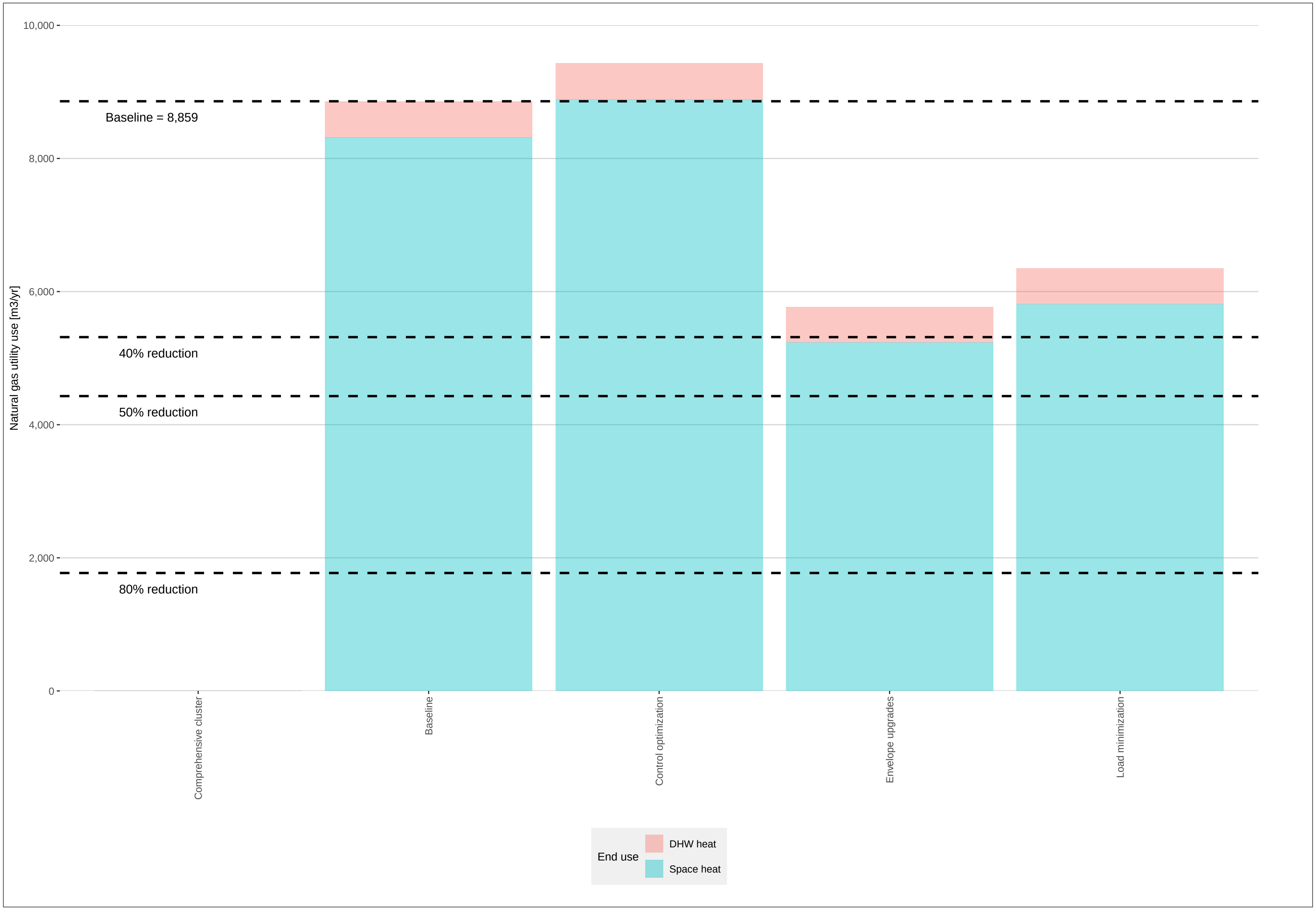


Figure 157: Natural gas utility use expected yearly for each scenario by end use

## 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.

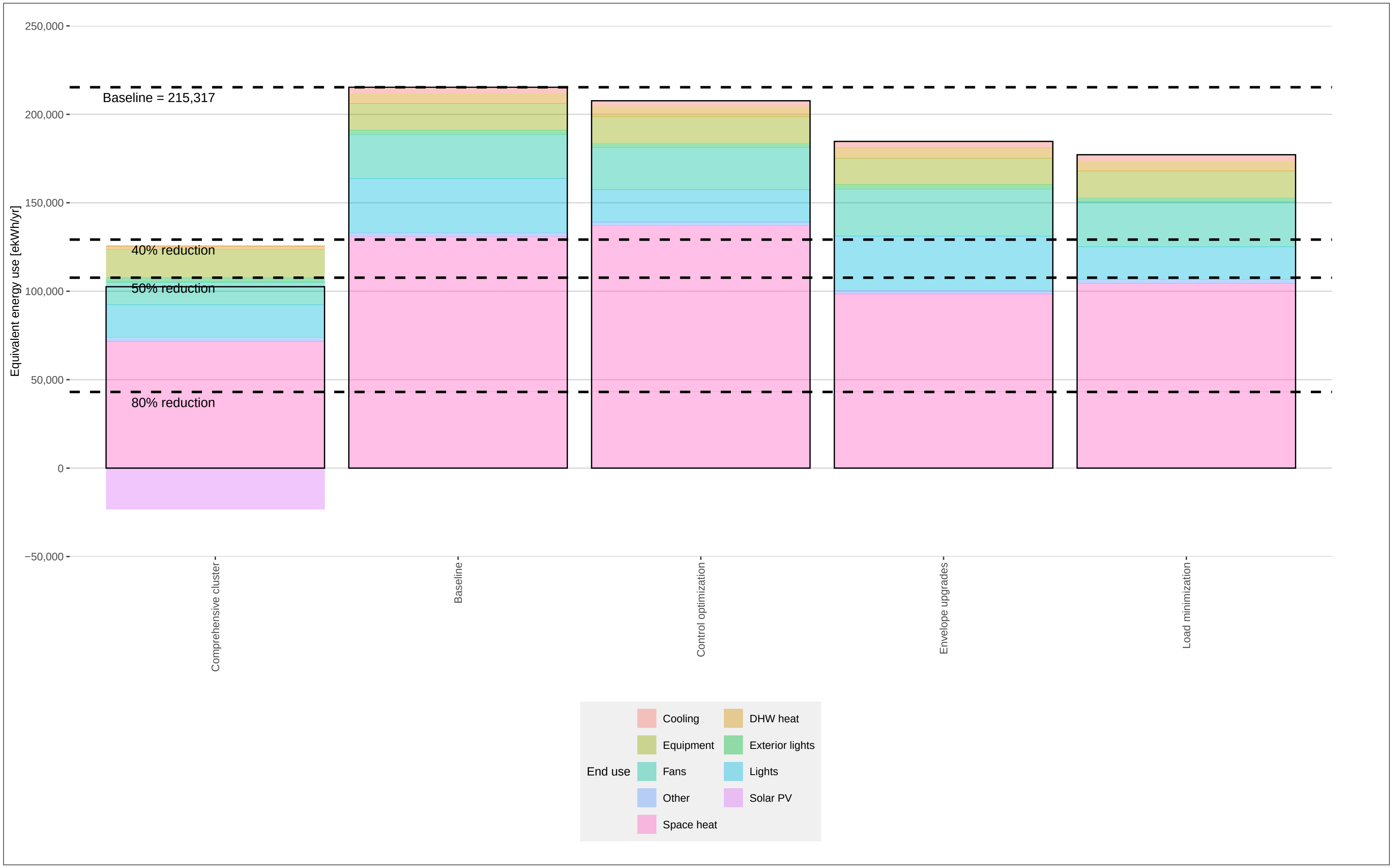


Figure 158: Equivalent energy use expected yearly for each scenario by end use

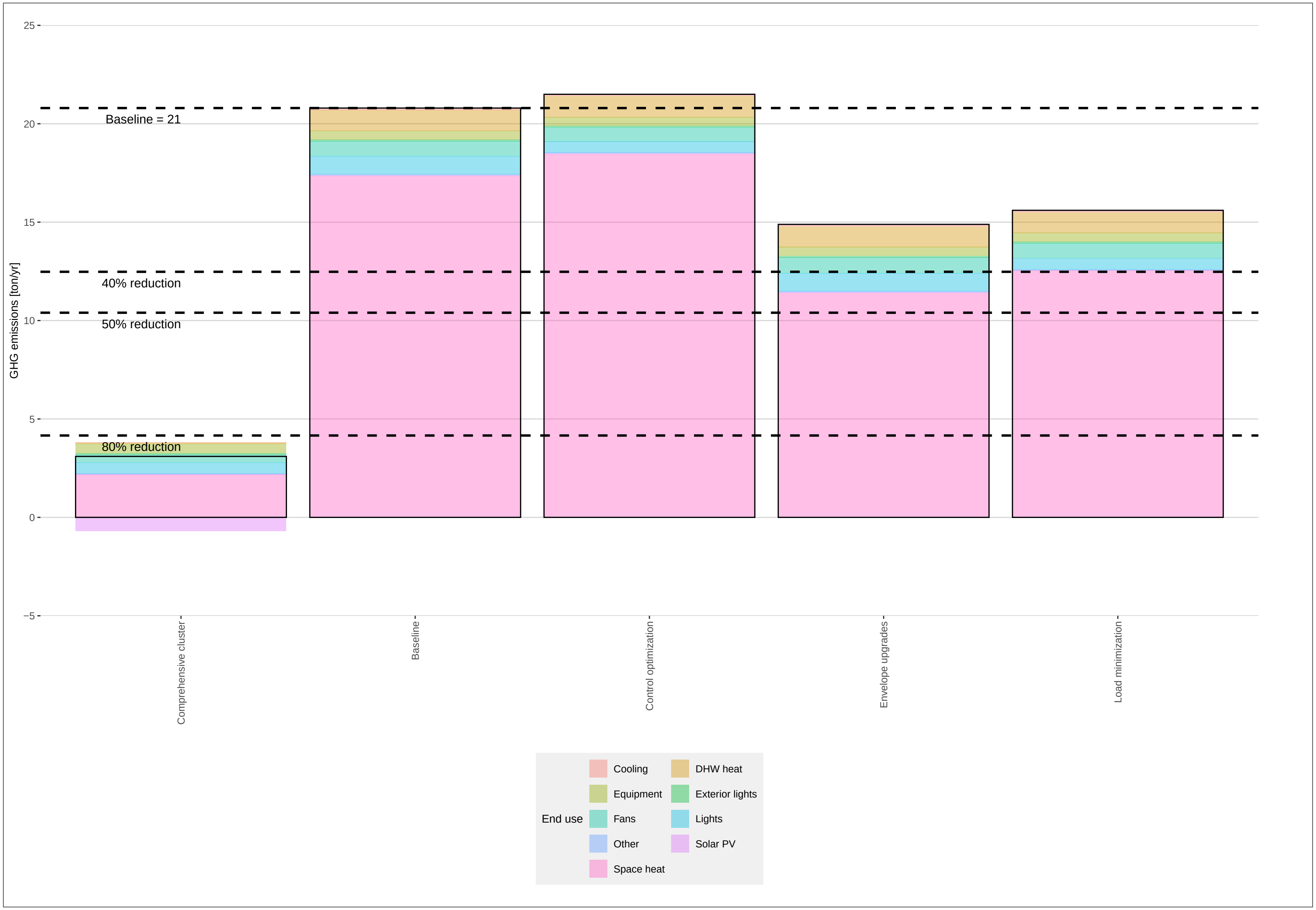


Figure 159: GHG emissions expected yearly for each scenario by end use

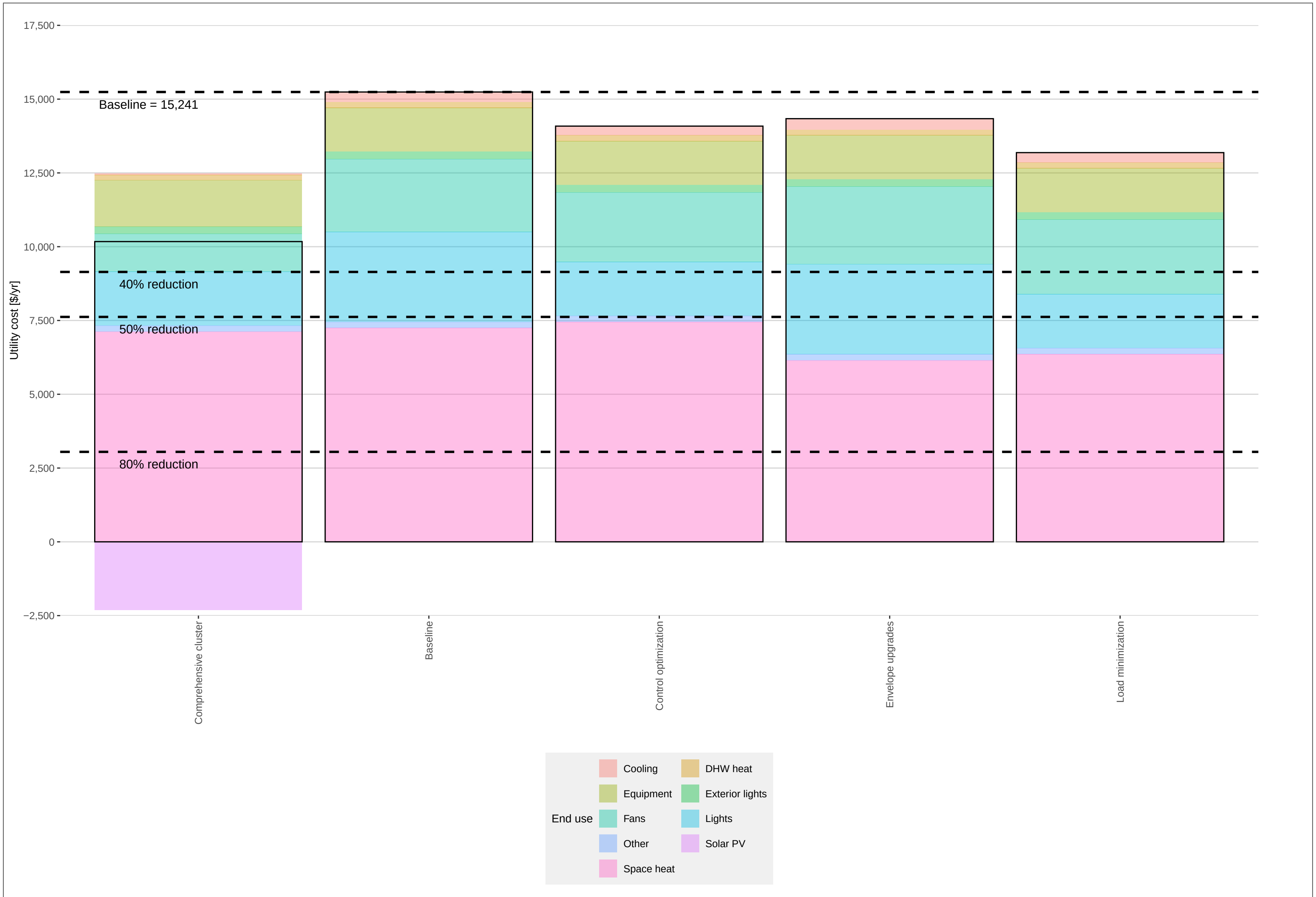


Figure 160: Utility costs expected yearly for each scenario by end use

## Financial performance comparison

The following figures compare the financial performance between each scenario.

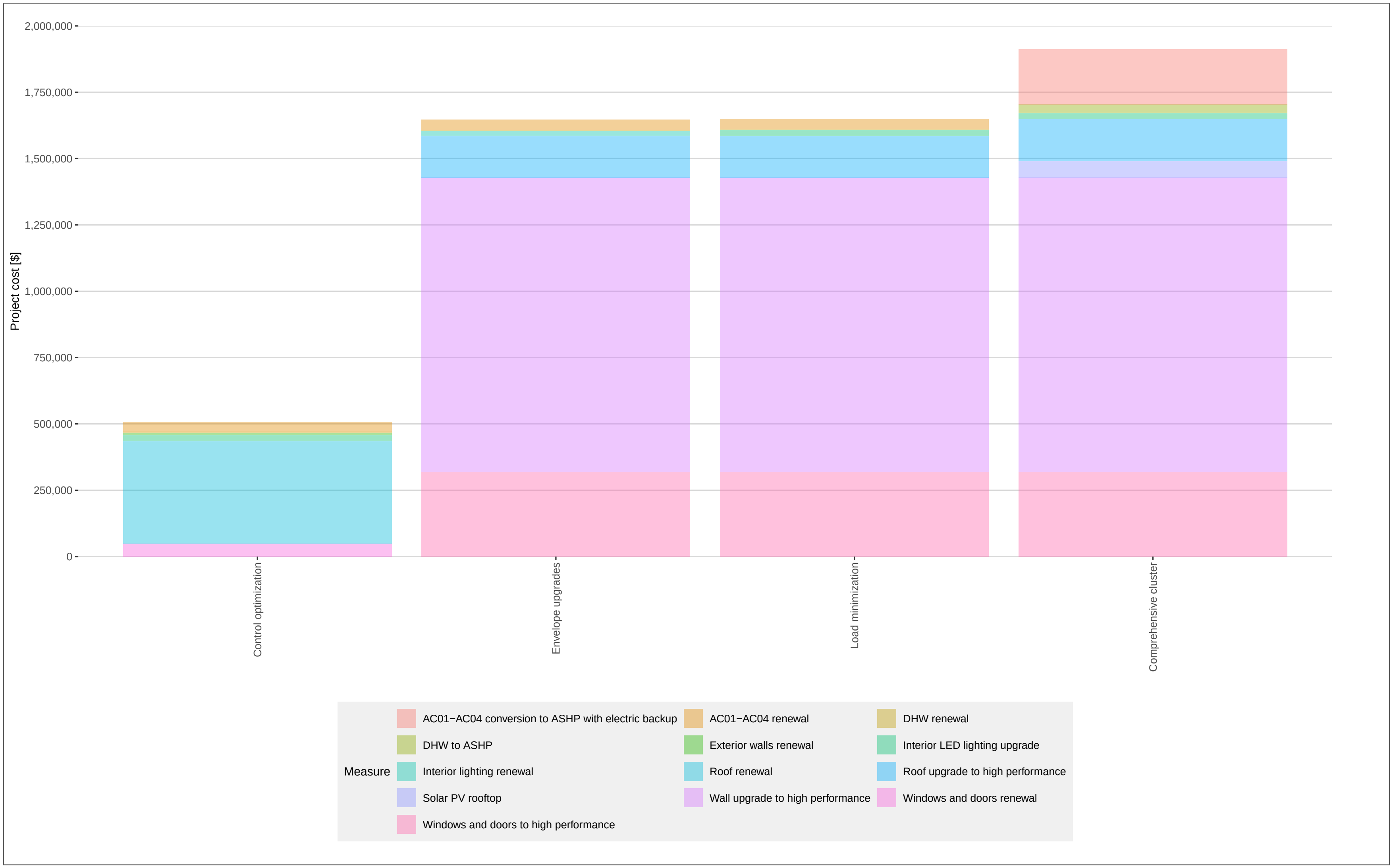


Figure 161: Project cost expected for each scenario by measure

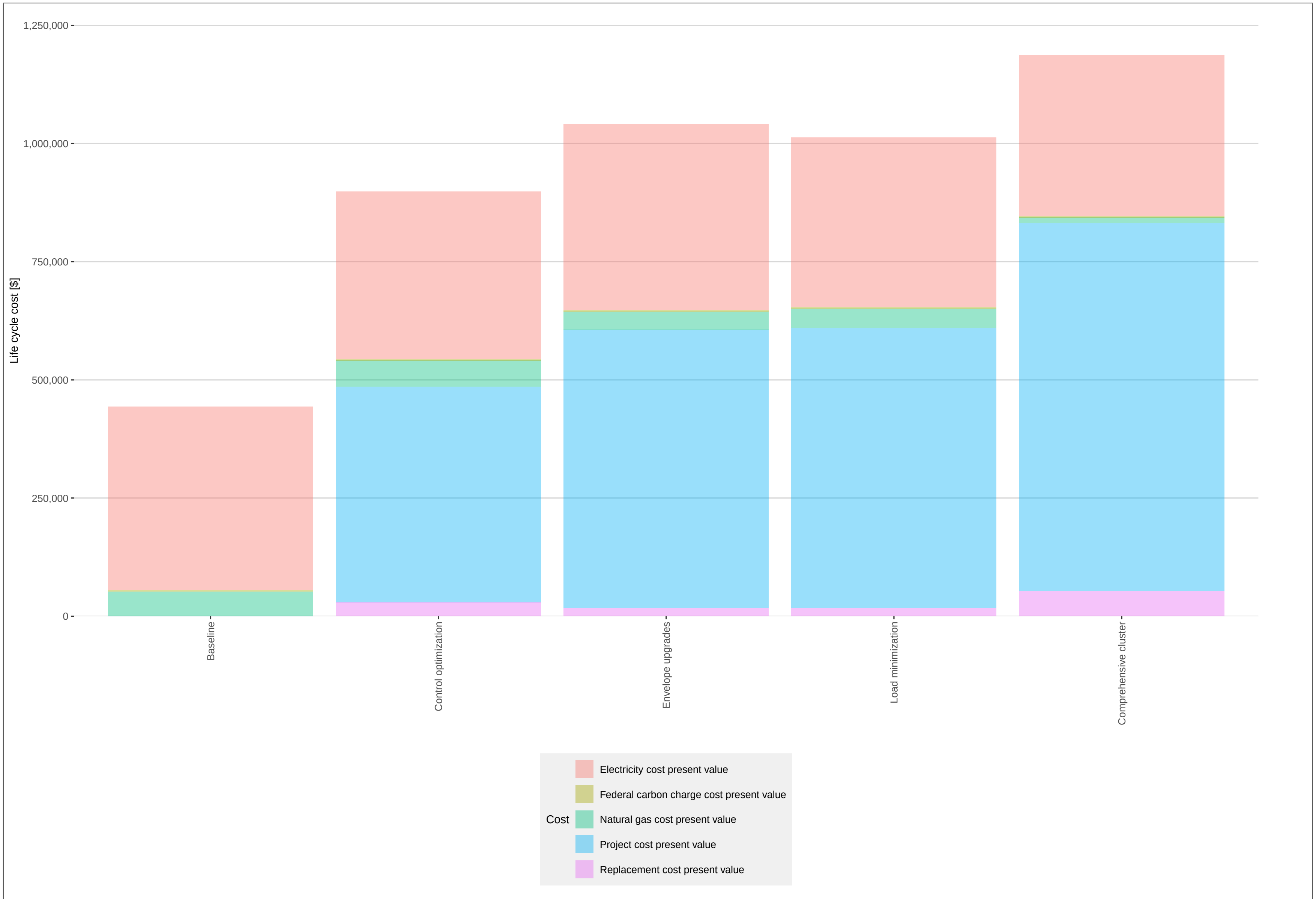


Figure 162: Life cycle cost expected for each scenario by cost item

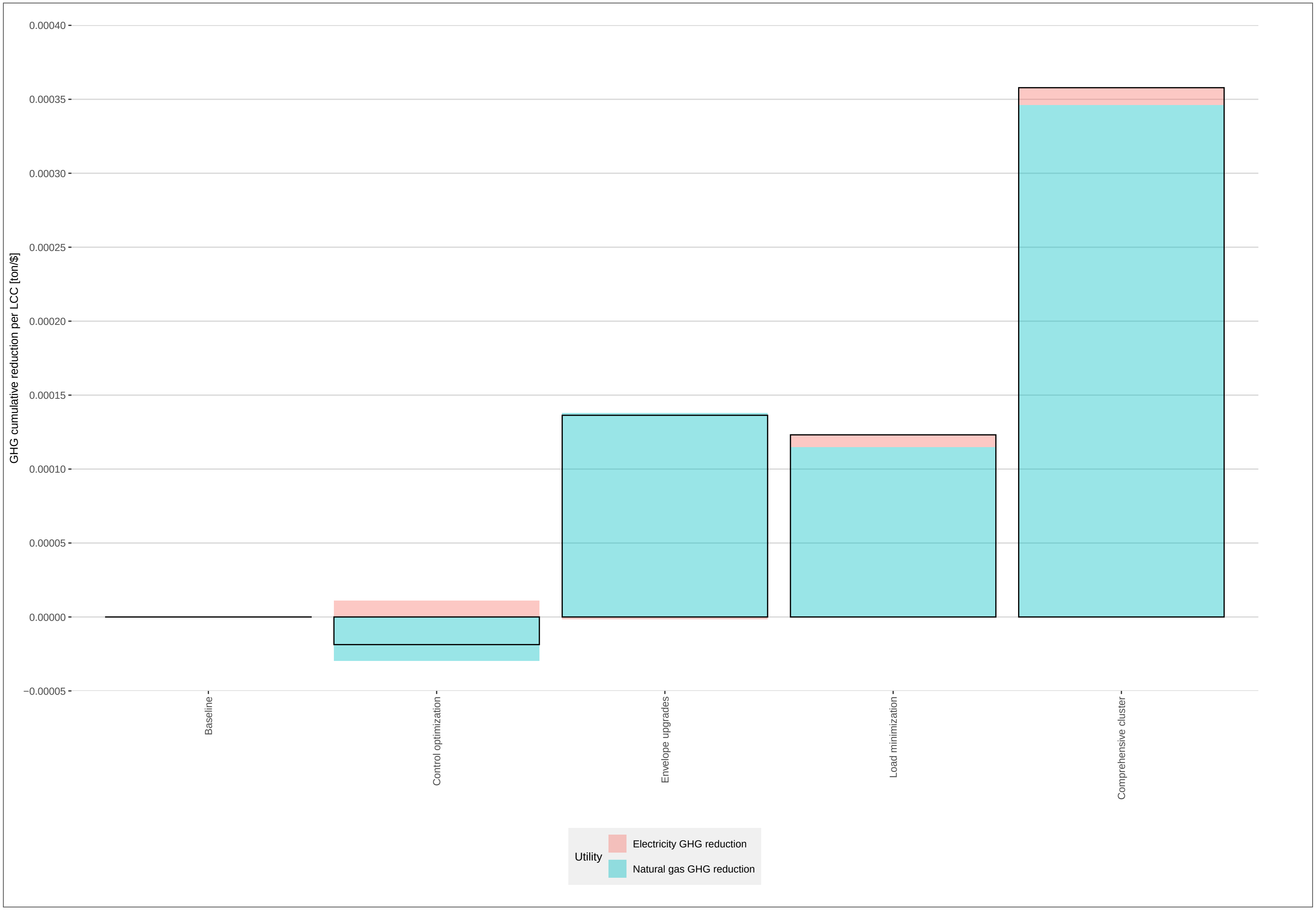


Figure 163: GHG cumulative reduction per life cycle cost (LCC) dollar expected for each scenario by utility

## 6.5 Plan scenario development

## Plan scenario identification and objectives

The plan scenarios that were analyzed and their objectives are summarized in Table 44.

Table 44: 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 44. Results of the plan scenario composition are presented in Figure 164, 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 45 to 50.

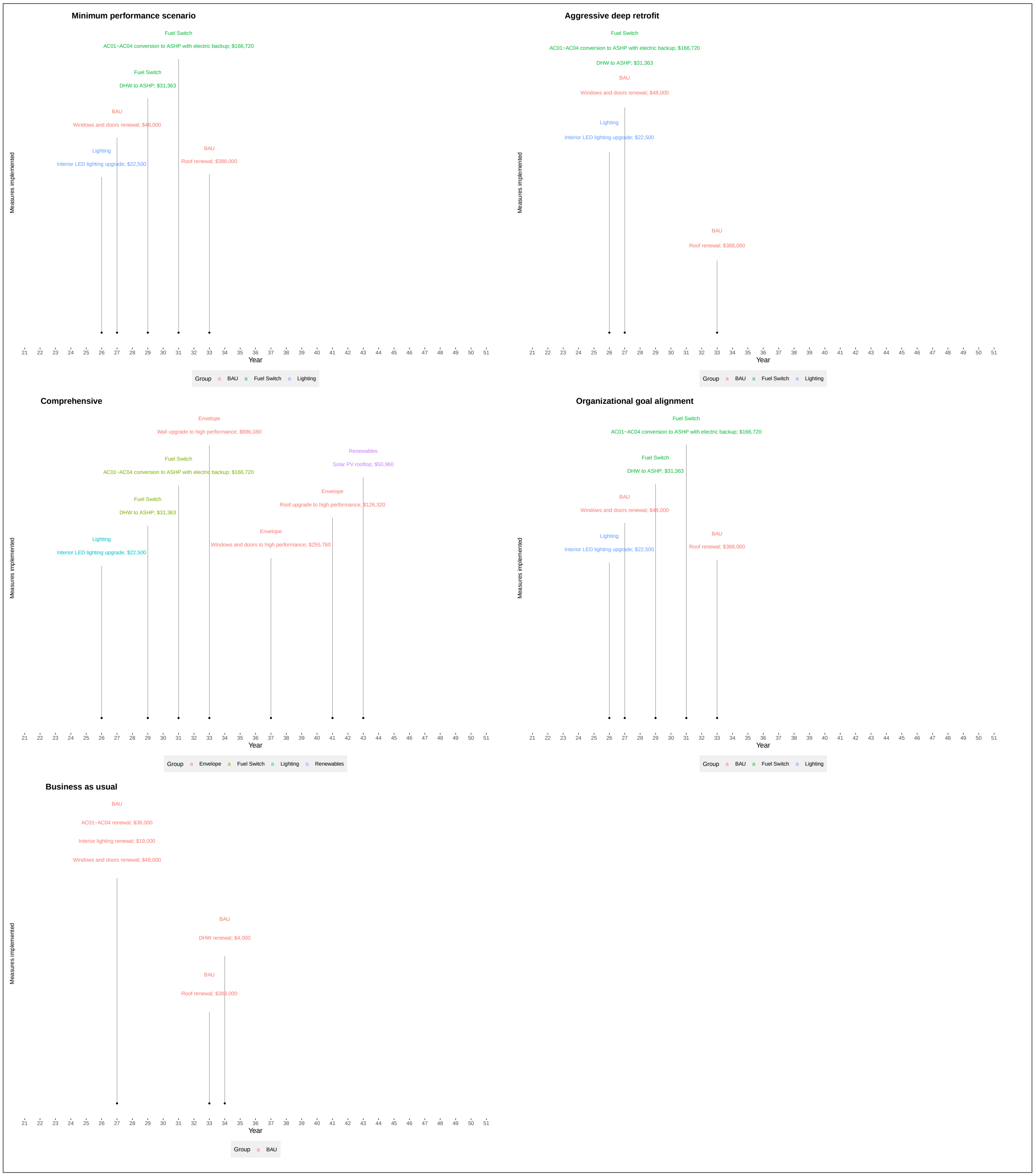


Figure 164: Plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

Table 45: Scenario composition summary

| **Measure** | **Minimum performance scenario** | **Aggressive deep retrofit** | **Comprehensive** | **Organizational goal alignment** |
|---|---|---|---|---|
| AC01-AC04 conversion to ASHP with electric backup | ✔ | ✔ | ✔ | ✔ |
| AC01-AC04 conversion to ASHP with natural gas backup | ✖ | ✖ | ✖ | ✖ |
| Carbon offsets 20 | ✖ | ✖ | ✖ | ✖ |
| DHW to ASHP | ✔ | ✔ | ✔ | ✔ |
| Interior LED lighting upgrade | ✔ | ✔ | ✔ | ✔ |
| Roof upgrade to high performance | ✖ | ✖ | ✔ | ✖ |
| Solar PV rooftop | ✖ | ✖ | ✔ | ✖ |
| Wall upgrade to high performance | ✖ | ✖ | ✔ | ✖ |
| Windows and doors to high performance | ✖ | ✖ | ✔ | ✖ |
| AC01-AC04 renewal | ✖ | ✖ | ✖ | ✖ |
| DHW renewal | ✖ | ✖ | ✖ | ✖ |
| Exterior walls renewal | ✔ | ✔ | ✖ | ✔ |
| Interior lighting renewal | ✖ | ✖ | ✖ | ✖ |
| Roof renewal | ✔ | ✔ | ✖ | ✔ |
| Windows and doors renewal | ✔ | ✔ | ✖ | ✔ |

Table 46: Minimum performance scenario measure implementation timeline

| **Measure** | **Year** |
|---|---|
| Interior LED lighting upgrade | 2026 |
| Windows and doors renewal | 2027 |
| DHW to ASHP | 2029 |
| AC01-AC04 conversion to ASHP with electric backup | 2031 |
| Roof renewal | 2033 |
| Exterior walls renewal | 2056 |

Table 47: Aggressive deep retrofit measure implementation timeline

| **Measure** | **Year** |
|---|---|
| Interior LED lighting upgrade | 2026 |
| AC01-AC04 conversion to ASHP with electric backup | 2027 |
| DHW to ASHP | 2027 |
| Windows and doors renewal | 2027 |
| Roof renewal | 2033 |
| Exterior walls renewal | 2056 |

Table 48: Comprehensive measure implementation timeline

| **Measure** | **Year** |
|---|---|
| Interior LED lighting upgrade | 2026 |
| DHW to ASHP | 2029 |
| AC01-AC04 conversion to ASHP with electric backup | 2031 |
| Wall upgrade to high performance | 2033 |
| Windows and doors to high performance | 2037 |
| Roof upgrade to high performance | 2041 |
| Solar PV rooftop | 2043 |

Table 49: Organizational goal alignment measure implementation timeline

| Measure | Year |
|---|---|
| Interior LED lighting upgrade | 2026 |
| Windows and doors renewal | 2027 |
| DHW to ASHP | 2029 |
| AC01-AC04 conversion to ASHP with electric backup | 2031 |
| Roof renewal | 2033 |
| Exterior walls renewal | 2056 |

Table 50: Business as usual measure implementation timeline

| Measure | Year |
|---|---|
| AC01-AC04 renewal | 2027 |
| Interior lighting renewal | 2027 |
| Windows and doors renewal | 2027 |
| Roof renewal | 2033 |
| DHW renewal | 2034 |
| Exterior walls renewal | 2056 |

## 6.6 Plan performance analysis

Figures 165 through 168 present the projected yearly electricity use, natural gas use, GHG emissions and life cycle costs associated with each plan scenario.


Figure 165: Electricity yearly utility use projection for each scenario


Figure 166: Natural gas yearly utility use projection for each scenario

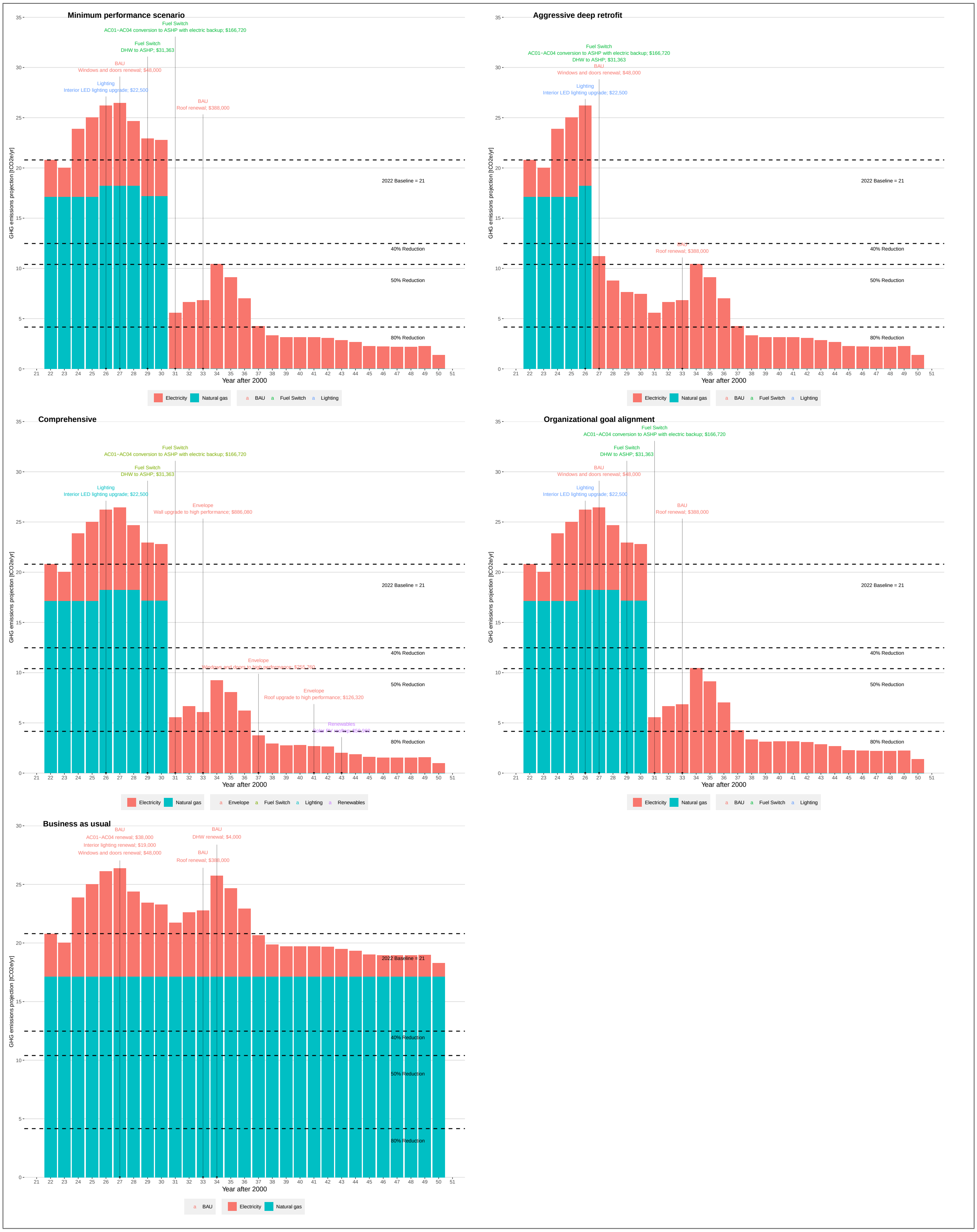


Figure 167: GHG yearly emissions projection for each scenario

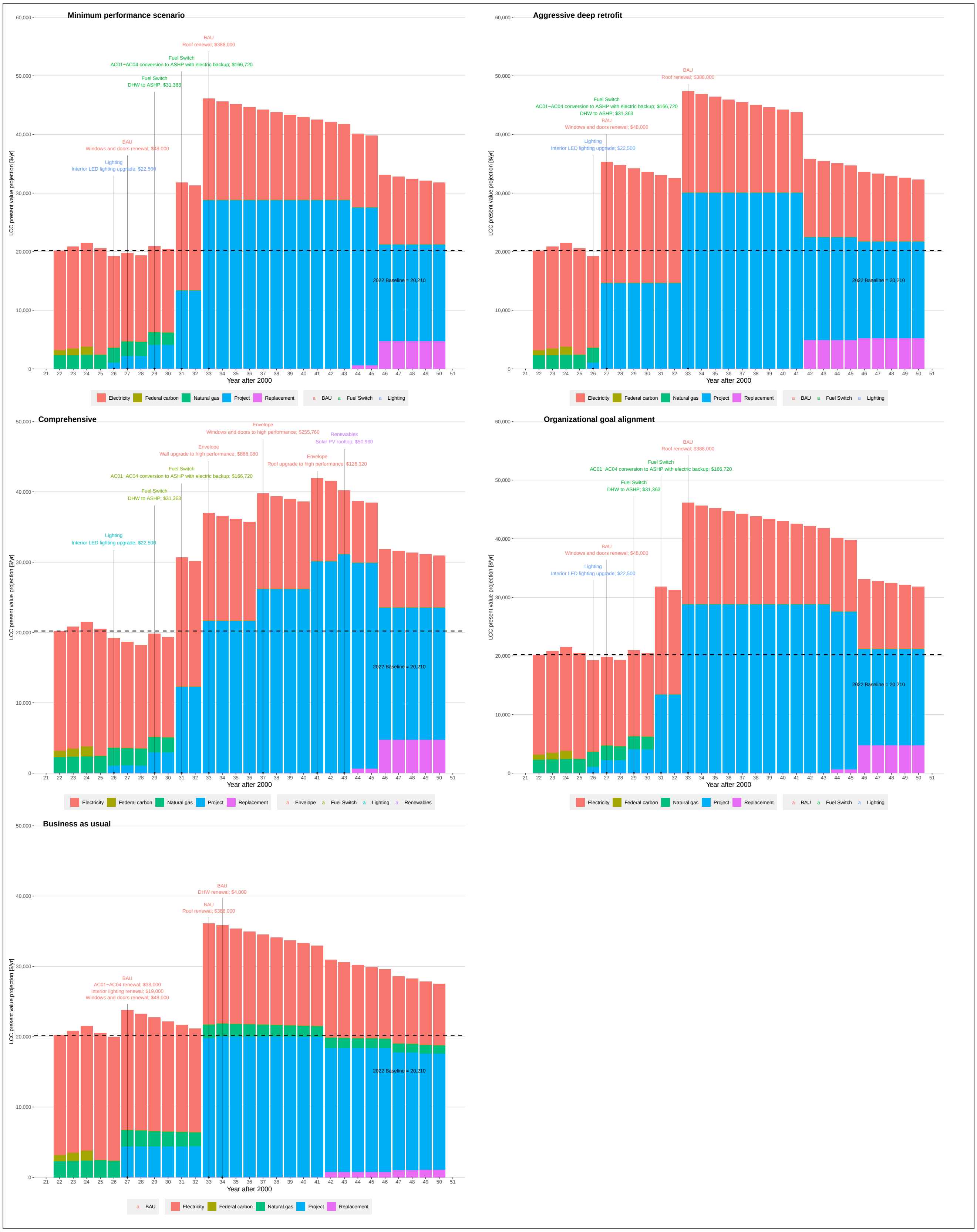


Figure 168: Life cycle yearly cost (after discounting to present value) projection for each scenario

## 6.7 Plan performance summary

## Plan performance summary

Table 51 summarizes the performance of each plan scenario with respect to utility use, GHG emissions, utility cost, and financial metrics. The first half of Table 51 represents the estimated performance in the final year (2050) of the evaluation period. The second half of Table 51 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 51 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 168).

Table 51: 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] | 147,188 | 147,188 | 102,552 | 147,188 | 121,792 |
| | Electricity monthly peak (av) | [kW] | 39.8 | 39.8 | 34.4 | 39.8 | 33.6 |
| | Electricity yearly peak (max) | [kW] | 62.5 | 62.5 | 56.8 | 62.5 | 46.2 |
| | Natural gas use | [m3/yr] | 0 | 0 | 0 | 0 | 8,859 |
| GHG emissions final | Electricity GHGs | [tCO2e/yr] | 1.4 | 1.4 | 1.0 | 1.4 | 1.2 |
| | Natural gas GHGs | [tCO2e/yr] | 0.0 | 0.0 | 0.0 | 0.0 | 17.1 |
| | Carbon offsets GHGs | [tCO2e/yr] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Total GHGs | [tCO2e/yr] | 1.4 | 1.4 | 1.0 | 1.4 | 18.3 |
| Utility cost final | Electricity utility cost | [$/yr] | 35,884 | 35,884 | 25,002 | 35,884 | 29,693 |
| | Natural gas utility cost | [$/yr] | 0 | 0 | 0 | 0 | 4,010 |
| | 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 | [$/yr] | 35,884 | 35,884 | 25,002 | 35,884 | 33,703 |
| Utility use cumulative | Electricity use | [kWh] | 3,977,014 | 4,127,743 | 3,438,315 | 3,977,014 | 3,531,960 |
| | Natural gas use | [m3] | 81,513 | 44,873 | 81,513 | 81,513 | 256,920 |
| GHG emissions cumulative | Electricity GHGs | [tCO2e] | 139 | 148 | 127 | 139 | 129 |
| | Natural gas GHGs | [tCO2e] | 158 | 87 | 158 | 158 | 496 |
| | Carbon offsets GHGs | [tCO2e] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Total GHGs | [tCO2e] | 297 | 235 | 285 | 297 | 625 |
| Utility cost cumulative | Electricity utility cost | [$] | 755,000 | 778,996 | 638,915 | 755,000 | 661,621 |
| | Natural gas utility cost | [$] | 22,978 | 12,149 | 22,978 | 22,978 | 89,342 |
| | Carbon offsets utility cost | [$] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Federal carbon charge | [$] | 3,338 | 3,338 | 3,338 | 3,338 | 3,338 |
| | Total utility cost | [$] | 781,316 | 794,484 | 665,231 | 781,316 | 754,301 |
| Financial cumulative | Project cost | [$] | 796,282 | 777,085 | 2,302,668 | 796,282 | 568,626 |
| | Replacement cost | [$] | 197,928 | 185,010 | 197,928 | 197,928 | 44,508 |
| | Life cycle cost | [$] | 970,940 | 1,021,793 | 899,230 | 970,940 | 812,288 |

## 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. Full 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, all heating systems must be electrified, using electricity as a backup heating source.

### Comprehensive

- The comprehensive scenario demonstrates the upper limit of energy-efficiency that the Haileybury Medical Centre could achieve, based on the measures that were analyzed under this Pathway to Decarbonization Feasibility Study.

# 7 END