

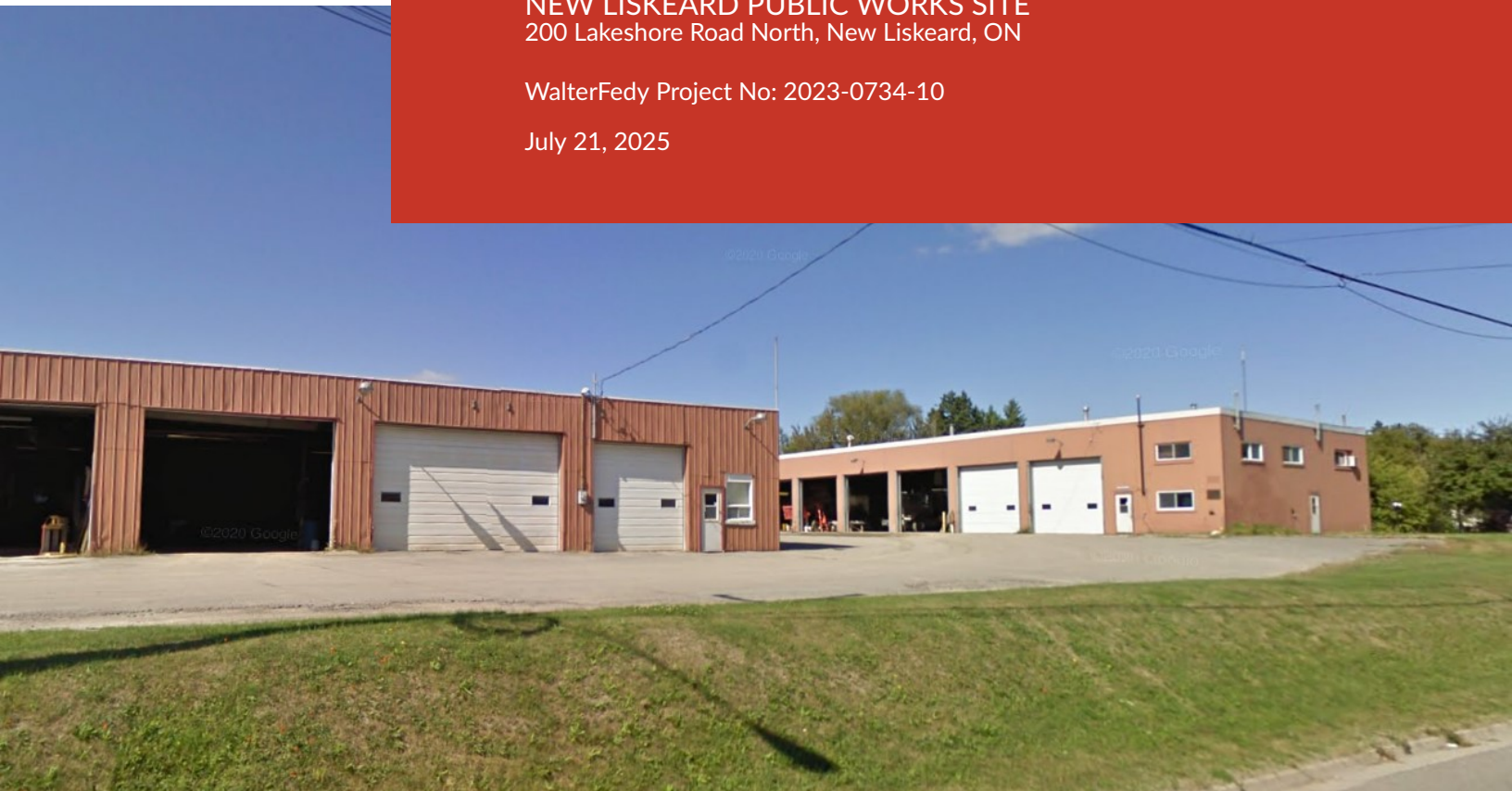
PATHWAY TO DECARBONIZATION FEASIBILITY STUDY

CITY OF TEMISKAMING SHORES

NEW LISKEARD PUBLIC WORKS SITE
200 Lakeshore Road North, New Liskeard, ON

WalterFedy Project No: 2023-0734-10

July 21, 2025



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Project Number: 2023-0734-10

July 21, 2025

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

Dear Mathew,

RE: Pathway to Decarbonization Feasibility Study

WalterFedy is pleased to submit the attached Pathway to Decarbonization Feasibility Study report to the City of Temiskaming Shores. This study covers the agreed-upon scope and provides a Pathway to Decarbonization Feasibility Study for the New Liskeard Public Works Site, which is located at 200 Lakeshore Road North in New Liskeard, ON. Certain parts of this report are designed to be viewed in digital/PDF format. This approach will enable the reader to zoom in on images and navigate the document using the provided hyperlinks.

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

All of which is respectfully submitted,

WALTERFEDY



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

jmansfield@walterfedy.com
519 576 2150 x 336

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EXECUTIVE SUMMARY

WalterFedy was engaged by the City of Temiskaming Shores to complete a Pathway to Decarbonization Feasibility Study for the New Liskeard Public Works Site. The objective of this engagement is to identify and analyze measures that reduce utility use, GHG emissions, and utility costs at the New Liskeard Public Works Site, 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 2024-04-18 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 New Liskeard Public Works Site. 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 New Liskeard Public Works Site 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.

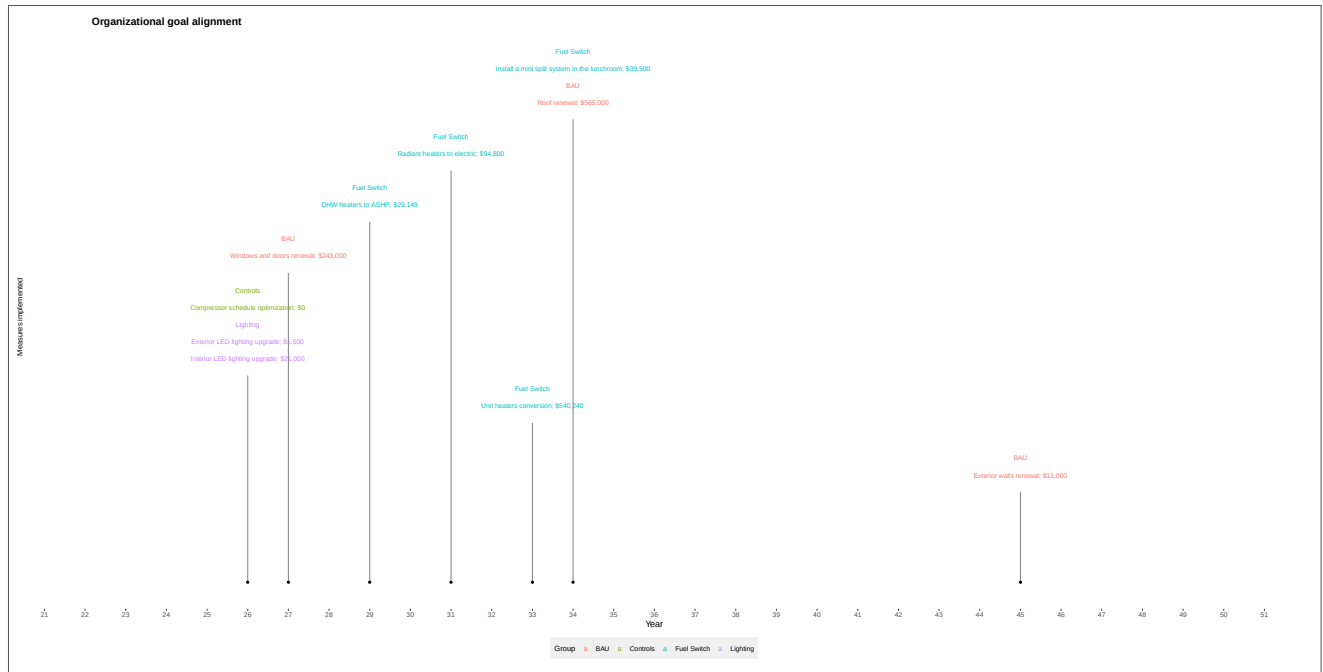


Figure 1: Recommended plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

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

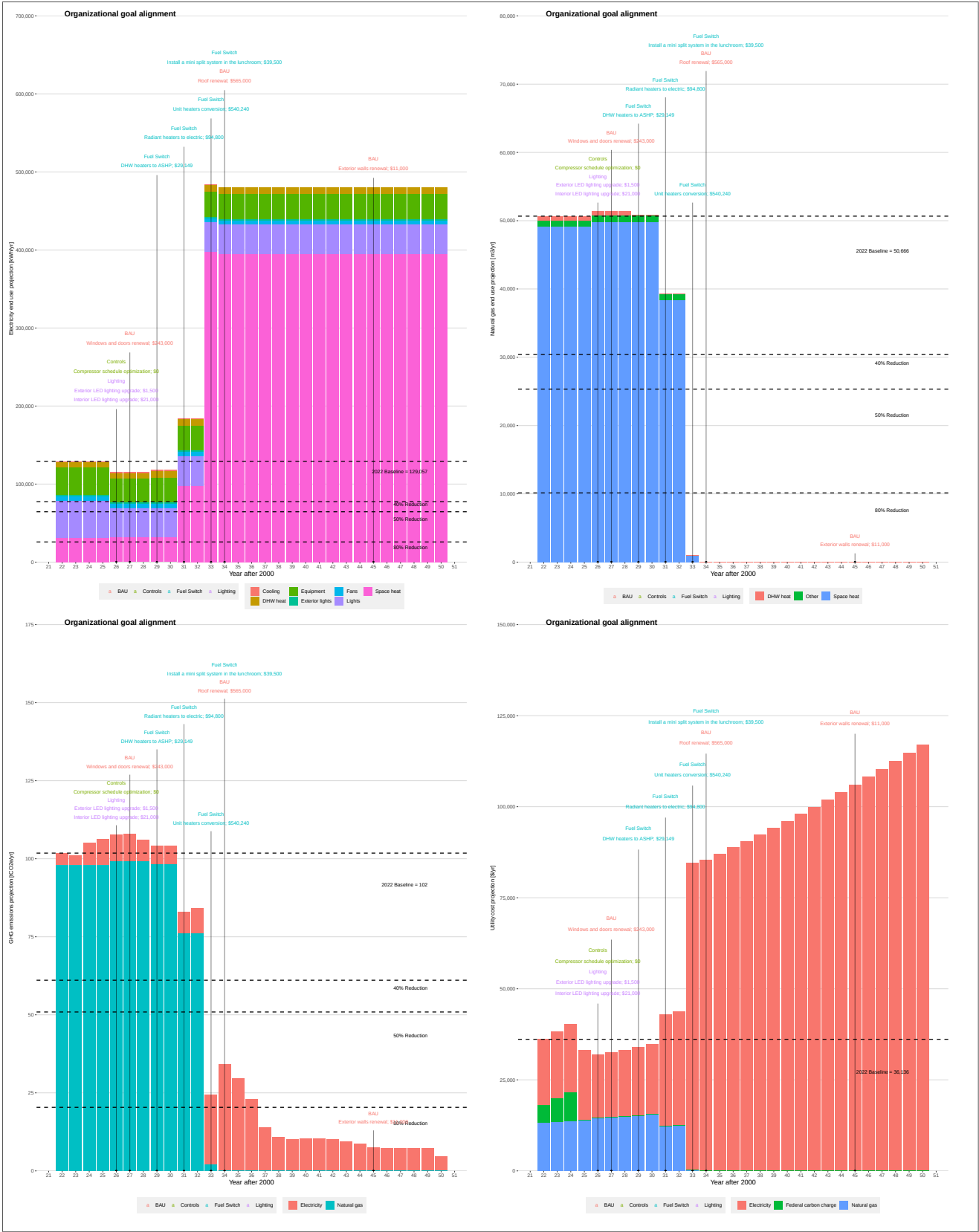


Figure 2: Recommended scenario performance

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]	480,302	480,302	254,135	480,302	129,057
	Electricity monthly peak (av)	[kW]	164	164	133	164	38
	Electricity yearly peak (max)	[kW]	249	249	197	249	55
	Natural gas use	[m3/yr]	0	0	0	0	50,666
GHG emissions final	Electricity GHGs	[tCO2e/yr]	4.6	4.6	2.4	4.6	1.2
	Natural gas GHGs	[tCO2e/yr]	0.0	0.0	0.0	0.0	97.9
	Carbon offsets GHGs	[tCO2e/yr]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e/yr]	4.6	4.6	2.4	4.6	99.1
Utility cost final	Electricity utility cost	[\$/yr]	117,098	117,098	61,958	117,098	31,464
	Natural gas utility cost	[\$/yr]	0	0	0	0	22,932
	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]	117,098	117,098	61,958	117,098	54,396
Utility use cumulative	Electricity use	[kWh]	10,113,914	12,158,611	8,108,714	10,113,914	3,742,663
	Natural gas use	[m3]	537,919	254,034	537,919	537,919	1,469,319
GHG emissions cumulative	Electricity GHGs	[tCO2e]	308	419	273	308	136
	Natural gas GHGs	[tCO2e]	1,039	491	1,039	1,039	2,839
	Carbon offsets GHGs	[tCO2e]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e]	1,347	910	1,313	1,347	2,976
Utility cost cumulative	Electricity utility cost	[\$]	2,019,664	2,351,130	1,574,989	2,019,664	701,091
	Natural gas utility cost	[\$]	154,142	68,749	154,142	154,142	510,943
	Carbon offsets utility cost	[\$]	0.00	0.00	0.00	0.00	0.00
	Federal carbon charge	[\$]	19,091	19,091	19,091	19,091	19,091
	Total utility cost	[\$]	2,192,898	2,438,971	1,748,223	2,192,898	1,231,125
Financial cumulative	Project cost	[\$]	1,970,933	1,864,789	7,080,823	1,970,933	1,100,856
	Replacement cost	[\$]	692,403	620,975	692,403	692,403	38,801
	Life cycle cost	[\$]	2,307,641	2,713,635	2,312,182	2,307,641	1,349,175

1 INTRODUCTION

1.1 Overview

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

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

1.2 Background

1.2.1 Corporate Greenhouse Gas Reduction Plan

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

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

This study will contribute to the decarbonization studies of its buildings. The New Liskeard Public Works Site 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 New Liskeard Public Works Site represented 90 tCO₂e in 2019, or 4.6% 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 New Liskeard Public Works Site.

Table 2: Asset management summary for this facility

Group	Metric	Unit	Value
Financial	Content Value Estimated	[\$]	788,010
	Building Land Tank	[\$]	3,072,708
	Replacement Cost	[\$]	3,860,718
Information	Install Date	[yr]	1983
	Age	[yrs]	42
Condition Rating	Structure Condition Score	[-]	3.75
	Final Condition Score	[-]	3.75
Risk	Probability of Failure	[-]	2
	Consequence of Failure	[-]	4.5
	Risk Score	[-]	2.5

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.** Available facility documents were reviewed, including the following.
 - 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 2024-04-18 to review the energy systems applicable to the desired retrofit scenario.

2.2 Facility overview

An overview of the New Liskeard Public Works Site is provided in Table 4.

Table 4: Facility overview

Description	Unit	Value
Name	[-]	New Liskeard Public Works Site
Address	[-]	200 Lakeshore Road North
Location	[-]	New Liskeard, ON
Type	[-]	Public works
Construction year	[-]	1983
Gross floor area	[m2]	1,553
Gross floor area	[ft2]	16,720

An aerial view of the New Liskeard Public Works Site is provided in Figure 3. This figure indicates buildings A, B, and C, as they will be referenced in this report.

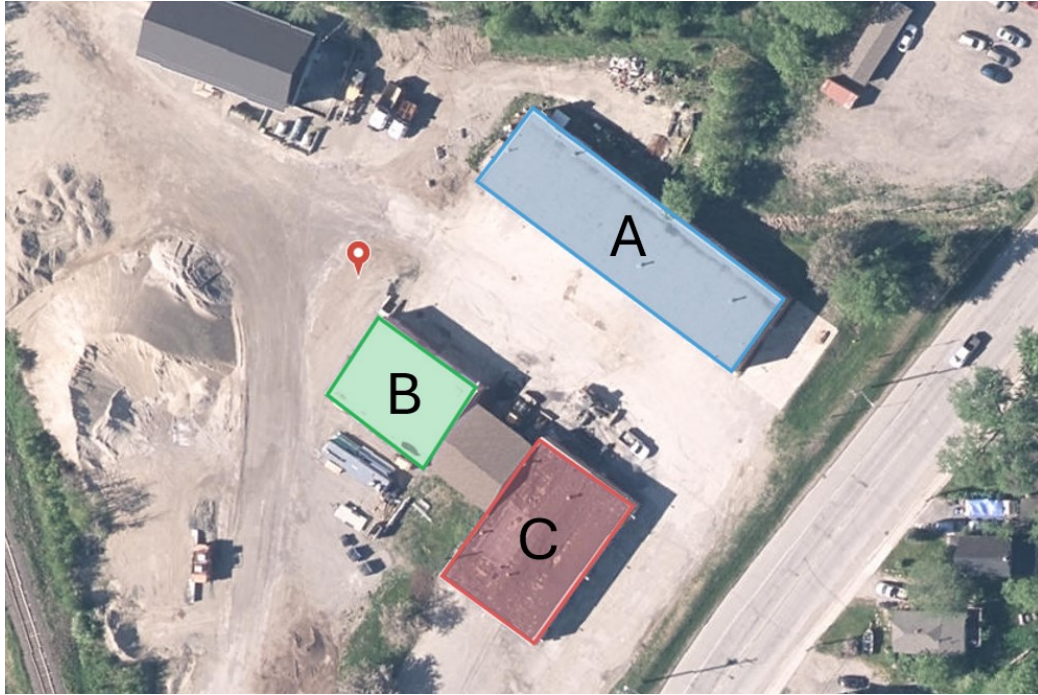


Figure 3: New Liskeard Public Works Site aerial view

2.3 Building information

Renovations - Building A

The following renovations are known:

- **Building addition (2015):** Plans to add an addition to Building A were provided as a drawing set. However, this addition did not proceed.
- **Roof replacement (2014):** The roof membrane was replaced for Building A.
- **Unit heater replacement (c. 2019):** Unit heaters in the bay area were replaced with three new natural gas-fired unit heaters.

Renovations - Building B

The following renovations are known:

- **Roof replacement (2014):** The roof membrane was replaced for Building B.

Renovations - Building C

There are no known renovations at Building C.

Additions - All Buildings

There have been no additions to any of the buildings.

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
- Natural gas-fired generator

Utility bill responsibility

Utility bill responsibility is as follows:

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

Commissioning history

No commissioning history has been documented.

Previous studies

The following is a summary of known previous studies:

- Energy audits: None
- Engineering studies: None
- Building condition assessments: None

Documentation availability

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

- Floor plans of each building.
- 2015 proposed addition to Building A that did not proceed.

2.4 Space use

Type summary

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

- Bays
- Offices
- Changerooms
- Storage
- Washrooms
- Lunch room

Building C's changerroom used to be an office per the floor plans.

Occupancy scheduling

The facility operation hours are typically from 07:00 to 16:00 from Monday to Friday during the summer. However, workers can be present if an after hours issue arises. From November to March, the facility is often run 24/7, although people are do not consistently occupy the building after hours.

It is assumed that the peak occupancy of each building is:

- Building A: 15
- Building B: 5
- Building C: 5

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]	-	-
Building A - Bays	730	UH01-04	Site visit.
Building A - Offices and lunchroom	309	Electric baseboards	Site visit.
Building A - Storage and men's washroom	176	Electric baseboards	Site visit.
Building B	267	IH01-03	Site visit.
Building C - Changeroom	68	UH07	Site visit.
Building C - Bays	422	UH08-UH10	Site visit.

Space use documentation

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

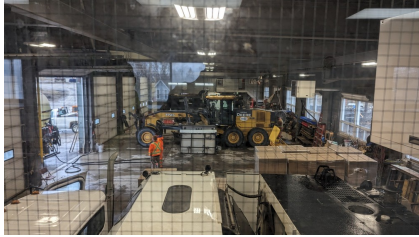


Figure 4: A - Bay Area



Figure 5: A - Lunchroom



Figure 6: A - SW office



Figure 7: A - Parts Storage

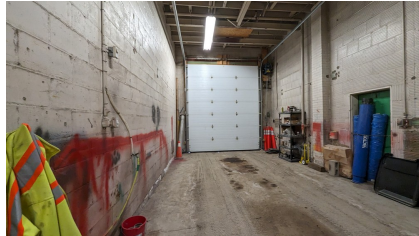


Figure 8: B - Wash bay



Figure 9: B - Work area



Figure 10: B - Lunch area

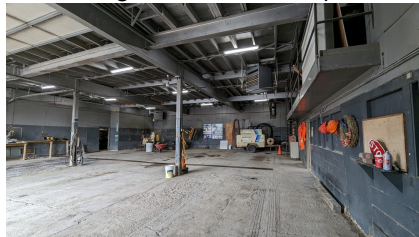


Figure 11: C - Bay area



Figure 12: C - Mezzanine

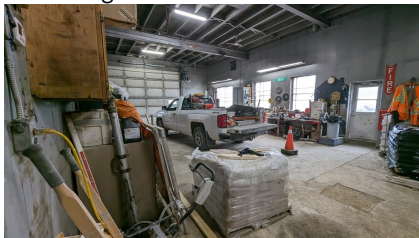


Figure 13: C - Water bay

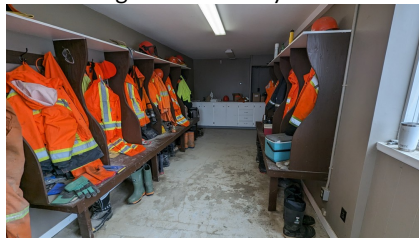


Figure 14: C - Changeroom

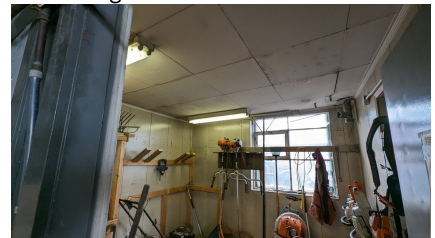


Figure 15: C - Equipment storage

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]
2,173	2,162	1,838	74.3	249

Overview

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

Roof

- Building A and C: the exterior layer of the roof is a modified bitumen membrane, which was replaced in 2014. It's assumed that no additional insulation was added at this time. The overall roof assembly is assumed to have a U-Value of 0.2581 W/m2K.
- Building B: the exterior layer of the roof is a white roof membrane. The overall roof assembly is assumed to have a U-Value of 0.2839 W/m2K.
- The roof was not inspected while on-site. Therefore, the roof condition is unknown.

Opaque Walls (above ground)

- The exterior walls appear to consist of metal siding on 2x4 strapping, on 190mm of concrete block or clay block.
- The overall U-Value is assumed to be 0.5678 W/m2K.
- The wall conditions appear to be poor to fair, as there were numerous areas with damaged siding.

Fenestration

Windows

- Buildings A and B have aluminum-framed, double-pane picture windows. However, Building C appears to have wood-framed, single pane windows.
- Windows in Buildings A and B appear in good condition, including sealant around windows. However, Building C's windows are in poor condition.
- The overall U-Value is assumed to be 3.7857 W/m2K for the window system at Buildings A and B with a SHGC of 0.35. The overall U-Value at Building C is assumed to be 7.0982 W/m2K.

Doors

- The facility has hollow metal doors and overhead doors.
- Numerous entrance doors were either propped open or had poor weather stripping.
- The overall fenestration-to-wall ratio is estimated to be 15%, confirmed via the table above, 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 average infiltration rate of 0.525 Lps/m² of the above-grade building envelope area will be assumed here, to account for the bay doors often being left open.

Building Envelope documentation

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



Figure 16: A - Bay doors



Figure 17: A - Bay window



Figure 18: A - SE entrance



Figure 19: A - Metal siding



Figure 20: A - West elevation



Figure 21: A - Lunchroom window



Figure 22: A - Lunchroom windows



Figure 23: A - Seals on windows are in fair condition



Figure 24: A - SE entrance door propped open by deadbolt



Figure 25: B - Main entrance



Figure 26: B - North elevation



Figure 27: B - South elevation



Figure 28: B - South facing windows



Figure 29: B - Window seals are in fair condition



Figure 30: Back of the salt storage



Figure 31: C - Water bay door



Figure 32: C - Damage to SE corner



Figure 33: C - Damage on the north elevation



Figure 34: C - Under the metal facade is brick



Figure 35: C - Loader bay and entrance doors



Figure 36: C - Windows in the water bay are in poor condition



Figure 37: North elevation of the salt storage

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]	-
EF01	-	-	Welding booth	2,000	1.5	Assumption.

Table 8: Heating systems summary

Tag	Serves	Utility	Efficiency	Output	Data source
-	-	-	[decimal]	[btuh]	-
UH01	Building A - Bays	Natural gas	0.83	249,000	Nameplate.
UH02	Building A - Bays	Natural gas	0.83	249,000	Nameplate.
UH03	Building A - Bays	Natural gas	0.83	249,000	Nameplate.
UH04	Building A - Shop	Natural gas	0.80	100,000	Nameplate.
UH05	Building A - 2nd floor washroom	Natural gas	0.82	246,000	Nameplate.
UH06	Building B - Entrance	Natural gas	0.80	100,000	Assumption.
UH07	Building C - Changeroom	Electricity	1.00	10,236	Assumption.
UH08	Building C - General bays	Natural gas	0.80	200,000	Nameplate.
UH09	Building C - General bays	Natural gas	0.80	200,000	Nameplate.
UH10	Building C - Water bay	Natural gas	0.80	140,000	Nameplate.
IH01	Building B - West Bay	Natural gas	0.60	75,000	Nameplate.
IH02	Building B - West Bay	Natural gas	0.60	60,000	Nameplate.
IH03	Building B - East Bay	Natural gas	0.60	60,000	Assumption.
DHW01	Building A - East	Electricity	1.00	5,118	Nameplate.
DHW02	Building A - West	Electricity	1.00	20,473	Nameplate.
DHW03	Building B	Natural gas	0.90	32,400	Nameplate.
DHW04	Building C	Electricity	1.00	15,355	Nameplate.

Table 9: Cooling systems summary

Tag	Serves	Efficiency	Output	Data source
-	-	[decimal]	[ton]	-
AC01	Building A - Front Office	3	1	Assumption.
AC02	Building A - Lunch room	3	1	Assumption.
AC03	Building B - Lunch room	3	1	Assumption.

System type

The facility utilizes a combination of unit heaters, infrared heaters, and baseboard heaters for heating. Lunch rooms and offices have window air conditioners. There appeared to be only one exhaust fan for a welding booth. A summary of this system is as follows:

- 9 of the 10 unit heaters are natural gas powered, and the last is electric.
- IH01-IH03 are located in Building B only.
- All unit heaters are controlled by non-programmable thermostats.

- Most thermostats were set to OFF for the unit heaters.
- Electric basboard or cabinet heaters are used in the lunch room and offices.
- One exhaust fan was observed that serves the weld booth in Building A.

Central Plant

There is no centralized plant at this facility.

Distribution system

There are no pumps present at this site. Only one duct for the exhaust booth in Building A.

Controls

Controls consist mostly of non-programmable thermostats for the unit heaters, infrared heaters, and electric heating. Observed temperature setpoints were noted:

- Building A, back office had a setpoint of 10C.
- Building A, front office had a setpoint of 25C.
- UH01: 15C.
- UH02: OFF.
- UH03: 17C, reading 15C. Note: The bay doors were open during the visit.
- UH04: 18C, reading 18C. Note: The bay doors were open during the visit.
- UH05: 64F, reading 68F.
- UH06: 70F, reading 71F. This unit was in a HOLD.
- UH07: 30C.
- UH08: OFF. Was reading 48F.
- UH09: OFF. Was reading 49F.
- UH10: 62F, reading 62F. This unit was in a HOLD.
- IH01: 73F.
- IH02: OFF.
- IH01: 70F.

HVAC system documentation

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

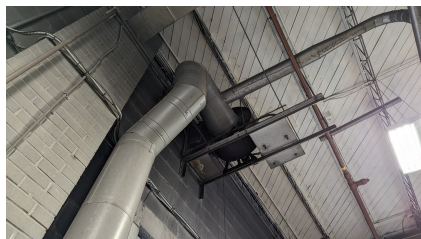


Figure 38: A - EF01



Figure 39: A - UH01

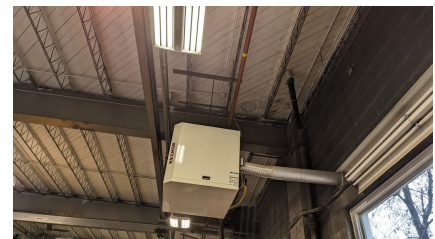


Figure 40: A - UH02



Figure 41: A - UH03



Figure 42: A - UH04



Figure 43: A - UH05



Figure 44: A - UH01 thermostat



Figure 45: A - UH02 thermostat



Figure 46: A - UH03 thermostat



Figure 47: A - UH04 - thermostat



Figure 48: A - UH05 - thermostat

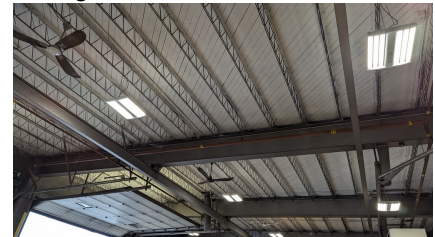


Figure 49: A - High bay ceiling fans



Figure 50: A - Portable dehumidifier



Figure 51: A - Back office thermostat



Figure 52: A - Portable air conditioner



Figure 53: A - AC02 - lunchroom air conditioner



Figure 54: A - AC01 - front office air conditioner



Figure 55: A - Lunchroom baseboard electric heater



Figure 56: A - Electric cabinet heater in vestibule



Figure 57: A - Thermostat controlling electric heater



Figure 58: A - Electric cabinet heater in the front office



Figure 59: A - Old thermostat for a former unit heater



Figure 60: A - Wall thermostat in the women's washroom



Figure 61: A - Electric baseboard heat in the back office

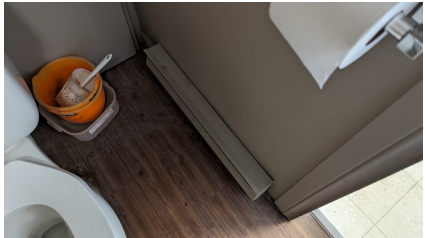


Figure 62: A - Electric baseboard in the women's washroom

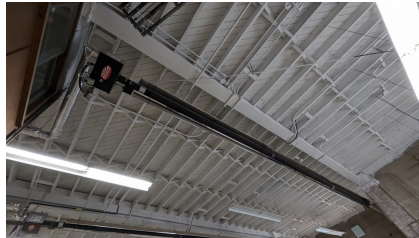


Figure 63: B - IH01

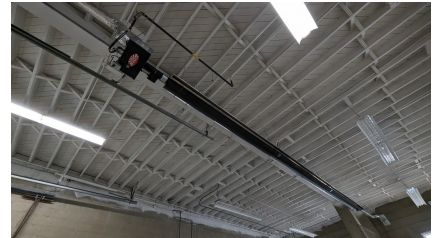


Figure 64: B - IH02

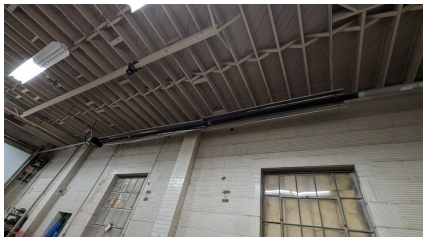


Figure 65: B - IH03



Figure 66: B - UH06

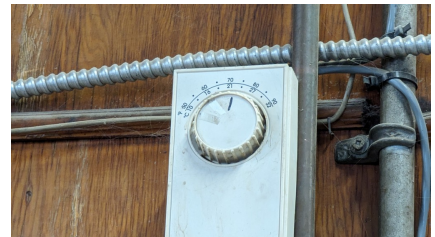


Figure 67: B - IH01 - thermostat



Figure 68: B - IH02 - thermostat

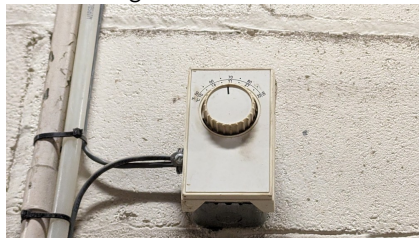


Figure 69: B - IH03 - thermostat

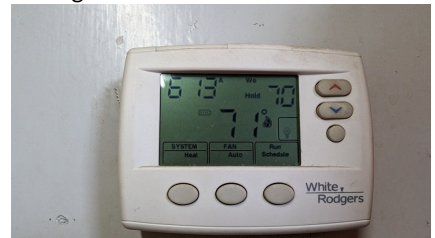


Figure 70: B - UH06 - thermostat



Figure 71: B - AC03 - window air conditioner



Figure 72: C - UH07



Figure 73: C - UH08

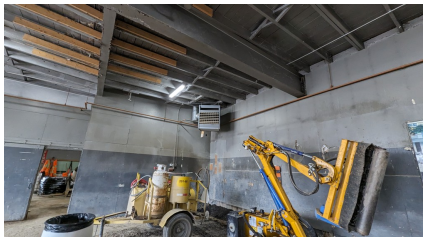


Figure 74: C - UH09

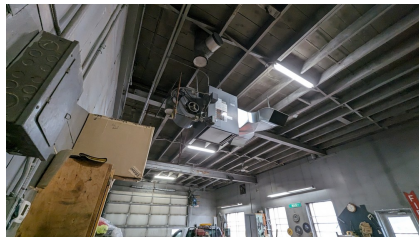


Figure 75: C - UH10



Figure 76: C - UH07 - thermostat

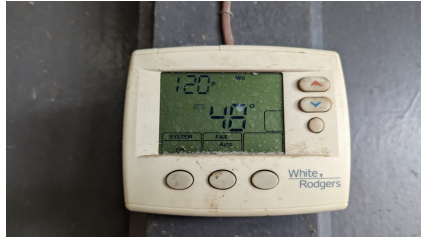


Figure 77: C - UH08 - thermostat



Figure 78: C - UH09 - thermostat

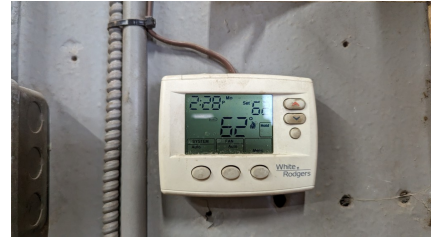


Figure 79: C - UH10 - thermostat



Figure 80: C - Ceiling fan in the bay area



Figure 81: C - Old thermostat in the bay area



Figure 82: C - Electric heater in the women's washroom

2.7 Domestic hot water

Overview

Three of the four DHW heaters are electric, and the fourth is natural gas-fired. Tank sizes are as follows:

- DHW01: 12 USG
- DHW02: 48 USG
- DHW03: 50 USG (natural gas)
- DHW02: 46 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 83: A - DHW01



Figure 84: A - DHW02



Figure 85: A - DHW02 - install date

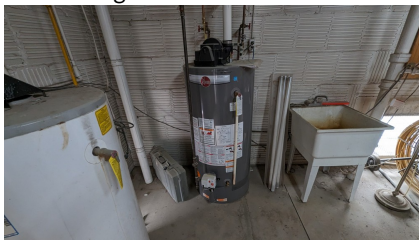


Figure 86: B - DHW03



Figure 87: B - DHW03 - setting



Figure 88: C - DHW04

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]	-
Building A - Bays	730	6	4,383	Assumption.
Building A - Offices and lunchroom	309	8	2,472	Assumption.
Building A - Storage and men's washroom	176	10	1,755	Assumption.
Building B	267	10	2,672	Assumption.
Building C - Changeroom	68	10	680	Assumption.
Building C - Bays	422	6	2,532	Assumption.

Interior lighting

Fixtures

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

- Type A: exhaust fan with a light
- Type B: 2'x4' recessed, LED flat panel
- Type C: 2'x4' recessed, 4 lamp, T8 fluorescent
- Type D: 1'x4' wall mounted, 2 lamp, LED lamp retrofitted
- Type E: 2'x4' surface-mounted, 4 lamp, T8 fluorescent
- Type F: LED high bay
- Type G: 1'x4' suspended, 2 lamp, T8 fluorescent
- Type H: 2'x4' suspended, 4 lamp, T8 fluorescent
- Type I: LED bench fixture
- Type K: 1'x4' surface-mounted, 2 lamp, T12 fluorescent
- Type M: 1'x4' surface-mounted, 2 lamp, LED lamp retrofitted
- Type N: strip surface mounted, LED
- Type O: 1'x4' wall mounted, 2 lamp, T12 fluorescent
- Type P: socket with LED lamp
- Type Q: 1'x4' surface-mounted, 2 lamp, LED retrofitted

Controls

Interior lighting is controlled through manual switches.

Exterior lighting

Fixtures

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

- Type J: LED downlight
- Type L: CFL wall pack

Controls

External photocells or built-in photocells control the exterior fixtures.

Lighting system documentation

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



Figure 89: A - Manual switch in the office



Figure 90: A - Photocell



Figure 91: A - Type A - light and exhaust fan



Figure 92: A - Type B - LED 2x4 flat panel



Figure 93: A - Type C - 2x4 fixture with fluorescent lamps



Figure 94: A - Type D - LED brand



Figure 95: A - Type D - LED retrofitted fixtures

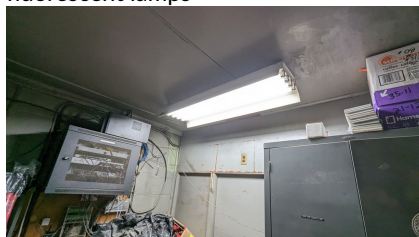


Figure 96: A - Type E - T12 fluorescent

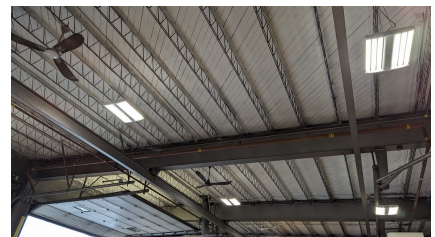


Figure 97: A - Type F - LED high bay



Figure 98: A - Type G - fluorescent fixture



Figure 99: A - Type H - 4 lamp fluorescent



Figure 100: A - Type J - LED downlight



Figure 101: B - Photocell



Figure 102: B - Type G - bay area



Figure 103: B - Type G - washroom



Figure 104: B - Type I - LED bench light



Figure 105: B - Type K - T12 fixture



Figure 106: C - Type D - LED retrofitted fixtures



Figure 107: C - Type J - LED downlight



Figure 108: C - Type L - wall pack with photocell



Figure 109: C - Type M



Figure 110: C - Type N - LED strip light

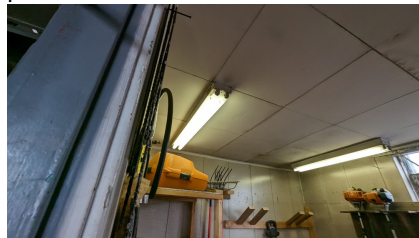


Figure 111: C - Type O - T12 fluorescent



Figure 112: C - Type P - LED lamps

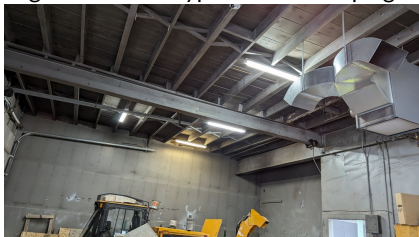


Figure 113: C - Type Q - LED lamps

2.9 Process and plug loads

Process

Various process loads are present at the facility, including:

- Power tools (grinder wheel, chop saw, mitre saw, drill press, etc.)
- Welding and cutting equipment (mig welder and plasma cutter)
- Air compressor
- IT equipment
- Pressure washers
- Washing machine

Plug loads

Various plug loads are present at the facility, including:

- Office equipment (photocopier)
- Personal computers
- Appliances (e.g., coffee maker, toaster, 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 114: A - Toaster



Figure 115: A - Microwave

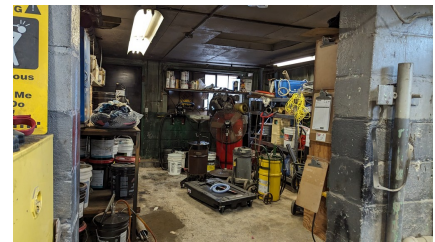


Figure 116: A - Compressor

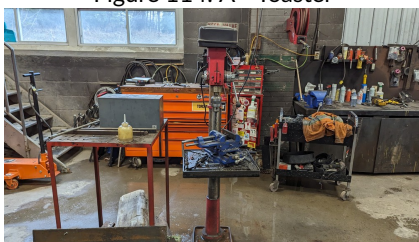


Figure 117: A - Drill press



Figure 118: A - Photocopier



Figure 119: A - Workstation



Figure 120: A - Coffee maker



Figure 121: A - Washing machine



Figure 122: A - Pressure washers

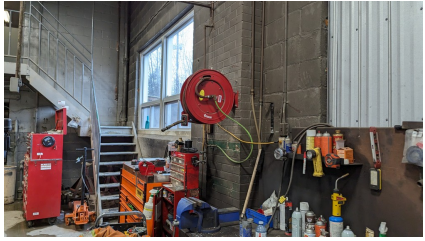


Figure 123: A - Compressed air reel



Figure 124: A - SW office workstation



Figure 125: A - Television in the bay area



Figure 126: A - Refrigerator in the lunchroom

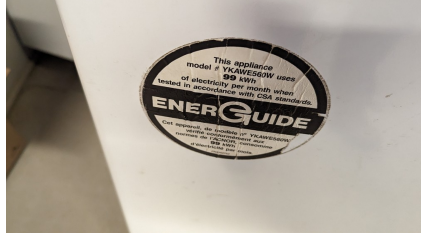


Figure 127: A - Washing machine - energy usage



Figure 128: A - IT equipment in the former locker room



Figure 129: A - Chop saw, mig welder, plasma cutter, and grind wheel



Figure 130: B - Garage opener

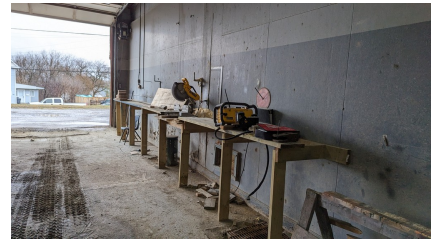


Figure 131: C - Mitre saw

2.10 Water fixtures

Water fixture summary

Water fixtures at New Liskeard Public Works Site are summarized in Table 11.

Table 11: Water fixture summary				
Serves	Unit count	Flow	Volume	Data source
-	-	[gpm]	[gpc]	-
Kitchen faucets	3	2.20	-	Assumption.
Washroom faucets	6	0.50	-	Assumption.
Laundry sink	5	0.50	-	Assumption.
Toilets	6	-	1.6	Assumption.
Urinals	2	-	1.0	Assumption.
Washroom faucets	1	0.50	-	Assumption.
Laundry sink	1	0.50	-	Assumption.

Overview

A summary of water fixtures is as follows:

- Handwashing faucets.
- Kitchen sinks.
- Laundry sinks.
- Toilets.
- Urinals.

Water fixture documentation

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



Figure 132: A - Urinals



Figure 133: A - Laundry sink

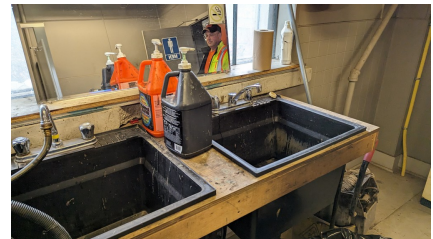


Figure 134: A - Laundry sinks



Figure 135: A - Lunchroom kitchen sink



Figure 136: A - Lunchroom washroom faucet



Figure 137: A - Lunchroom washroom toilet



Figure 138: A - Toilet in the men's washroom



Figure 139: A - Faucet in the women's washroom



Figure 140: A - Toilet in the women's washroom



Figure 141: B - Toilet



Figure 142: B - Laundry sink



Figure 143: B - Second-floor laundry sink



Figure 144: B - Handwashing faucet in washroom



Figure 145: C - Toilet



Figure 146: C - Laundry sink

2.11 Utility services

Utility services summary

Overview

The buildings utilize electricity from Hydro One Networks Inc. and natural gas from Enbridge.

There are two Hydro One electricity meters present. The first meter, J3974150, supplies electricity for Building C. The second meter, J3604502, is present in Building A. However, there is a disconnect for Building B. Furthermore, an owner submeter is present for Building B.

There is one natural gas meter that is present at Building C. Downstream of the meter, it proceeds underground to Building A.

Utility services documentation

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



Figure 147: A - LDC meter cabinet



Figure 148: A - Natural gas from building C



Figure 149: C - LDC meter



Figure 150: C - Natural gas meter

2.12 Onsite energy sources

Overview

This site has one 11 kW natural gas-fired emergency generator at Building A. It's assumed that the unit is operated weekly, similar to City Hall.

There are no renewable energy systems present at this facility.

Onsite energy sources documentation

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



Figure 151: A - 11kW natural gas generator

2.13 Electrical infrastructure

Overview

The existing systems is 200A at 600V - 3Ph service running at a maximum load of 30 kW, which is approximately 18% of the full load of 166.3 kW of the building. The main equipment is a 200 A switchboard, which has 1 spare.

Panel summary

The seven panels at this site are summarized below:

Panel summary - Building A

- Panel A. Serves baseboard heaters, receptacles, and lights.
- Panel B. Serves lights, hot water tank, receptacles, ceiling fans, unit heaters, and subpanel in the stock room.
- Panel C. Serves lights, receptacles, equipment, and feeds the generator panel.
- Panel D (Generator panel). Serves doors, lights, and fuel pumps,
- Panel E (Main power distribution panel). Serves the compressor, welder, lighting transformer (east and west end), and ventilation fan.

Panel summary - Building B

- Panel F. Serves the unit heater, receptacles, lights, and hot water tank.

Panel summary - Building C

- Panel G. Serves the hot water tank, lighting, receptacles, south parking lot sub panel, and washroom heater.
- Panel H. Not legible.

Electrical infrastructure documentation

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

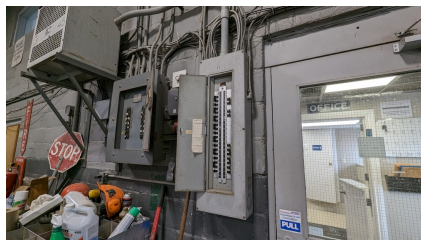


Figure 152: A - Panel A



Figure 153: A - Panel B



Figure 154: A - Panel C

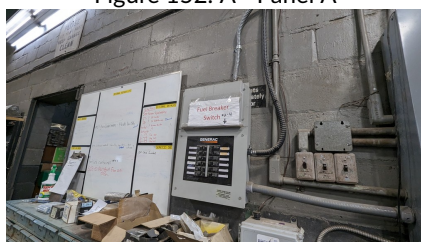


Figure 155: A - Panel D



Figure 156: A - Panel E



Figure 157: A - Incoming mass



Figure 158: A - 15 kVA transformer

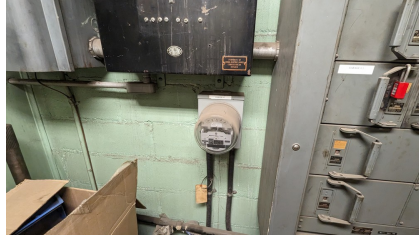


Figure 159: A - Garage No. 3 submeter



Figure 160: A - 45 kVA transformer in the bay area



Figure 161: B - Panel F

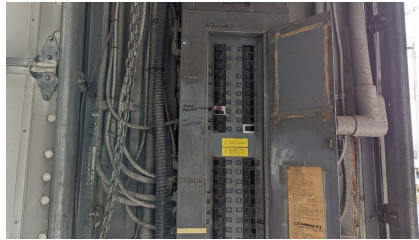


Figure 162: C - Panel G



Figure 163: C - Panel H

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 New Liskeard Public Works Site.
 - 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 New Liskeard Public Works Site 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 New Liskeard Public Works Site.
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	[tCO ₂ e/kWh]	0.0000302	Environment and Climate Change Canada Data Catalogue, Electricity Grid Intensities-1
Natural gas	[tCO ₂ e/m ³]	0.0019324	National Inventory Report, 1990-2023, Table 1-1, Table A61.1-1 and Table A61.1-3

- 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)	[\$/m ³]	0.2600
GHG emissions	Federal carbon charge	[\$/tCO ₂ e]	50.0000

3.3 Electricity metered utility use

Hourly electricity use is plotted in Figure 164.

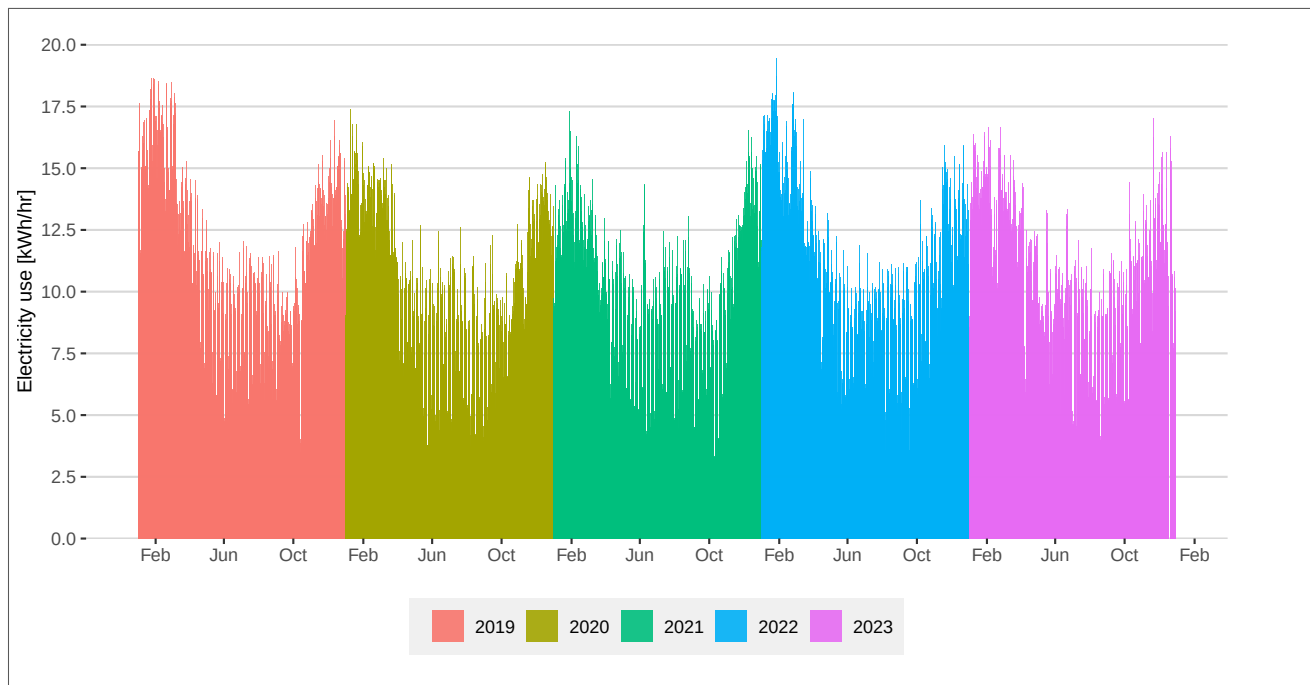


Figure 164: Hourly electricity use

The same hourly electricity use data is plotted in Figure 165, which highlights how electricity use is influenced by year, season, day of week and hour of day. The vertical axis on Figure 165 may be rescaled relative to in Figure 164 for greater resolution.

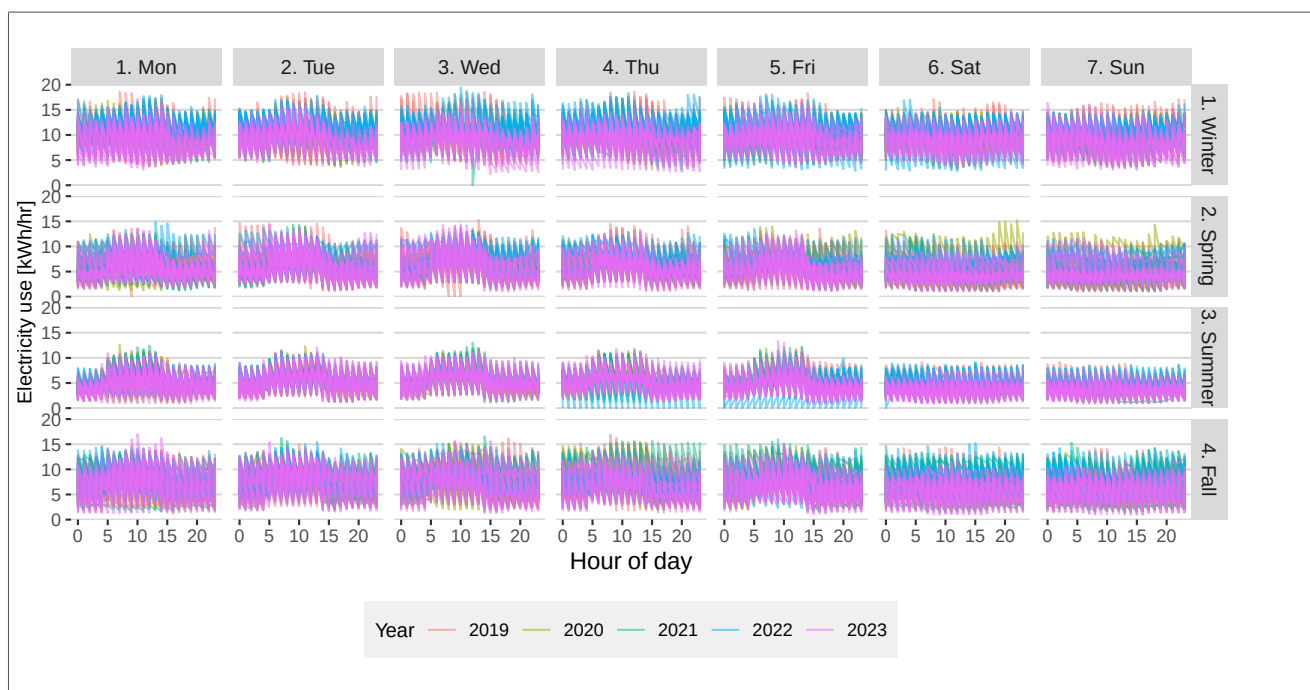


Figure 165: Hourly electricity use hairball plot

Monthly electricity use is plotted in Figure 166.

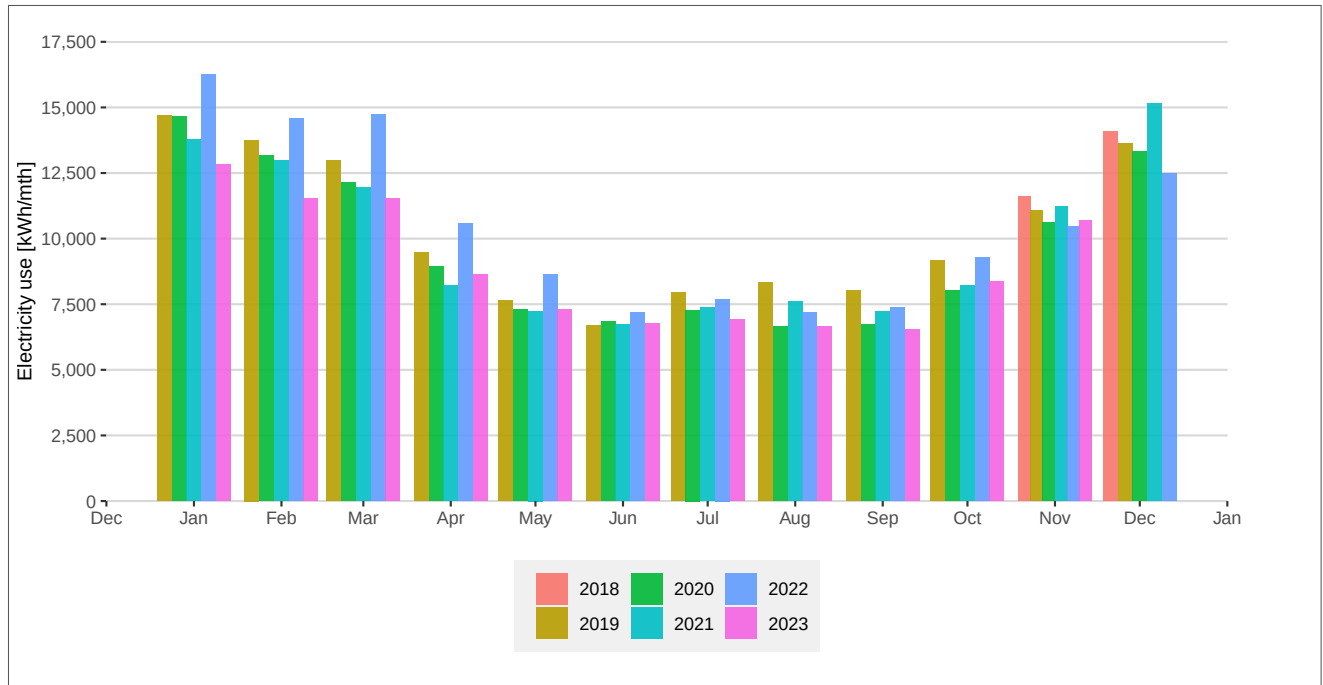


Figure 166: Monthly electricity use

3.4 Natural gas metered utility use

Monthly natural gas use is plotted in Figure 167.

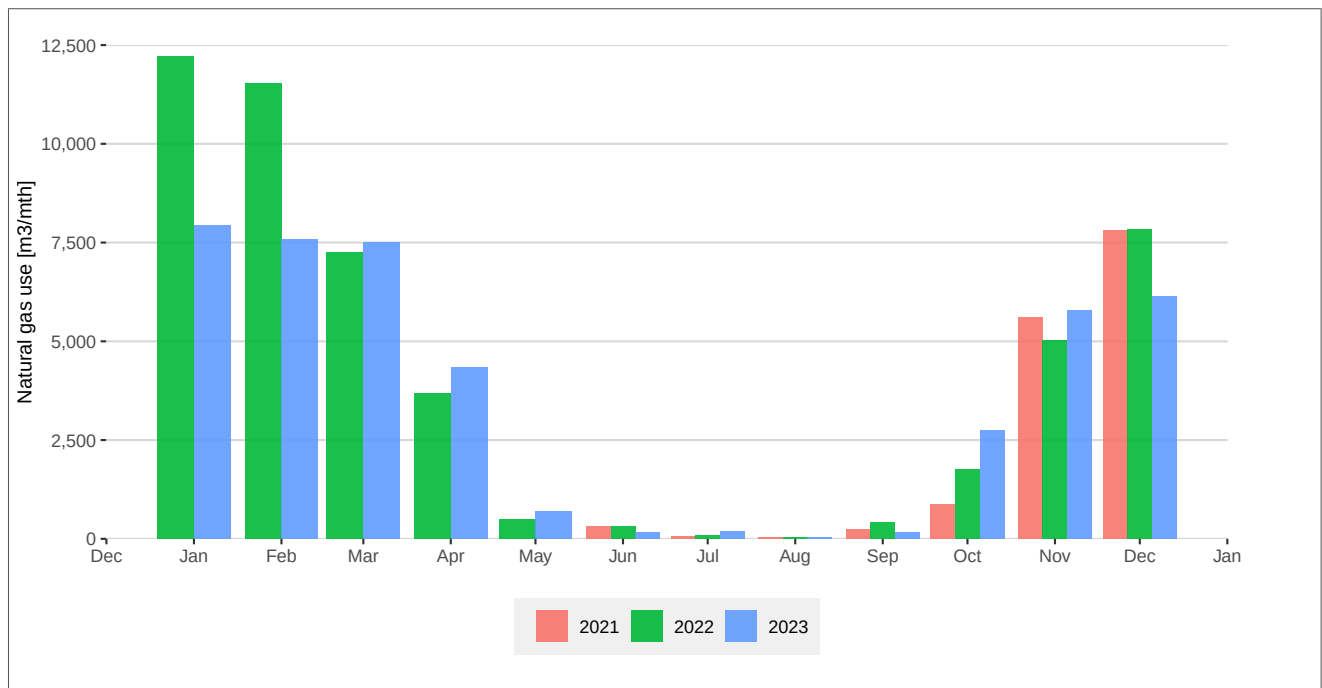


Figure 167: Monthly natural gas use

3.5 Utility use baseline

Baseline year

The baseline year for New Liskeard Public Works Site, 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 performance

Category	Utility	Unit	Value
Utility use	Electricity use	[kWh/yr]	129,057
	Natural gas use	[m3/yr]	50,666
	Carbon offset use	[tCO2e/yr]	0
Equivalent energy use	Electricity energy	[kWh/yr]	129,057
	Natural gas energy	[kWh/yr]	534,868
	Total energy	[kWh/yr]	663,926
GHG emissions	Electricity GHGs	[tCO2e/yr]	4
	Natural gas GHGs	[tCO2e/yr]	98
	Carbon offsets GHGs	[tCO2e/yr]	0
	Total GHGs	[tCO2e/yr]	102
Utility cost	Electricity utility cost	[\$/yr]	12,802
	Natural gas utility cost	[\$/yr]	13,173
	Carbon offsets utility cost	[\$/yr]	0
	Federal carbon charge	[\$/yr]	4,895
	Total utility cost	[\$/yr]	30,871

3.6 Benchmarking analysis

Benchmarking analysis results are presented in the following figures.

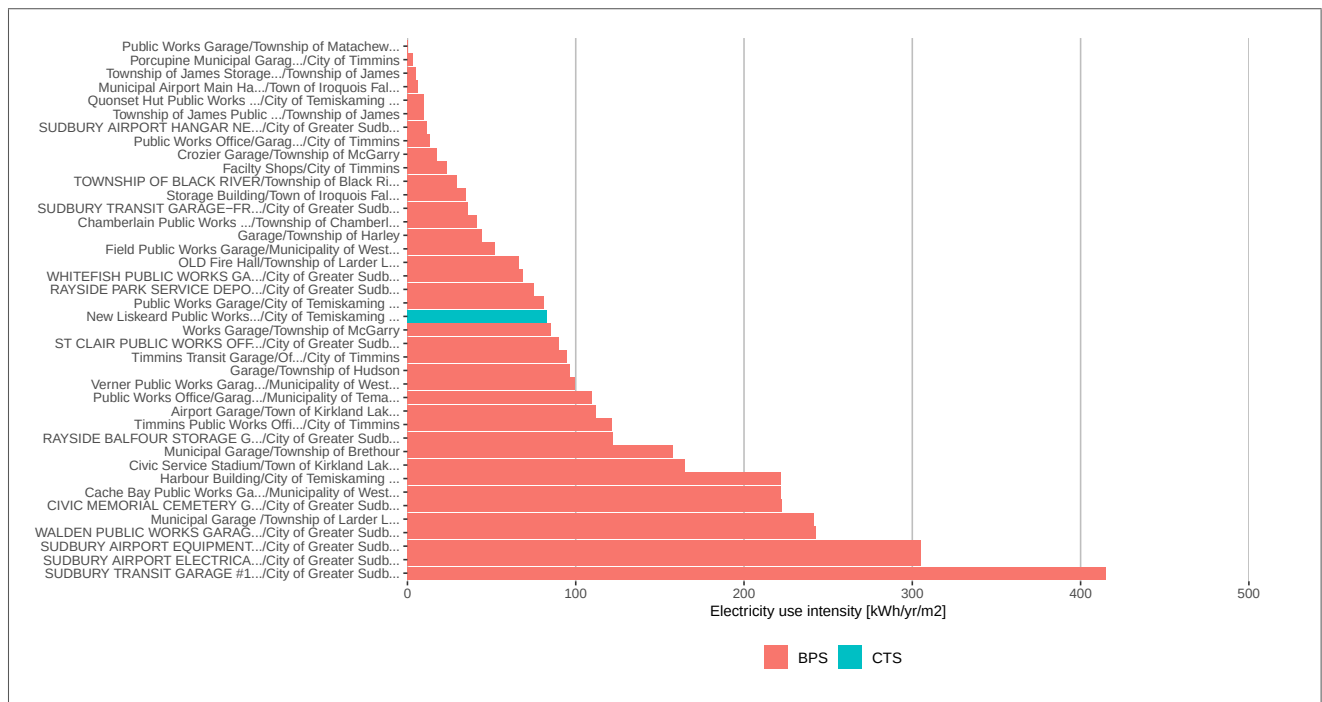


Figure 168: Electricity use intensity benchmarking analysis comparison

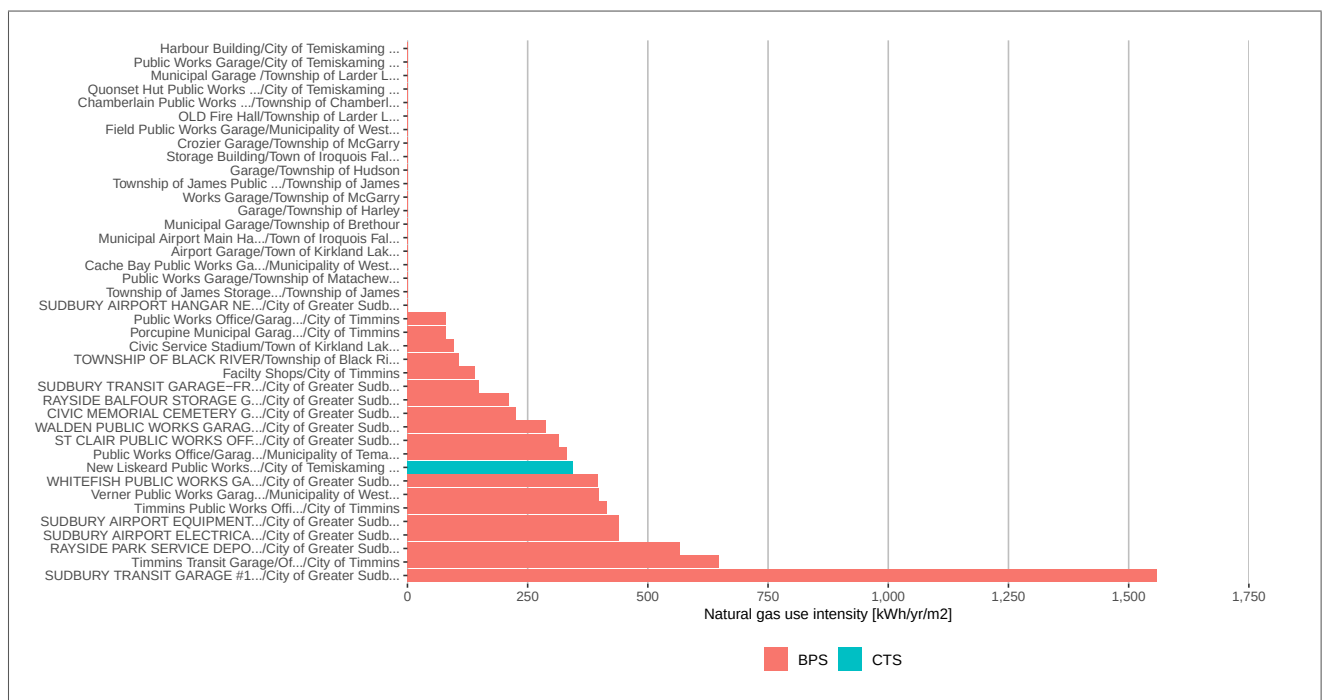


Figure 169: Natural gas use intensity benchmarking analysis comparison

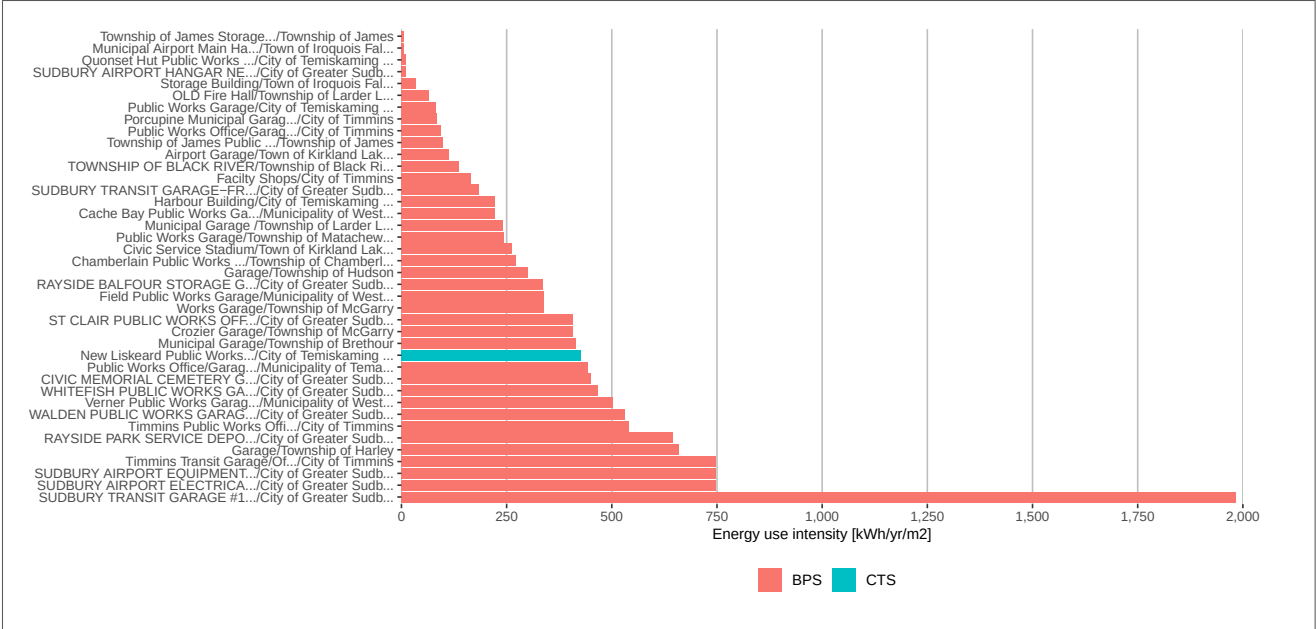


Figure 170: Total energy use intensity benchmarking analysis comparison

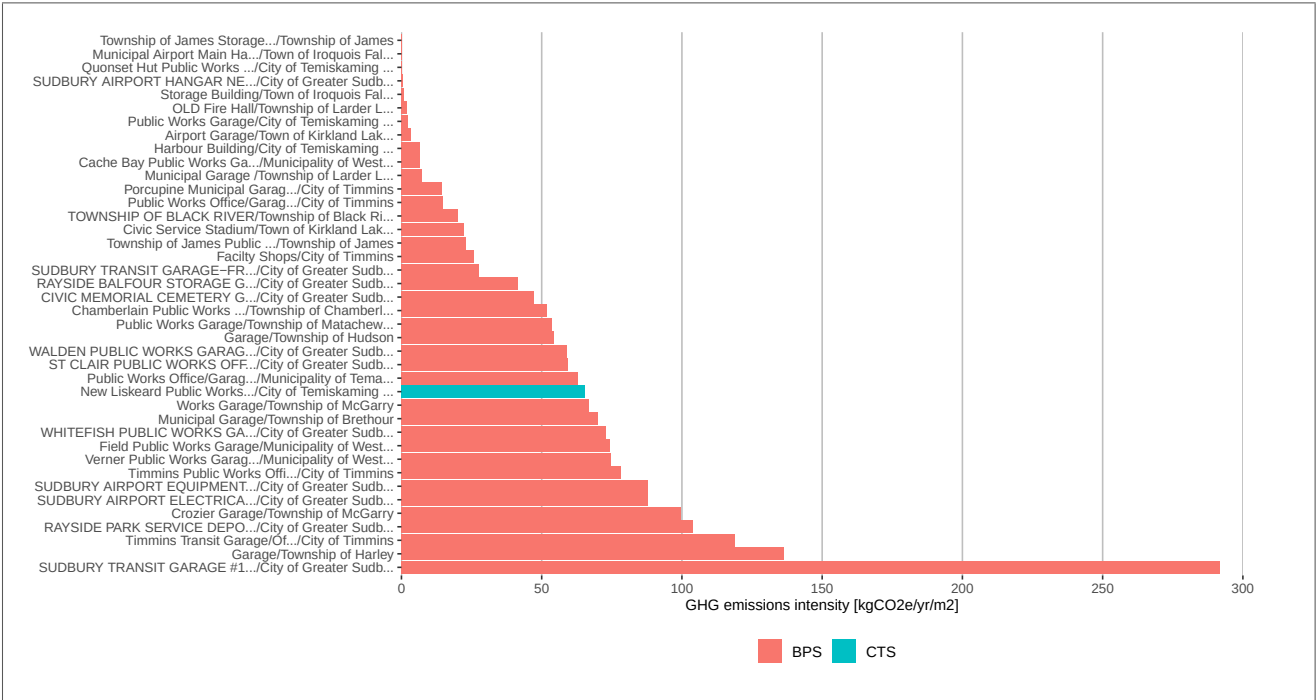


Figure 171: GHG emissions intensity benchmarking analysis comparison

3.7 ENERGY STAR Portfolio Manager benchmarking analysis

The scorecard is shown in Figure 172.

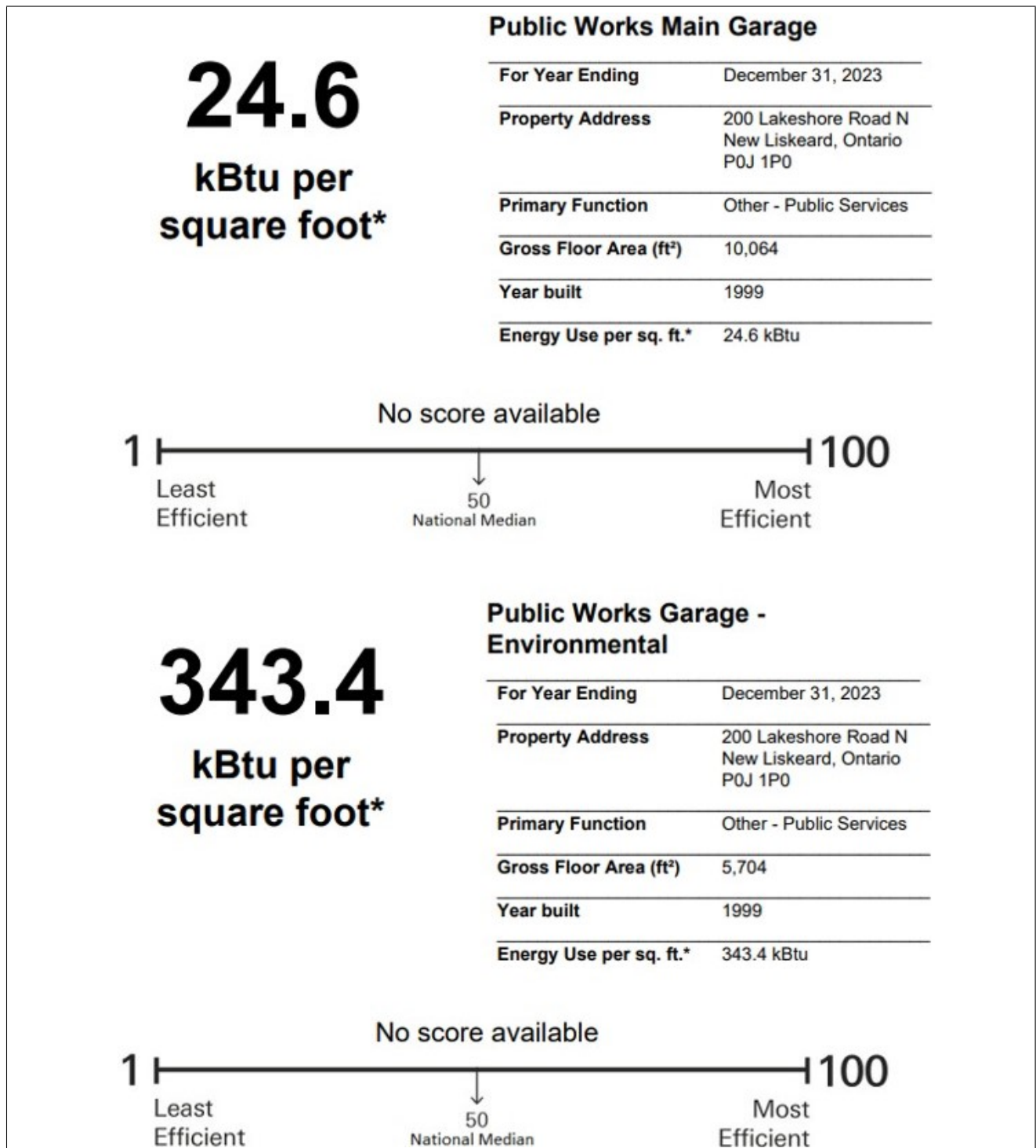


Figure 172: Energy Star energy performance scorecard.

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 Section 2.

Electricity - Hourly

- Hourly electricity consumption typically peaks during the winter, due to electric heating.
- Hourly consumption is typically under 30 kWh and above 5 kWh.
- A "W-shape" profile suggests heating in the winter and a small amount of cooling in the summer.
- Hourly consumption during unoccupied hours is around 5-10 kWh. The primary contributors to this are thought to be due to a 5 hp compressor in Building A and standby losses from the electric DHW.

Electricity - Monthly

- **2018:** The dataset provided started in November 2018 and did not allow for a full year of comparison.
- **2019:** The electricity consumption is highest in the winter months and lowest during the summer as a result of electric heating.
- **2020:** Consumption is similar to 2019. There is no noticeable impact due to the effects of the COVID-19 pandemic.
- **2021:** Metered electricity data is similar to previous years.
- **2022:** Metered electricity data is similar to previous years. Consumption from January to May is slightly higher than in previous years.
- **2023:** Metered electricity data is similar to previous years.

Natural gas

- Natural gas consumption has maintained a relatively consistent profile year over year, with the exception of January and February. 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.
- Natural gas consumption in the winter of 2023 is lower than it is in 2022, suggesting that there might have been operational changes during those months.
- Of the thirty data points available for monthly natural gas consumption, only 11 were actual readings, not estimates. This observation can lead to calibration issues, as the model may not pass ASHRAE Guideline 14.

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.
	DHW heat	Domestic hot water heating energy use.
	Equipment	Equipment energy use.
	Exterior lights	Exterior lighting energy use.
	Fans	Fan motor energy use.
	Lights	Lighting energy use.
	Space heat	Space heating energy use.
Natural gas	DHW heat	Domestic hot water heating energy use.
	Other	Metered use less modelled 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 173. See Table 16 for end use definitions.

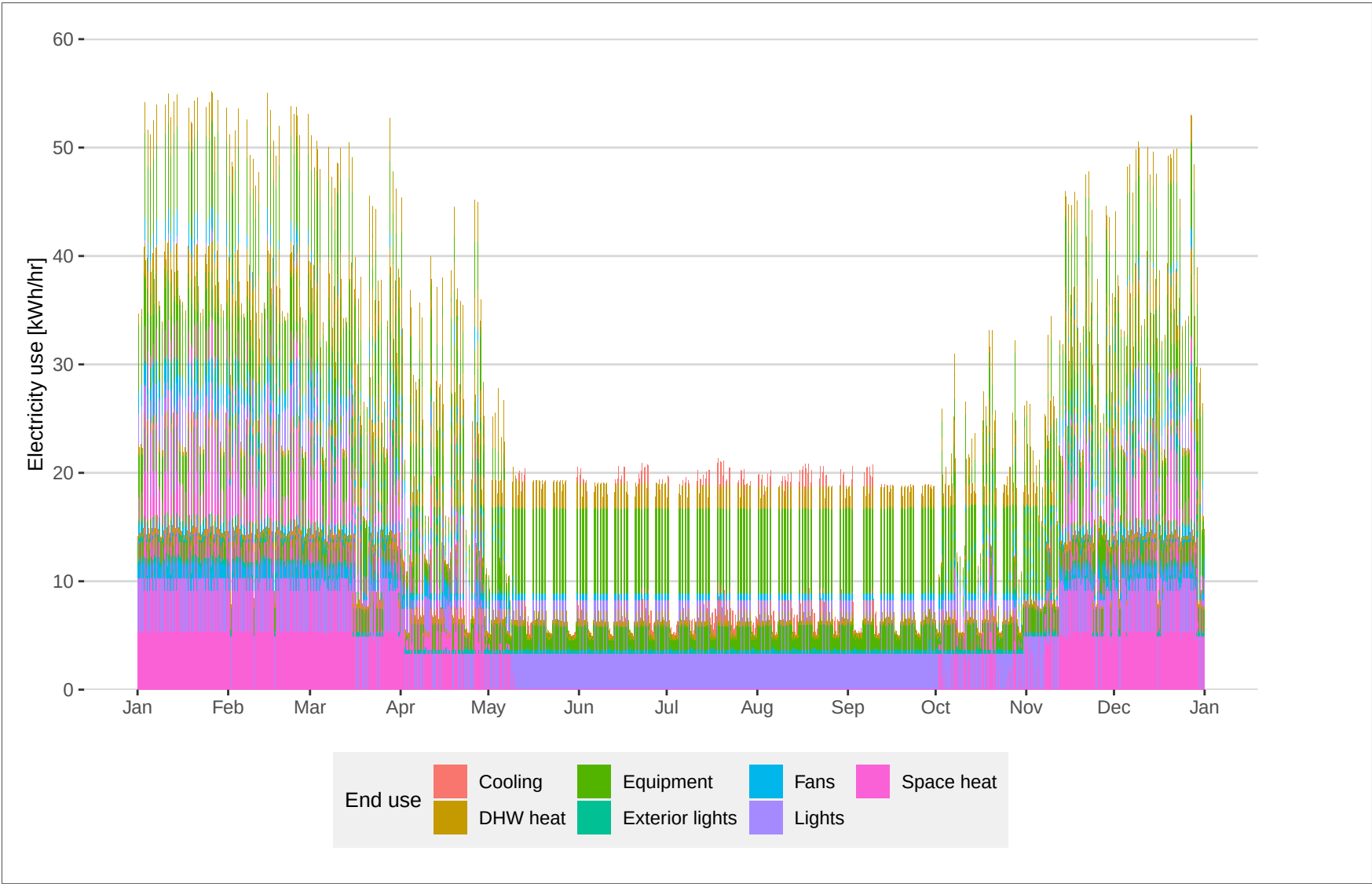


Figure 173: Hourly electricity utility use by end use (made by calibrated energy model)

Natural gas

The hourly natural gas utility use profile by end use made by the energy model is plotted in Figure 174. See Table 16 for end use definitions.

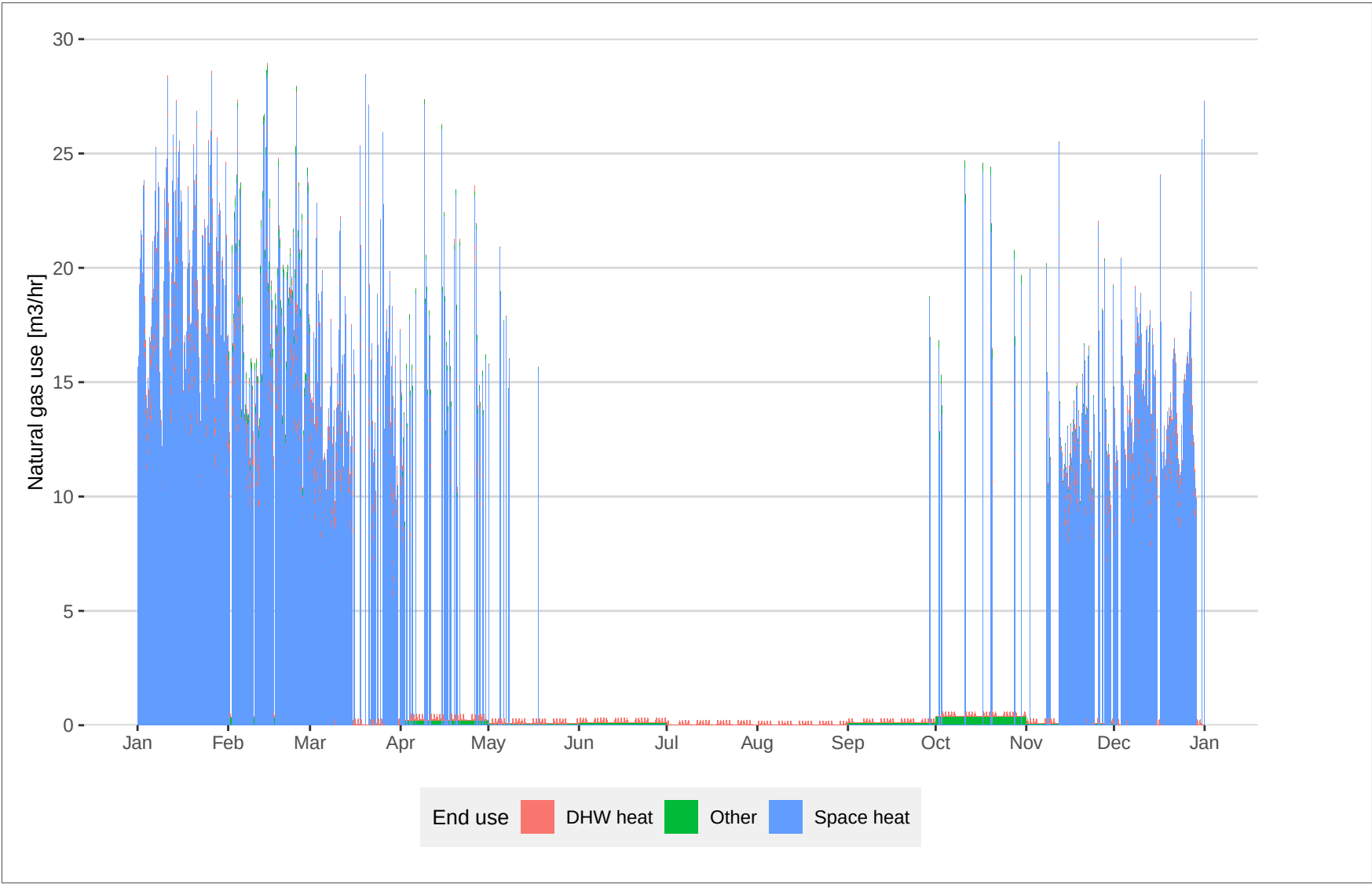
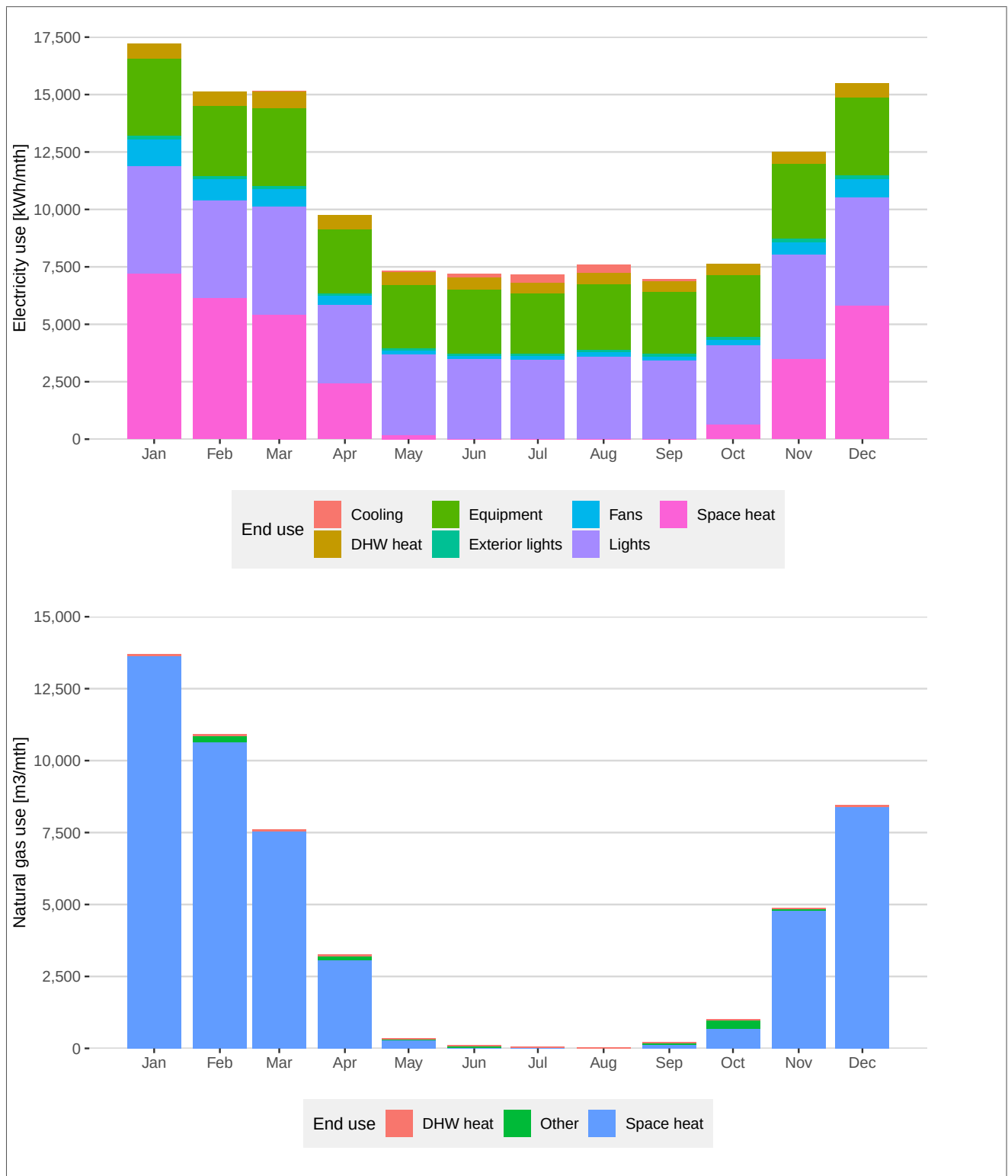


Figure 174: Hourly natural gas utility use by end use (made by calibrated energy model)

4.3 Monthly utility use profiles

Monthly utility use profiles for each modelled utility are presented in Figure 175.



4.4 Calibration analysis

Electricity

Figure 176 compares the metered utility use with the modelled use to check how well the model is calibrated.

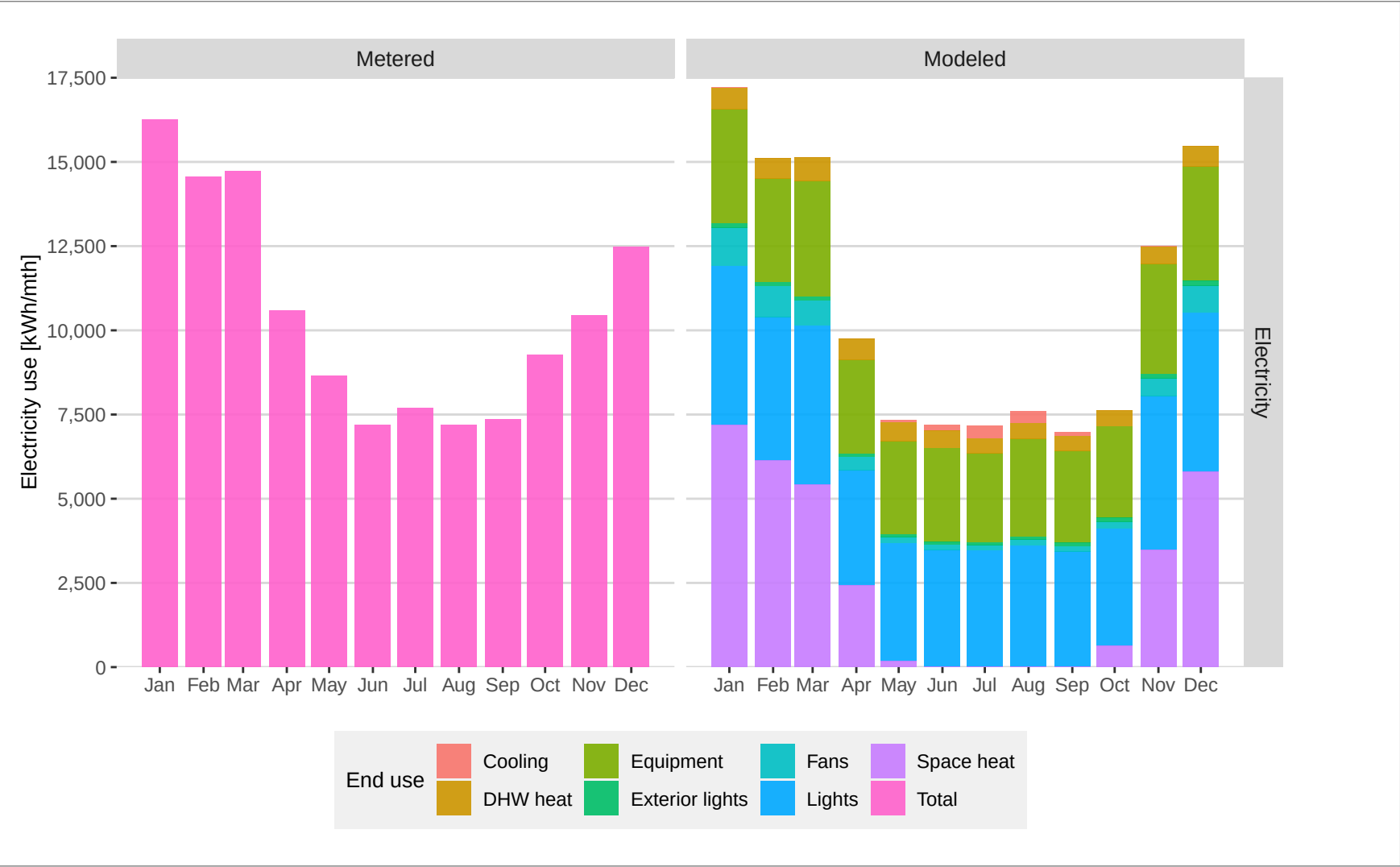


Figure 176: Electricity calibration analysis (metered vs modelled utility use)

Natural gas

Figure 177 compares the metered utility use with the modelled use to check how well the model is calibrated.

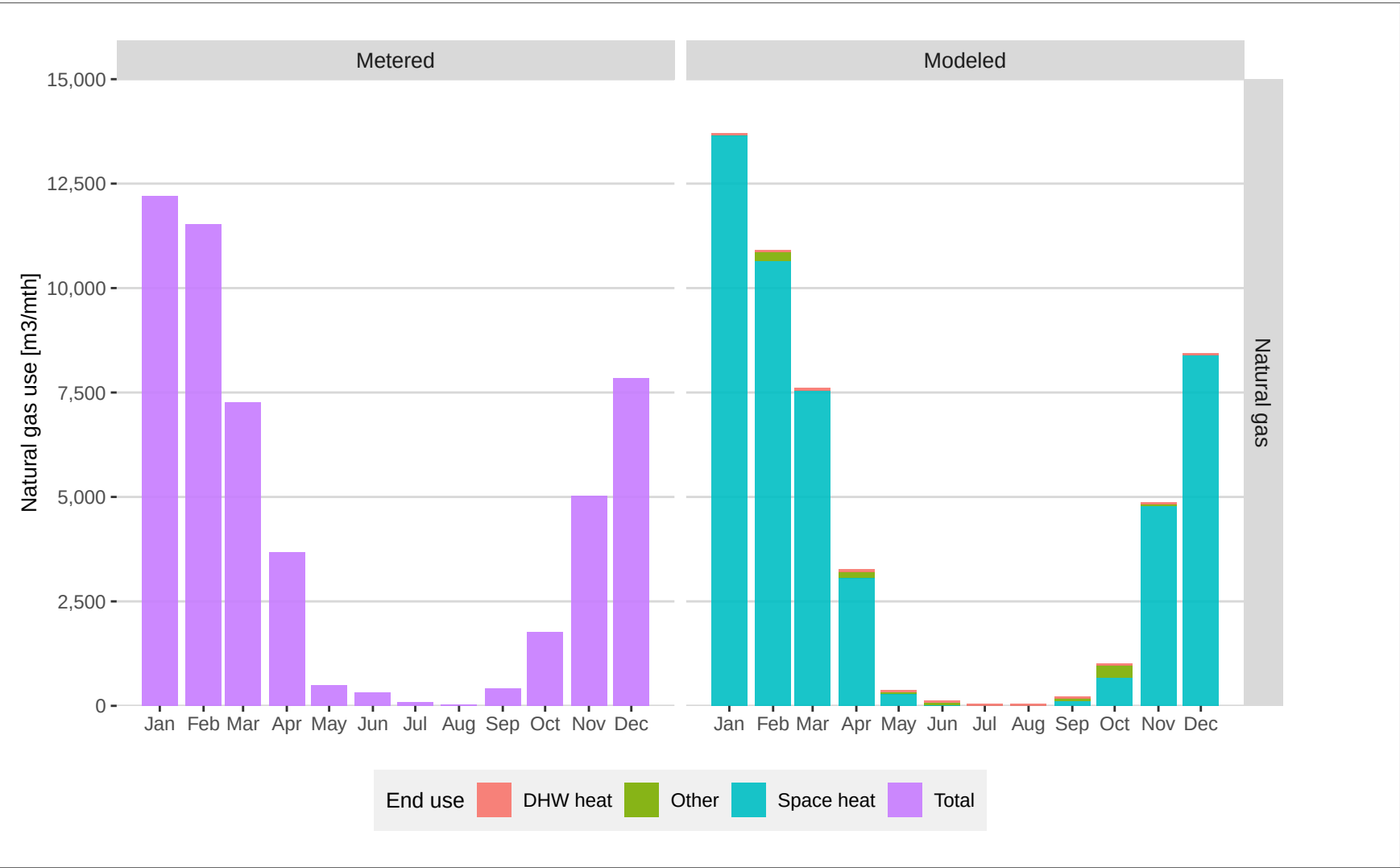


Figure 177: Natural gas calibration analysis (metered vs modelled utility use)

Statistical calibration analysis

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

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

Statistical calibration analysis results were calculated and are summarized in Table 17.

Table 17: Statistical calibration analysis summary

Utility	Description	Unit	ASHRAE 14	Model	Pass/Fail
Electricity	Mean bias error	[%]	< +/- 5	-2.3	Pass
	Root mean square error	[%]	< 15	12.9	Pass
Natural gas	Mean bias error	[%]	< +/- 5	-0.0	Pass
	Root mean square error	[%]	< 15	14.3	Pass

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 176 and 177 both demonstrate a strong agreement between monthly trends observed in the metered utility use data and the monthly utility use predicted by the calibrated energy model.
- Electricity and natural gas use were successfully calibrated according to the standards of ASHRAE Guideline 14.
- Note that to achieve alignment between metered and modelled data, it was assumed that the heating was not used often if the outdoor temperature was above 0 C.
- The successful energy model calibration is largely due to the methodology used in developing the calibrated energy model. Under this methodology, the major systems affecting utility use were studied in detail (see Section 2), including their operations, so that these systems could be explicitly modelled one-to-one, precisely reflecting the unique operations associated with each system. Examples of such major systems include all unit heaters and infrared heaters.
- Therefore, there can be confidence that the utility use impacts quantified in the various measure and scenario analyses under this report are reasonable.

Electricity

- Figure 176 indicates strong agreement between modelled and metered data.

- The peak and trough hourly consumption align with the metered interval data.

Natural gas

- Figure 177 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 (only 4 readings are actual readings, the rest are estimates).

4.5 End use analysis

Electricity

The yearly electricity end use breakdown calculated by the energy model is plotted in Figure 178. See Table 16 for end use definitions.

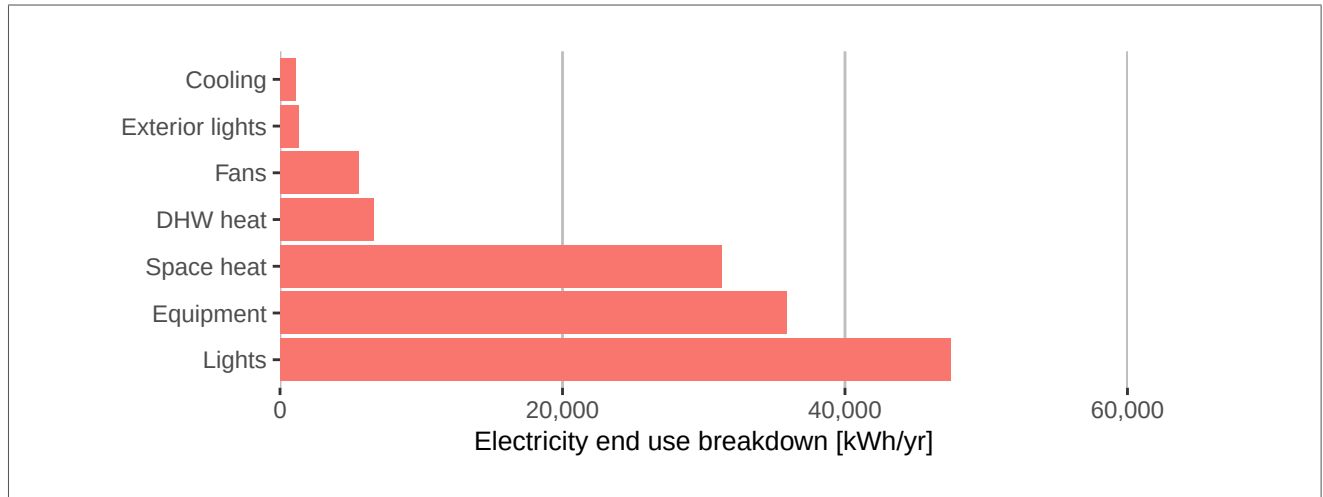


Figure 178: Electricity end use breakdown (calculated by calibrated energy model)

Natural gas

The yearly natural gas end use breakdown calculated by the energy model is plotted in Figure 179. See Table 16 for end use definitions.

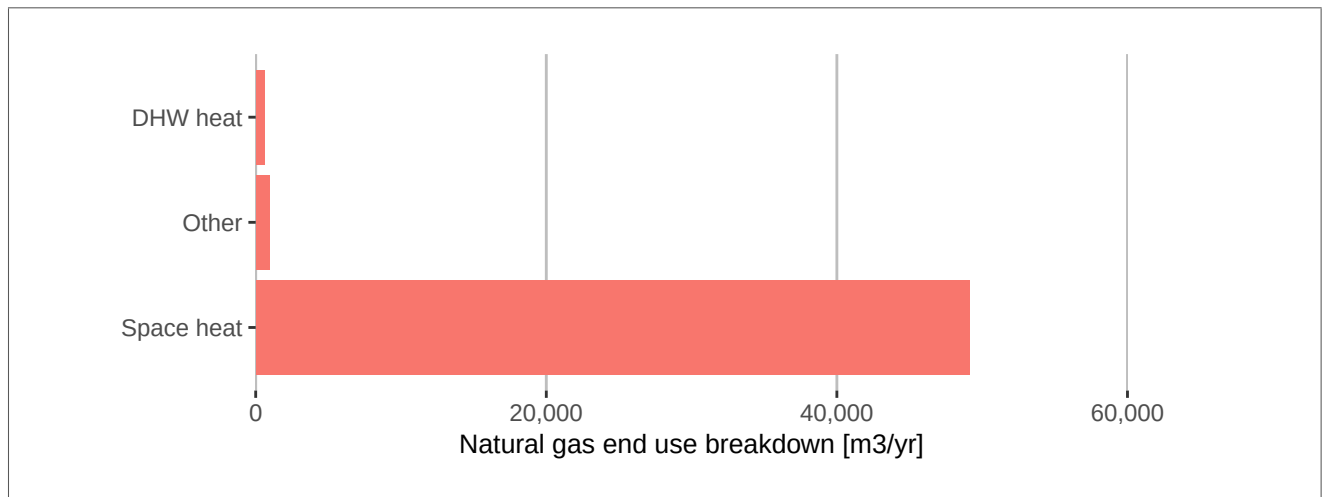


Figure 179: Natural gas end use breakdown (calculated by calibrated energy model)

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 5.15). 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 5.16.

4. **Measure analysis summary.** Measure analysis results for all measures were summarized in table format in Section 5.17.

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 Up to a maximum of \$100,000
FCM CBR GHG reduction pathway grant	Up to 80% of project costs (grant + loan) Up to \$5 million (grant + loan) Up to 25% of funding can be grant

- Life cycle cost analysis assumptions are summarized in Table 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 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 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 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 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 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	
Carbon offsets 20	Analyzed.
Compressor schedule optimization	Analyzed.
DHW heaters to ASHP	Analyzed.
Exterior LED lighting upgrade	Analyzed.
Install a mini split system in the lunchroom	Analyzed.
Interior LED lighting upgrade	Analyzed.
Radiant heaters to electric	Analyzed.
Roof upgrade to high performance	Analyzed.
Solar PV rooftop	Analyzed.
Unit heaters conversion	Analyzed.
Wall upgrade to high performance	Analyzed.
Windows and doors to high performance	Analyzed.
DHW renewal	Business as usual.
Exterior lighting renewal	Business as usual.
Exterior walls renewal	Business as usual.
Infrared renewal	Business as usual.
Interior lighting renewal	Business as usual.
Roof renewal	Business as usual.
Unit heaters renewal	Business as usual.
Windows and doors renewal	Business as usual.
Solar PV canopy	Not analyzed: given the site logistics of large vehicles, it would be difficult to include ground-mounted solar PV here.

5.4 Carbon offsets 20

Measure description

Existing condition

The facility is currently purchasing no carbon offsets.

Opportunity

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

Utility-savings mechanism

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

Design description

Net zero definition

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

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

The terms of this formula are defined as follows.

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

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

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

Renewable energy certificates

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

Carbon offsets

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

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

Cost rates

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

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

Utility analysis

Utility analysis methodology

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

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

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

Utility analysis results

Table 23: Carbon offsets 20 analysis results summary

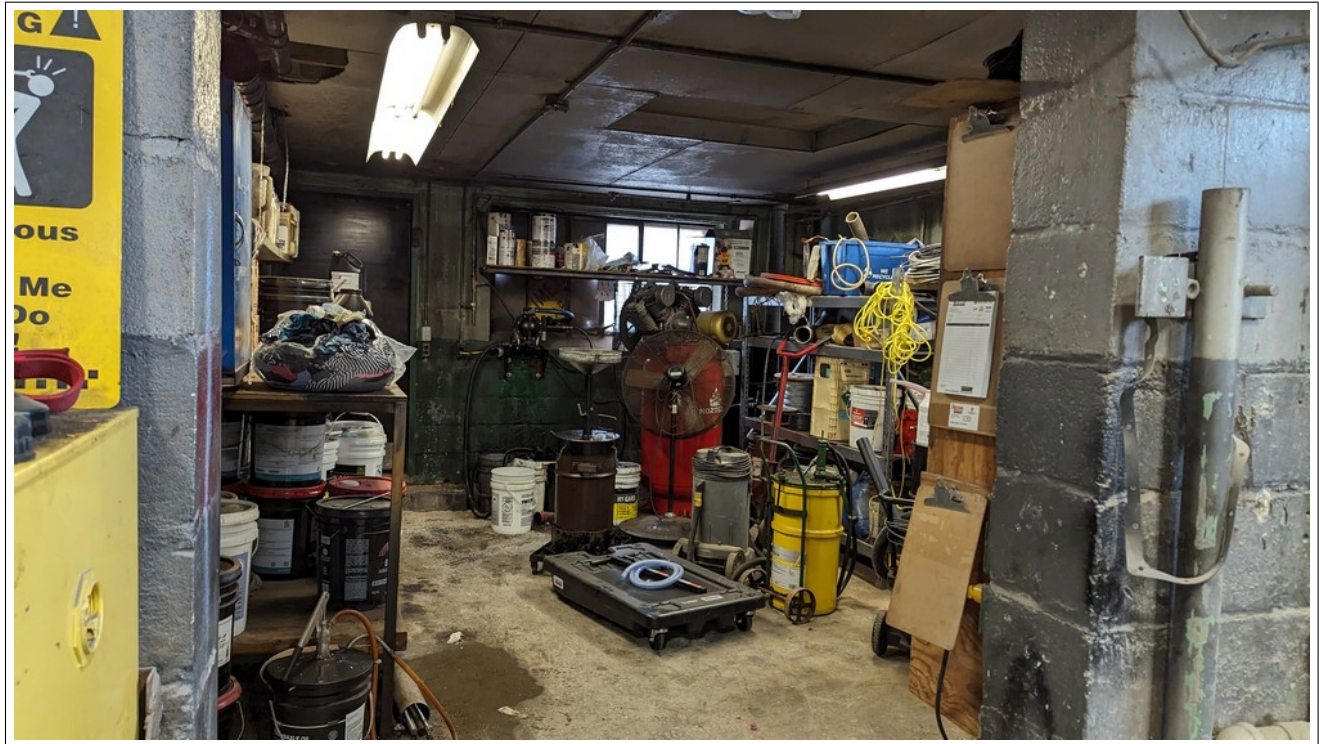
Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	129,057	129,057	0	0
	Natural gas use	[m3/yr]	50,666	50,666	0	0
	Carbon offset use	[tCO ₂ e/yr]	0	20.4	-20.4	—
Equivalent energy use	Electricity energy	[kWh/yr]	129,057	129,057	0	0
	Natural gas energy	[kWh/yr]	534,868	534,868	0	0
	Total energy	[kWh/yr]	663,926	663,926	0	0
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	3.9	3.9	0	0
	Natural gas GHGs	[tCO ₂ e/yr]	97.9	97.9	0	0
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	-20.4	20.4	—
	Total GHGs	[tCO ₂ e/yr]	102	81.4	20.4	20.0
Utility cost	Electricity utility cost	[\$/yr]	12,802	12,802	0	0
	Natural gas utility cost	[\$/yr]	13,173	13,173	0	0
	Carbon offsets utility cost	[\$/yr]	0	611	-611	—
	Federal carbon charge	[\$/yr]	4,895	4,895	0	0
	Total utility cost	[\$/yr]	30,871	31,482	-611	-2.0
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	—	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	—	—	—
	Life cycle cost	[\$]	729,038	740,177	—	—
	Net present value	[\$]	0	-11,139	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	—	—	—
	Simple payback period	[yr]	—	—	—	—

5.5 Compressor schedule optimization

Measure description

Existing condition

There is an air compressor at the facility. Based on the facility's hourly electricity baseload, it is thought that this air compressor may be operational 24/7.



Opportunity

Optimize the compressor schedule so that it is only used when needed.

Utility-savings mechanism

Reduced electricity use due to reduced compressor operation. Natural consumption is expected to increase due to less internal heat gain from the air compressor not operating.

Design description

Project cost estimate

There is no project cost as it is assumed that staff are capable of implementing this measure.

Table 24: Project cost estimate (Compressor schedule optimization)

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

Utility analysis

Utility analysis methodology

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

- **Baseline.** The compressor is assumed to operate 24/7. The air compressor is assumed to be equipped with a 5hp motor.
- **Proposed.** The compressor is assumed to operate from 7am to 3pm on weekdays. It's assumed that the air compressor will be turned off by staff at the end of the workday.

Utility analysis results

Table 25: Compressor schedule optimization analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	129,057	124,609	4,448	3.4
	Natural gas use	[m3/yr]	50,666	50,977	-311	-0.61
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	129,057	124,609	4,448	3.4
	Natural gas energy	[kWh/yr]	534,868	538,153	-3,284	-0.61
	Total energy	[kWh/yr]	663,926	662,762	1,164	0.18
GHG emissions	Electricity GHGs	[tCO2e/yr]	3.9	3.8	0.13	3.4
	Natural gas GHGs	[tCO2e/yr]	97.9	98.5	-0.60	-0.61
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	102	102	-0.47	-0.46
Utility cost	Electricity utility cost	[\$/yr]	12,802	12,361	441	3.4
	Natural gas utility cost	[\$/yr]	13,173	13,254	-80.9	-0.61
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	4,895	4,925	-30.1	-0.61
	Total utility cost	[\$/yr]	30,871	30,541	330	1.1
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	0	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	0	—	—
	Life cycle cost	[\$]	729,038	718,955	—	—
	Net present value	[\$]	0	10,083	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	0	—	—
	Simple payback period	[yr]	—	0.0	—	—

5.6 DHW heaters to ASHP

Measure description

Existing condition

Three of the four DHW heaters are electric, and the fourth (DHW03 in Building B) is natural gas-fired. DHW03 was recently replaced.



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

Overview

Replace the existing gas fired hot water heater with a new 80USG hybrid heat pump hot water heater. The new heat pump shall be a Rheem Proterra or equivalent system. The unit shall be operated in hybrid mode.

Electrical

The ASHP will add approximately 5 kW of power to the existing system, which will put the system at 35 kW, which is approximately 21% of the full load of the electrical capacity of the building. The current system could support this additional load.

Project cost estimate

Table 26: Project cost estimate (DHW heaters to ASHP)

Category	Line item	Unit	Value
Materials and labour	Supply	[\$]	5,000
	Install	[\$]	2,500
	Electrical	[\$]	12,000
Contingency	Subtotal after Materials and labour	[\$]	19,500
	General Contingency (50%)	[\$]	9,800
Total	Total	[\$]	29,300

Utility analysis

Utility analysis methodology

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

- **Baseline.** DHW03 is gas-fired and operates at an efficiency of 90%.
- **Proposed.** DHW03 is replaced by an ASHP at a COP of 3.5.

Utility analysis results

Table 27: DHW heaters to ASHP analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	129,057	131,595	-2,537	-2.0
	Natural gas use	[m3/yr]	50,666	50,063	603	1.2
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	129,057	131,595	-2,537	-2.0
	Natural gas energy	[kWh/yr]	534,868	528,502	6,366	1.2
	Total energy	[kWh/yr]	663,926	660,097	3,829	0.58
GHG emissions	Electricity GHGs	[tCO2e/yr]	3.9	4.0	-0.08	-2.0
	Natural gas GHGs	[tCO2e/yr]	97.9	96.7	1.2	1.2
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	102	101	1.1	1.1
Utility cost	Electricity utility cost	[\$/yr]	12,802	13,054	-252	-2.0
	Natural gas utility cost	[\$/yr]	13,173	13,016	157	1.2
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	4,895	4,837	58.3	1.2
	Total utility cost	[\$/yr]	30,871	30,908	-36.6	-0.12
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	29,300	—	—
	Incentive amount	[\$]	0	151	—	—
	Incremental project cost	[\$]	0	29,149	—	—
	Life cycle cost	[\$]	729,038	767,190	—	—
	Net present value	[\$]	0	-38,152	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	26,775	—	—
	Simple payback period	[yr]	—	—	—	—

5.7 Exterior LED lighting upgrade

Measure description

Existing condition

The majority of exterior lighting has been replaced with LED fixtures. However, one wallpack remains as CFL on Building C.



Opportunity

Replace the last non-LED fixture with an LED equivalent fixture.

Utility-savings mechanism

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

Design description

Overview

The lighting system shall be designed to meet the latest ASHRAE 90.1 energy codes, IESNA standards, the New Liskeard Public Works Site standards and other applicable regulations and standards.

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

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

With the extended lifespan associated with LED fixtures, the likelihood of a complete fixture failure is significantly less likely than previous fixture types. Rather, the user would witness a slow degradation of the lighting output of

the fixtures. It would be recommended that an annual lighting review is conducted to measure the lighting levels after dusk or before dawn. At the 70% output level, the owner would expect a much quicker decline in the loss of lighting output in each fixture. As such, at the 70% lighting level, it would be recommended that the fixtures be replaced.

Type L fixtures should be replaced.

Project cost estimate

Table 28: Project cost estimate (Exterior LED lighting upgrade)

Category	Line item	Unit	Value
Materials and labour	Exterior LED lighting upgrade	[\$]	1,000
Contingency	Subtotal after Materials and labour	[\$]	1,000
	General Contingency (50%)	[\$]	500
Total	Total	[\$]	1,500

Utility analysis

Utility analysis methodology

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

- **Baseline:** Exterior lighting is assumed to consume 0.3 kW.
- **Proposed:** It is assumed that the exterior lighting is replaced with an LED equivalent and the resulting exterior lighting consumes 0.27 kW.

Utility analysis results

Table 29: Exterior LED lighting upgrade analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	129,057	128,927	131	0.10
	Natural gas use	[m3/yr]	50,666	50,666	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	129,057	128,927	131	0.10
	Natural gas energy	[kWh/yr]	534,868	534,868	0	0
	Total energy	[kWh/yr]	663,926	663,795	131	0.02
GHG emissions	Electricity GHGs	[tCO2e/yr]	3.9	3.9	0.00	0.10
	Natural gas GHGs	[tCO2e/yr]	97.9	97.9	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	102	102	0.00	0.00
Utility cost	Electricity utility cost	[\$/yr]	12,802	12,790	13.0	0.10
	Natural gas utility cost	[\$/yr]	13,173	13,173	0	0
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	4,895	4,895	-0.00	-0.00
	Total utility cost	[\$/yr]	30,871	30,858	13.0	0.04
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	1,500	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	1,500	—	—
	Life cycle cost	[\$]	729,038	730,256	—	—
	Net present value	[\$]	0	-1,218	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	379,843	—	—
	Simple payback period	[yr]	—	>20	—	—

5.8 Install a mini split system in the lunchroom

Measure description

Existing condition

The lunch rooms and office spaces are heated with electric baseboard or cabinet heaters, and cooled with window air conditioners.



Opportunity

Replace the electric heater and unitary AC with a mini split.

Utility-savings mechanism

Reduced energy use due to improved efficiency of heating and cooling.

Design description

Overview

Replace the window AC units and resistance heating elements with a ductless multi-head mini-split. The unit shall be similar to a Moovair 3T multi-head unit connected to 3 wall mounted indoor units. The indoor units shall be located to serve the offices and lunch room.

Electrical

The ASHP will add approximately 5 kW of power to the existing system, which will put the system at 35 kW, which is approximately 21% of the full load of the electrical capacity of the building. The current system could support this additional load.

Project cost estimate

Table 30: Project cost estimate (Install a mini split system in the lunchroom)

Category	Line item	Unit	Value
Construction	Supply	[\$]	9,000
	Installation	[\$]	6,000
	Electrical	[\$]	5,000
	General requirements (25%)	[\$]	5,000
Contingency	Subtotal after Construction	[\$]	25,000
	Design Contingency (25%)	[\$]	6,200
	Construction Contingency (10%)	[\$]	2,500
Design, Contractors, PM	Subtotal after Contingency	[\$]	33,700
	Engineering Design and Field Review (10%)	[\$]	3,400
	Contractor Fee (7%)	[\$]	2,400
Total	Total	[\$]	39,500

Utility analysis

Utility analysis methodology

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

- **Baseline.** The lunch room and office are heated electric baseboards, with an efficiency of 100%. They are cooled by unitary air conditioners with a COP of 3.
- **Proposed.** Primary heating and cooling is provided from a mini-split with heating and cooling COPs of 2.8 and 4.1 (14 EER), respectively. Backup heating is provided by electric resistance, with an efficiency of 100%.

Utility analysis results

Table 31: Install a mini split system in the lunchroom analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	129,057	125,307	3,750	2.9
	Natural gas use	[m3/yr]	50,666	49,755	911	1.8
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	129,057	125,307	3,750	2.9
	Natural gas energy	[kWh/yr]	534,868	525,251	9,618	1.8
	Total energy	[kWh/yr]	663,926	650,558	13,368	2.0
GHG emissions	Electricity GHGs	[tCO2e/yr]	3.9	3.8	0.11	2.9
	Natural gas GHGs	[tCO2e/yr]	97.9	96.1	1.8	1.8
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	102	99.9	1.9	1.8
Utility cost	Electricity utility cost	[\$/yr]	12,802	12,430	372	2.9
	Natural gas utility cost	[\$/yr]	13,173	12,936	237	1.8
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	4,895	4,807	88.0	1.8
	Total utility cost	[\$/yr]	30,871	30,174	697	2.3
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	39,500	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	39,500	—	—
	Life cycle cost	[\$]	729,038	761,516	—	—
	Net present value	[\$]	0	-32,478	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	21,081	—	—
	Simple payback period	[yr]	—	>20	—	—

5.9 Interior LED lighting upgrade

Measure description

Existing condition

Some areas of the building currently operate with LED fixtures (e.g, some of the bay lights). 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 New Liskeard Public Works Site 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 A, C, E, G, H, K, and O fixtures should be replaced.

Project cost estimate

Table 32: Project cost estimate (Interior LED lighting upgrade)

Category	Line item	Unit	Value
Materials and labour	Interior LED lighting upgrade	[\$]	14,000
Contingency	Subtotal after Materials and labour	[\$]	14,000
	General Contingency (50%)	[\$]	7,000
Total	Total	[\$]	21,000

Utility analysis

Utility analysis methodology

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

- **Baseline:** The lighting power density for each space is summarized in Table 10.
- **Proposed:** It is assumed that the lpd for each space type is reduced by 20% as parts of the facility have already undergone some conversions to LED. Operation schedules are maintained.

Utility analysis results

Table 33: Interior LED lighting upgrade analysis results summary

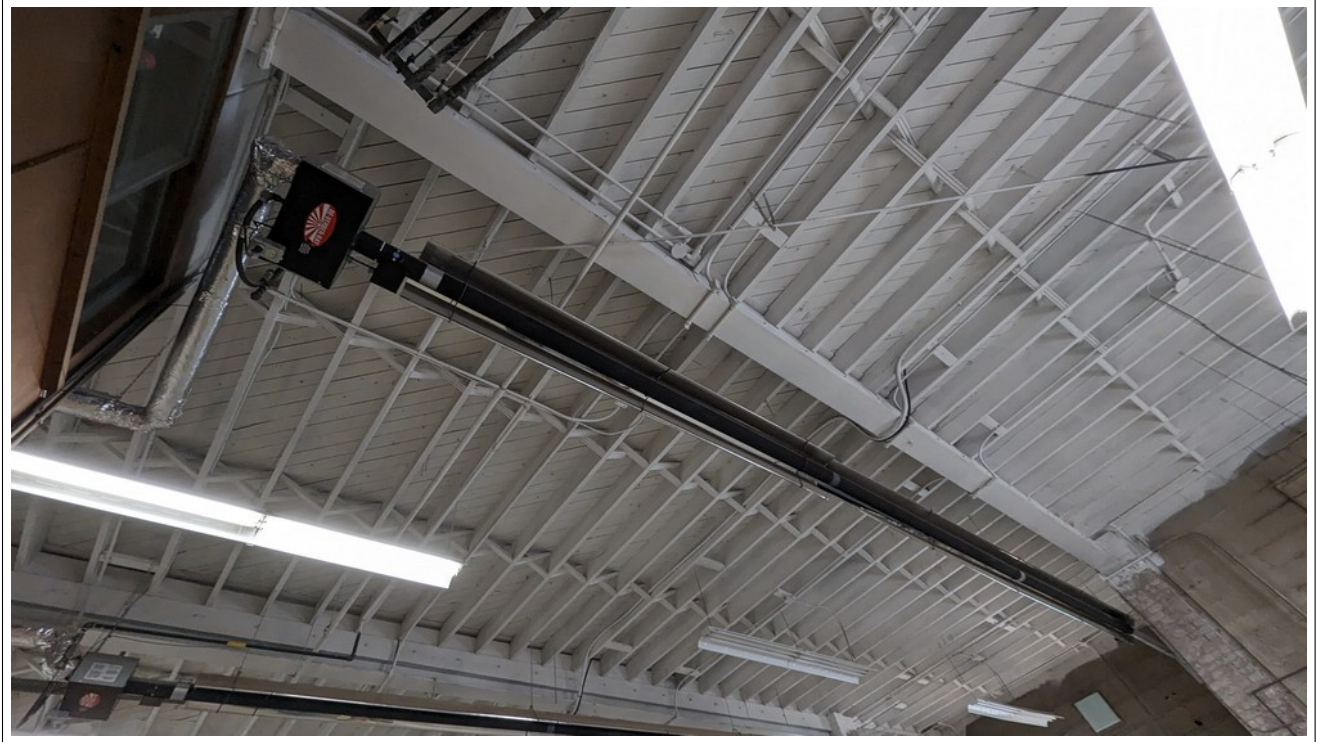
Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	129,057	119,700	9,358	7.3
	Natural gas use	[m3/yr]	50,666	51,056	-390	-0.77
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	129,057	119,700	9,358	7.3
	Natural gas energy	[kWh/yr]	534,868	538,987	-4,119	-0.77
	Total energy	[kWh/yr]	663,926	658,687	5,239	0.79
GHG emissions	Electricity GHGs	[tCO2e/yr]	3.9	3.6	0.28	7.3
	Natural gas GHGs	[tCO2e/yr]	97.9	98.7	-0.75	-0.77
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	102	102	-0.47	-0.46
Utility cost	Electricity utility cost	[\$/yr]	12,802	11,874	928	7.3
	Natural gas utility cost	[\$/yr]	13,173	13,275	-101	-0.77
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	4,895	4,933	-37.7	-0.77
	Total utility cost	[\$/yr]	30,871	30,082	789	2.6
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	21,000	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	21,000	—	—
	Life cycle cost	[\$]	729,038	728,377	—	—
	Net present value	[\$]	0	661	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	-44,553	—	—
	Simple payback period	[yr]	—	>20	—	—

5.10 Radiant heaters to electric

Measure description

Existing condition

The East and West Bays in Building B are heated by the infrared heaters IH01-IH03, which are gas-fired.



Opportunity

Replace the gas-fired heaters with electric resistance equivalents.

Utility-savings mechanism

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

Design description

Overview

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

Electrical

The radiant heaters will add approximately 27 kW of power to the existing system, which will put the system at 57 kW, which is approximately 34% of the full load of the electrical capacity of the building.

Project cost estimate

Table 34: Project cost estimate (Radiant heaters to electric)

Category	Line item	Unit	Value
Construction	Supply and install	[\$]	18,000
	Electrical	[\$]	42,000
	General requirements (25%)	[\$]	15,000
Contingency	Subtotal after Construction	[\$]	75,000
	Design Contingency (25%)	[\$]	18,800
	Construction Contingency (10%)	[\$]	7,500
Design, Contractors, PM	Subtotal after Contingency	[\$]	101,300
	Engineering Design and Field Review (10%)	[\$]	10,100
	Contractor Fee (7%)	[\$]	7,100
Total	Total	[\$]	118,500

Utility analysis

Utility analysis methodology

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

- **Baseline.** Radiant heaters are gas-fired and operate at an efficiency of 60%.
- **Proposed.** Radiant heaters are electric resistance and operate at an efficiency of 100%.

Utility analysis results

Table 35: Radiant heaters to electric analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	129,057	194,666	-65,609	-50.8
	Natural gas use	[m3/yr]	50,666	39,318	11,348	22.4
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	129,057	194,666	-65,609	-50.8
	Natural gas energy	[kWh/yr]	534,868	415,067	119,802	22.4
	Total energy	[kWh/yr]	663,926	609,733	54,193	8.2
GHG emissions	Electricity GHGs	[tCO2e/yr]	3.9	5.9	-2.0	-50.8
	Natural gas GHGs	[tCO2e/yr]	97.9	76.0	21.9	22.4
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	102	81.9	19.9	19.6
Utility cost	Electricity utility cost	[\$/yr]	12,802	19,311	-6,508	-50.8
	Natural gas utility cost	[\$/yr]	13,173	10,223	2,951	22.4
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	4,895	3,799	1,096	22.4
	Total utility cost	[\$/yr]	30,871	33,332	-2,461	-8.0
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	118,500	—	—
	Incentive amount	[\$]	0	23,700	—	—
	Incremental project cost	[\$]	0	94,800	—	—
	Life cycle cost	[\$]	729,038	962,002	—	—
	Net present value	[\$]	0	-232,963	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	4,752	—	—
	Simple payback period	[yr]	—	—	—	—

5.11 Roof upgrade to high performance

Measure description

Existing condition

Building A and C: the exterior layer of the roof is a modified bitumen membrane, which was replaced in 2014. It's assumed that no additional insulation was added at this time. The overall roof assembly for Buildings A and C is assumed to have a U-Value of 0.2581 W/m²K. Building B: the exterior layer of the roof is a white roof membrane. The overall roof assembly for Building B is assumed to have a U-Value of 0.2839 W/m²K.

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

Building A

The existing roof(s) have a thermal performance of around R22-23. We recommend that the membrane be replaced at the end of its life, and that 50-100mm of additional insulation be added to what is existing, with a new PVC, EPDM or TPO membrane as the exterior finish.

Buildings B and C

The replacement roof on Garage B has a thermal performance of around R20. The thermal performance of the roof on Garage C is unknown. We recommend that the roof membranes be replaced at the end of their life, and that 75 - 120mm of additional insulation (a minimum of 150-200mm total) be added to what is existing, with a new PVC or EPDM membrane as the exterior finish. As noted above for the walls, this would require the rebuilding of the parapets and new parapet flashing.

Project cost estimate

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

Category	Line item	Unit	Value
Construction	Roof replacement	[\$]	563,000
	General requirements (25%)	[\$]	140,800
Contingency	Subtotal after Construction	[\$]	703,800
	Design Contingency (25%)	[\$]	176,000
	Construction Contingency (10%)	[\$]	70,400
Design, Contractors, PM	Subtotal after Contingency	[\$]	950,200
	Engineering Design and Field Review (10%)	[\$]	95,000
	Contractor Fee (7%)	[\$]	66,500
Total	Total	[\$]	1,111,700

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 0.05 BTU/hr.ft².F (R20) was assumed.
- **Proposed.** An average roof U-value of 0.025 BTU/hr.ft².F (R40) was assumed.

Utility analysis results

Table 37: Roof upgrade to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	129,057	128,423	634	0.49
	Natural gas use	[m3/yr]	50,666	48,520	2,147	4.2
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	129,057	128,423	634	0.49
	Natural gas energy	[kWh/yr]	534,868	512,207	22,661	4.2
	Total energy	[kWh/yr]	663,926	640,630	23,295	3.5
GHG emissions	Electricity GHGs	[tCO2e/yr]	3.9	3.9	0.02	0.49
	Natural gas GHGs	[tCO2e/yr]	97.9	93.8	4.1	4.2
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	102	97.6	4.2	4.1
Utility cost	Electricity utility cost	[\$/yr]	12,802	12,740	62.9	0.49
	Natural gas utility cost	[\$/yr]	13,173	12,615	558	4.2
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	4,895	4,688	207	4.2
	Total utility cost	[\$/yr]	30,871	30,043	828	2.7
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	1,111,700	—	—
	Incentive amount	[\$]	0	222,340	—	—
	Incremental project cost	[\$]	0	889,360	—	—
	Life cycle cost	[\$]	729,038	1,656,557	—	—
	Net present value	[\$]	0	-927,519	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	213,420	—	—
	Simple payback period	[yr]	—	>20	—	—

5.12 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) = 110 kW.

Proposed scope

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

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

Electrical

With the existing system, the panel is not rated high enough to accommodate the additional 110 kW of the solar. The panel will need to be rated at least 400A to accommodate the solar.

Project cost estimate

Table 38: Project cost estimate (Solar PV rooftop)

Category	Line item	Unit	Value
Materials and labour	Solar PV electricity system installed (assuming 110 kW at 2000 \$/kW)	[\$]	220,000
	Electrical	[\$]	30,000
Contingency	Subtotal after Materials and labour	[\$]	250,000
	General Contingency (20%)	[\$]	50,000
	Design Contingency (10%)	[\$]	25,000
Total	Total	[\$]	325,000

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 39: Solar PV rooftop analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	129,057	12,338	116,719	90.4
	Natural gas use	[m3/yr]	50,666	50,666	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	129,057	12,338	116,719	90.4
	Natural gas energy	[kWh/yr]	534,868	534,868	0	0
	Total energy	[kWh/yr]	663,926	547,206	116,719	17.6
GHG emissions	Electricity GHGs	[tCO2e/yr]	3.9	0.37	3.5	90.4
	Natural gas GHGs	[tCO2e/yr]	97.9	97.9	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	102	98.3	3.5	3.5
Utility cost	Electricity utility cost	[\$/yr]	12,802	1,224	11,579	90.4
	Natural gas utility cost	[\$/yr]	13,173	13,173	0	0
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	4,895	4,895	0	0
	Total utility cost	[\$/yr]	30,871	19,292	11,579	37.5
Financial	Assumed life	[yrs]	15	30	—	—
	Project cost	[\$]	0	325,000	—	—
	Incentive amount	[\$]	0	65,000	—	—
	Incremental project cost	[\$]	0	260,000	—	—
	Life cycle cost	[\$]	729,038	635,470	—	—
	Net present value	[\$]	0	93,568	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	73,760	—	—
	Simple payback period	[yr]	—	>20	—	—

5.13 Unit heaters conversion

Measure description

Existing condition

Unit heaters provide a large portion of the facility's heating, particularly in the bays and shop space for Buildings A and C. Most of the unit heaters are gas-fired.



Opportunity

Replace the natural gas unit heaters with electric resistance unit heaters.

Utility-savings mechanism

The primary intent of this measure is to reduce GHG emissions by converting the fuel used for heating from natural gas to electricity 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 nine (9) natural gas unit heaters with electric resistance unit heaters serving the main garage, and environmental buildings garage and storage spaces.

The new units shall be Reznor EUH 20kW units. The larger units shall be replaced with multiple smaller units such that three 20kW units will replace a single 240kBTU existing unit. In aggregate a total of 19 units will be installed across the three buildings.

Electrical

The unit heaters will add approximately 380 kW of power to the existing system which will put the system at 410 kW, which is approximately 246% of the full load of the electrical capacity of the building. The system would

need at least a 300kVA transformer upstream and a new 400A 600V 3P switchboard. The existing switchboard can be powered from the new. The current system could accommodate up to 5 heaters without a service upgrade.

Project cost estimate

Table 40: Project cost estimate (Unit heaters conversion)

Category	Line item	Unit	Value
Construction	Unit heater supply	[\$]	47,500
	Installation of unit heaters	[\$]	47,500
	Electrical	[\$]	247,000
	General requirements (25%)	[\$]	85,500
Contingency	Subtotal after Construction	[\$]	427,500
	Design Contingency (25%)	[\$]	106,900
	Construction Contingency (10%)	[\$]	42,800
Design, Contractors, PM	Subtotal after Contingency	[\$]	577,200
	Engineering Design and Field Review (10%)	[\$]	57,700
	Contractor Fee (7%)	[\$]	40,400
Total	Total	[\$]	675,300

Utility analysis

Utility analysis methodology

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

- **Baseline.** Most unit heaters are gas-fired unit heaters with average burner thermal efficiencies specified in Table 8.
- **Proposed.** All unit heaters are electric unit heaters, with an efficiency of 100%.

Utility analysis results

Table 41: Unit heaters conversion analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	129,057	424,035	-294,978	-229
	Natural gas use	[m3/yr]	50,666	13,088	37,578	74.2
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	129,057	424,035	-294,978	-229
	Natural gas energy	[kWh/yr]	534,868	138,168	396,700	74.2
	Total energy	[kWh/yr]	663,926	562,203	101,722	15.3
GHG emissions	Electricity GHGs	[tCO2e/yr]	3.9	12.8	-8.9	-229
	Natural gas GHGs	[tCO2e/yr]	97.9	25.3	72.6	74.2
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	102	38.1	63.7	62.6
Utility cost	Electricity utility cost	[\$/yr]	12,802	42,064	-29,262	-229
	Natural gas utility cost	[\$/yr]	13,173	3,403	9,770	74.2
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	4,895	1,265	3,631	74.2
	Total utility cost	[\$/yr]	30,871	46,732	-15,861	-51.4
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	675,300	—	—
	Incentive amount	[\$]	0	135,060	—	—
	Incremental project cost	[\$]	0	540,240	—	—
	Life cycle cost	[\$]	729,038	1,982,092	—	—
	Net present value	[\$]	0	-1,253,054	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	8,480	—	—
	Simple payback period	[yr]	—	—	—	—

5.14 Wall upgrade to high performance

Measure description

Existing condition

The exterior walls appear to consist of metal siding on 2x4 strapping, on 190mm of concrete block or clay block.



Opportunity

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

Utility-savings mechanism

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

Design description

Building A

The existing garage walls appear to be made of metal siding on 2x4 strapping over 190mm concrete block. The locker room includes 2x4 wood studs, one layer of batt insulation, and a vapor barrier. In the vestibule, there are 2x4 studs, plywood sheathing, and 0.5-inch gypsum board.

All windows seem to be framed in wood, suggesting that the existing walls may comprise both wood studs and steel support columns. The thermal performance of the walls is around R8, which falls short of the current building code requirement of R20. The girts that hold the metal siding are not thermally broken, further diminishing the thermal efficiency of the insulation layers they penetrate.

To improve the thermal performance, we recommend one of two options:

- Remove the siding, cut back the girts, and install additional insulation with an EIFS finish, fastening it to the concrete block through the existing insulation. This would also involve installing thermally broken girts and a new air barrier over the block.

- Remove the siding, girts, and insulation entirely, then apply sheathing with a new air barrier. This option would involve adding thermally broken girts and semi-rigid batt insulation, topped with new metal siding as the exterior finish.

Both options will necessitate rebuilding the parapets and replacing the parapet flashing.

Buildings B and C

The main walls of the building appear to be constructed with metal siding mounted on 2x4 strapping over 190mm concrete or clay block. Inside the office areas, there are wood studs, batt insulation, and a vapor barrier.

Currently, the walls provide a thermal performance rating of approximately R8, which is significantly below the requirement set by the current building code of R20.

We recommend removing the existing siding and girts, applying new sheathing with an updated air barrier, and installing thermally broken girts with semi-rigid batt insulation. The exterior finish should consist of new metal siding. Additionally, this project will necessitate the reconstruction of the parapets and their associated flashing.

Project cost estimate

Table 42: Project cost estimate (Wall upgrade to high performance)

Category	Line item	Unit	Value
Construction	Wall upgrade	[\$]	1,287,000
	General requirements (25%)	[\$]	321,800
Contingency	Subtotal after Construction	[\$]	1,608,800
	Design Contingency (25%)	[\$]	402,200
	Construction Contingency (10%)	[\$]	160,900
Design, Contractors, PM	Subtotal after Contingency	[\$]	2,171,900
	Engineering Design and Field Review (10%)	[\$]	217,200
	Contractor Fee (7%)	[\$]	152,000
Total	Total	[\$]	2,541,100

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 0.1 BTU/hr.ft².F (R10) was assumed.
- **Proposed.** An average wall U-value of 0.0345 BTU/hr.ft².F (R29) was assumed. Infiltration flow was assumed to be reduced by 10% in total relative to the Baseline for affected spaces.

Utility analysis results

Table 43: Wall upgrade to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	129,057	127,489	1,568	1.2
	Natural gas use	[m3/yr]	50,666	46,428	4,238	8.4
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	129,057	127,489	1,568	1.2
	Natural gas energy	[kWh/yr]	534,868	490,132	44,736	8.4
	Total energy	[kWh/yr]	663,926	617,621	46,304	7.0
GHG emissions	Electricity GHGs	[tCO2e/yr]	3.9	3.9	0.05	1.2
	Natural gas GHGs	[tCO2e/yr]	97.9	89.7	8.2	8.4
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	102	93.6	8.2	8.1
Utility cost	Electricity utility cost	[\$/yr]	12,802	12,647	156	1.2
	Natural gas utility cost	[\$/yr]	13,173	12,071	1,102	8.4
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	4,895	4,486	409	8.4
	Total utility cost	[\$/yr]	30,871	29,204	1,667	5.4
Financial	Assumed life	[yrs]	15	75	—	—
	Project cost	[\$]	0	2,541,100	—	—
	Incentive amount	[\$]	0	508,220	—	—
	Incremental project cost	[\$]	0	2,032,880	—	—
	Life cycle cost	[\$]	729,038	1,362,728	—	—
	Net present value	[\$]	0	-633,690	—	—
	Project cost per GHG reduction	[\$yr/tCO2e]	—	246,826	—	—
	Simple payback period	[yr]	—	>20	—	—

5.15 Windows and doors to high performance

Measure description

Existing condition

Buildings A and B have aluminum-framed, double-pane picture windows. Building C appears to have wood-framed, single pane windows. The facility has hollow metal doors and overhead doors. Numerous entrance doors were observed to be propped open or have poor weather stripping.



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.
- **Overhead Doors:** Replace the existing overhead doors with high-performance sectional insulated roll-up doors that use systems with polyurethane cores and a full perimeter seal.

Project cost estimate

Table 44: Project cost estimate (Windows and doors to high performance)

Category	Line item	Unit	Value
Construction	Window and door replacement	[\$]	331,000
	General requirements (25%)	[\$]	82,800
Contingency	Subtotal after Construction	[\$]	413,800
	Design Contingency (25%)	[\$]	103,400
	Construction Contingency (10%)	[\$]	41,400
Design, Contractors, PM	Subtotal after Contingency	[\$]	558,600
	Engineering Design and Field Review (10%)	[\$]	55,900
	Contractor Fee (7%)	[\$]	39,100
Total	Total	[\$]	653,600

Utility analysis

Utility analysis methodology

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

- **Baseline.** The average U-value of all windows and doors was assumed to be 0.667 and 0.881 BTU/hr.ft².F, respectively.
- **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 45: Windows and doors to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	129,057	127,668	1,390	1.1
	Natural gas use	[m3/yr]	50,666	43,136	7,530	14.9
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	129,057	127,668	1,390	1.1
	Natural gas energy	[kWh/yr]	534,868	455,372	79,496	14.9
	Total energy	[kWh/yr]	663,926	583,040	80,886	12.2
GHG emissions	Electricity GHGs	[tCO2e/yr]	3.9	3.9	0.04	1.1
	Natural gas GHGs	[tCO2e/yr]	97.9	83.4	14.6	14.9
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	102	87.2	14.6	14.3
Utility cost	Electricity utility cost	[\$/yr]	12,802	12,665	138	1.1
	Natural gas utility cost	[\$/yr]	13,173	11,215	1,958	14.9
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	4,895	4,168	728	14.9
	Total utility cost	[\$/yr]	30,871	28,048	2,823	9.1
Financial	Assumed life	[yrs]	15	40	—	—
	Project cost	[\$]	0	653,600	—	—
	Incentive amount	[\$]	0	130,720	—	—
	Incremental project cost	[\$]	0	522,880	—	—
	Life cycle cost	[\$]	729,038	1,006,468	—	—
	Net present value	[\$]	0	-277,430	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	35,830	—	—
	Simple payback period	[yr]	—	>20	—	—

5.16 Measure risk analysis

Utility use sensitivity

Figure 180 indicates how sensitive cumulative electricity and natural gas use are to variations in each risk parameter.

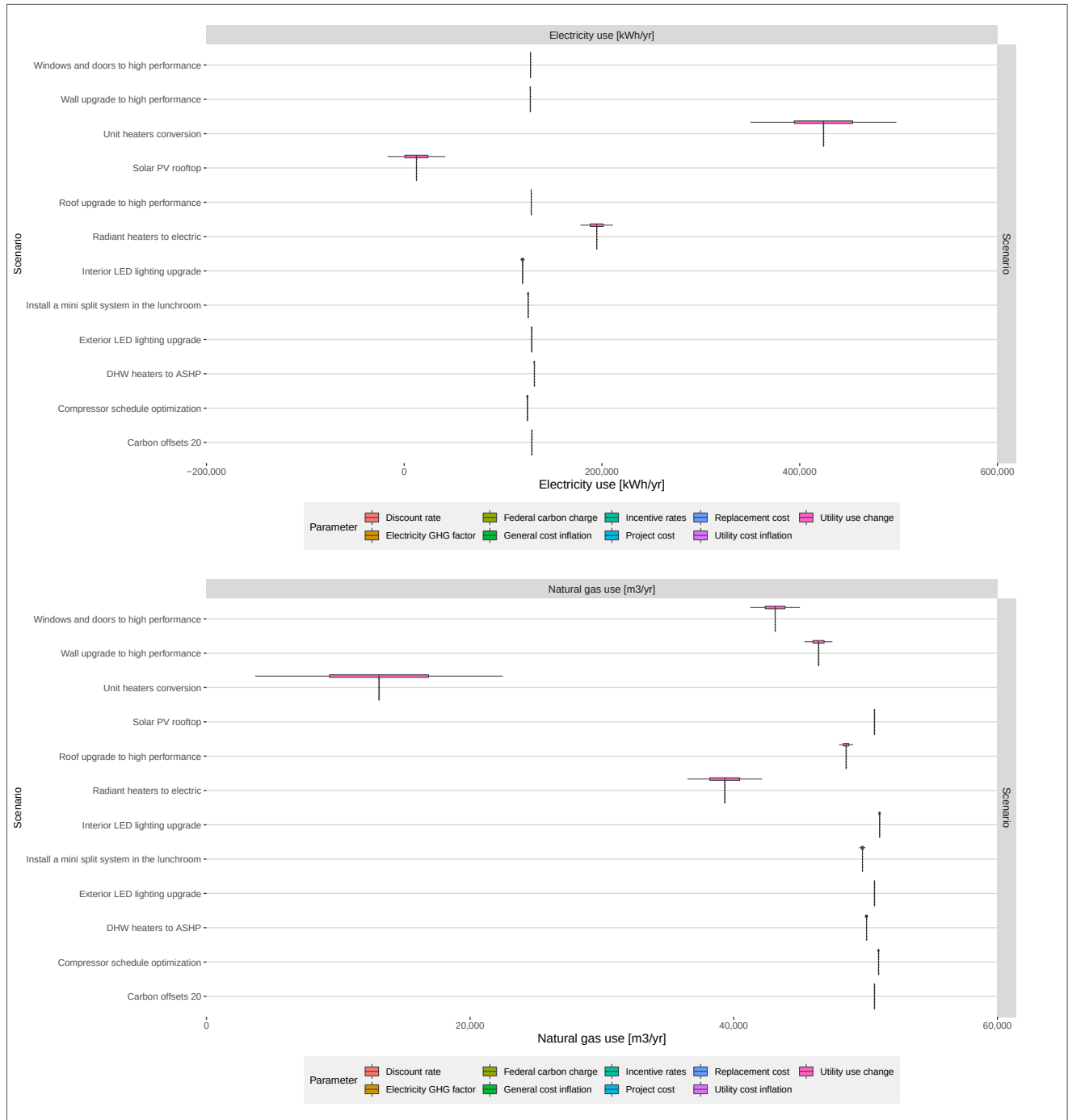


Figure 180: Utility cumulative use sensitivity analysis

GHG emissions and life cycle cost sensitivity

Figure 181 indicates how sensitive cumulative GHG emissions and life cycle costs are to variations in each risk parameter.

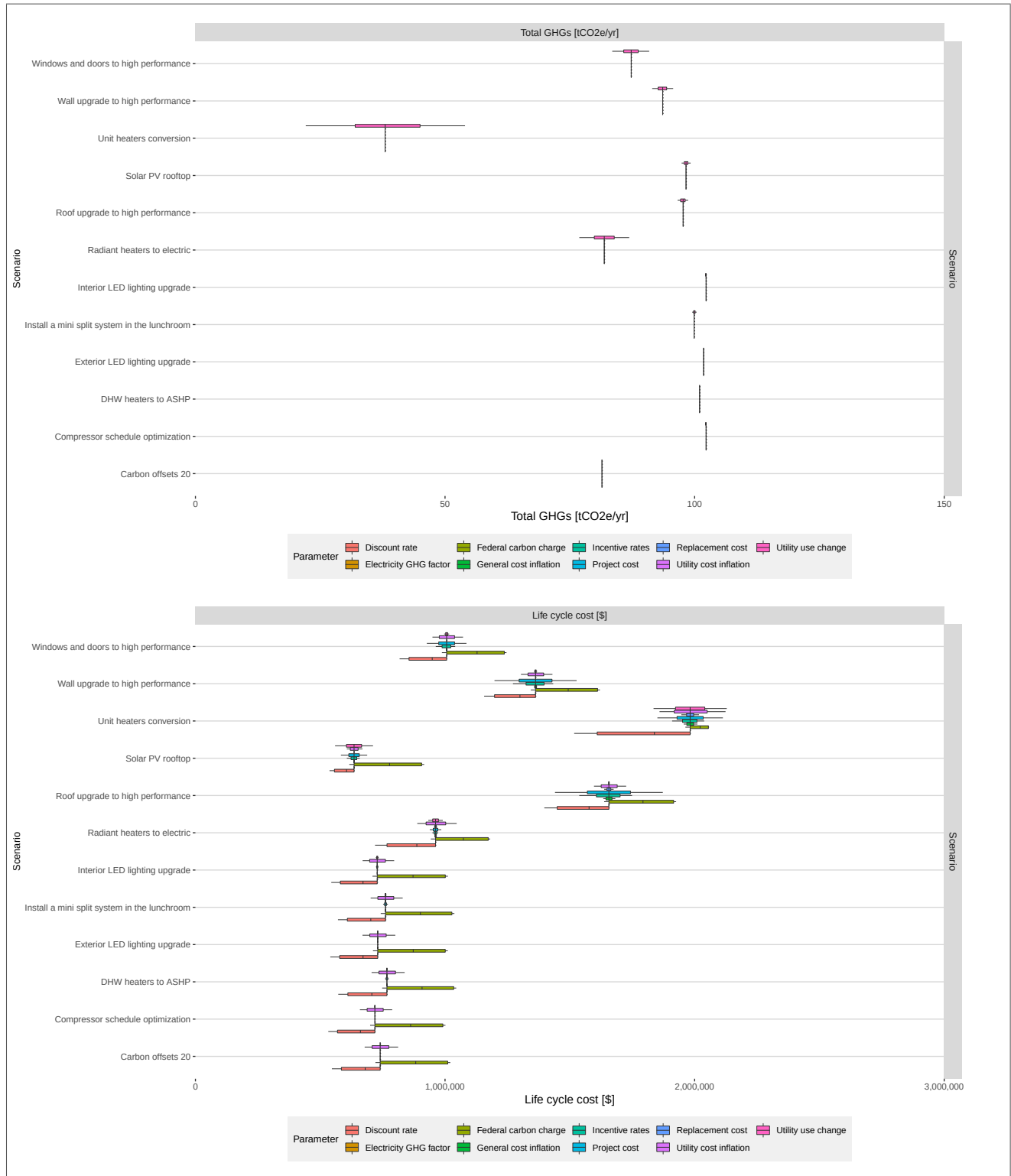


Figure 181: GHG cumulative emissions and life cycle cost sensitivity analysis

5.17 Measure analysis summary

For each analyzed measure, the analysis results are summarized in Table 46.

Table 46: 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]	[\$]	[\$]	[\$]	[\$]	[\$]	[\$/tCO2e]	[yr]
Baseline	129,057	100.0	50,666	100.0	663,926	100.0	102	100.0	30,871	100.0	15	0	0	0	729,038	0	-	-
Carbon offsets 20	0	0.0	0	0.0	0	0.0	20	20.0	-611	-2.0	20	-	0	-	740,177	-11,139	-	-
Compressor schedule optimization	4,448	3.4	-311	-0.6	1,164	0.2	-0	-0.5	330	1.1	15	0	0	0	718,955	10,083	-0	0
DHW heaters to ASHP	-2,537	-2.0	603	1.2	3,829	0.6	1	1.1	-37	-0.1	15	29,300	151	29,149	767,190	-38,152	26,775	-796
Exterior LED lighting upgrade	131	0.1	0	0.0	131	0.0	0	0.0	13	0.0	20	1,500	0	1,500	730,256	-1,218	379,843	116
Install a mini split system in the lunchroom	3,750	2.9	911	1.8	13,368	2.0	2	1.8	697	2.3	15	39,500	0	39,500	761,516	-32,478	21,081	57
Interior LED lighting upgrade	9,358	7.3	-390	-0.8	5,239	0.8	-0	-0.5	789	2.6	20	21,000	0	21,000	728,377	661	-44,553	27
Radiant heaters to electric	-65,609	-50.8	11,348	22.4	54,193	8.2	20	19.6	-2,461	-8.0	15	118,500	23,700	94,800	962,001	-232,963	4,752	-39
Roof upgrade to high performance	634	0.5	2,147	4.2	23,295	3.5	4	4.1	828	2.7	20	1,111,700	222,340	889,360	1,656,557	-927,519	213,420	1,074
Solar PV rooftop	116,719	90.4	0	0.0	116,719	17.6	4	3.5	11,579	37.5	30	325,000	65,000	260,000	635,470	93,568	73,760	22
Unit heaters conversion	-294,978	-228.6	37,578	74.2	101,722	15.3	64	62.6	-15,861	-51.4	15	675,300	135,060	540,240	1,982,092	-1,253,054	8,480	-34
Wall upgrade to high performance	1,568	1.2	4,238	8.4	46,304	7.0	8	8.1	1,667	5.4	75	2,541,100	508,220	2,032,880	1,362,728	-633,690	246,826	1,220
Windows and doors to high performance	1,390	1.1	7,530	14.9	80,886	12.2	15	14.3	2,823	9.1	40	653,600	130,720	522,880	1,006,468	-277,430	35,830	185
Total project cost	-	-	-	-	-	-	-	-	-	-	-	5,516,500	-	-	-	-	-	-
DHW renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	4,000	0	4,000	733,762	-4,724	-	-
Exterior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	1,000	0	1,000	730,078	-1,039	-	-
Exterior walls renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	75	11,000	0	11,000	732,600	-3,562	-	-
Infrared renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	16,000	0	16,000	746,375	-17,336	-	-
Interior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	27,000	0	27,000	757,103	-28,065	-	-
Roof renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	565,000	0	565,000	1,316,318	-587,280	-	-
Unit heaters renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	88,000	0	88,000	824,389	-95,350	-	-
Windows and doors renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	243,000	0	243,000	876,574	-147,536	-	-
BAU measure totals	-	-	-	-	-	-	-	-	-	-	-	955,000	-	-	-	-	-	-

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 47.
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 47.

Table 47: 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 182 and Table 48 present the results of this exercise, indicating which measures were assigned to which scenario.

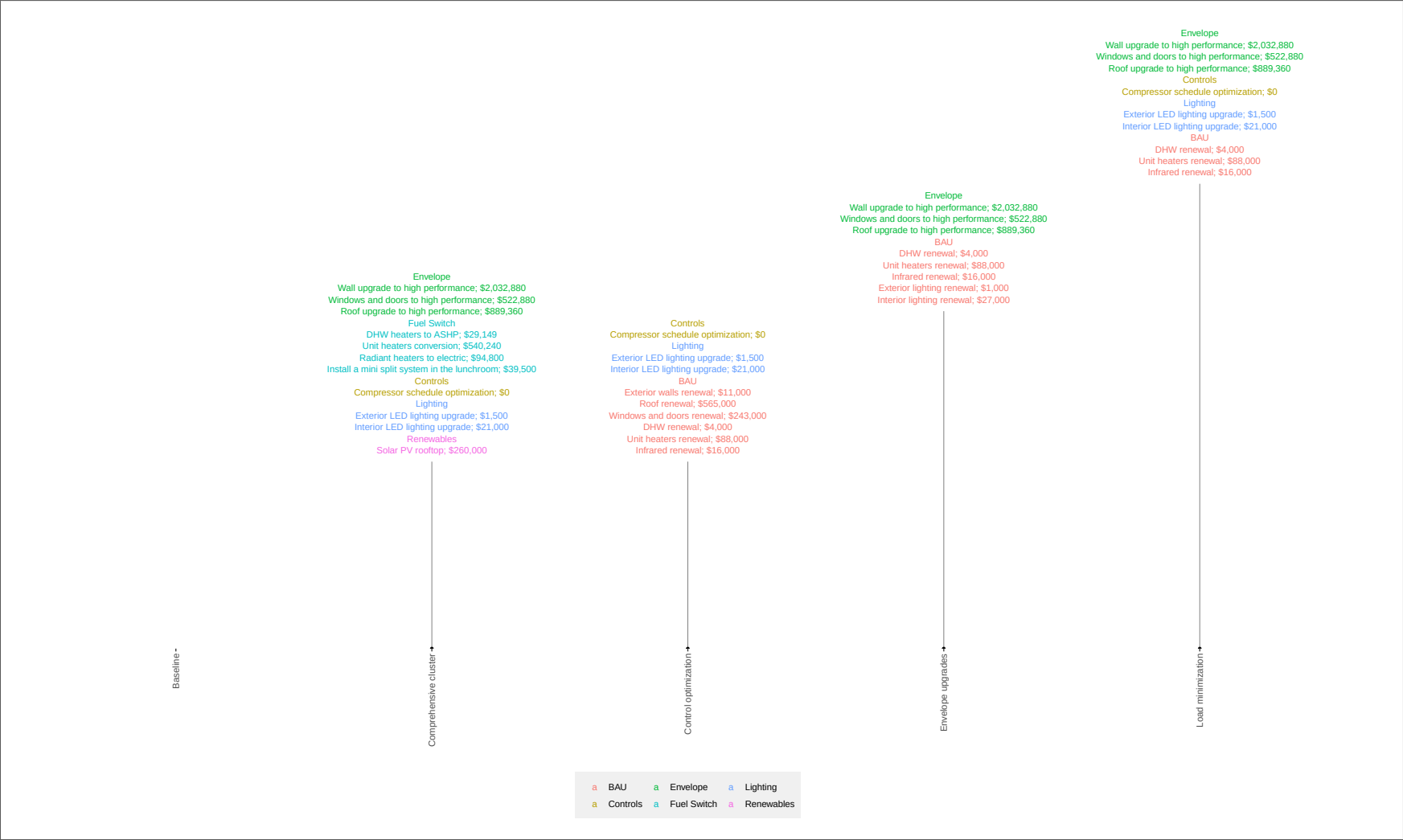


Figure 182: Scenario composition

Table 48: Cluster composition

Measure	Control optimization	Envelope upgrades	Load minimization	Comprehensive cluster
Carbon offsets 20	✗	✗	✗	✗
Compressor schedule optimization	✓	✗	✓	✓
DHW heaters to ASHP	✗	✗	✗	✓
Exterior LED lighting upgrade	✓	✗	✓	✓
Install a mini split system in the lunchroom	✗	✗	✗	✓
Interior LED lighting upgrade	✓	✗	✓	✓
Radiant heaters to electric	✗	✗	✗	✓
Roof upgrade to high performance	✗	✓	✓	✓
Solar PV rooftop	✗	✗	✗	✓
Unit heaters conversion	✗	✗	✗	✓
Wall upgrade to high performance	✗	✓	✓	✓
Windows and doors to high performance	✗	✓	✓	✓
DHW renewal	✓	✓	✓	✗
Exterior lighting renewal	✗	✓	✗	✗
Exterior walls renewal	✓	✗	✗	✗
Infrared renewal	✓	✓	✓	✗
Interior lighting renewal	✗	✓	✗	✗
Roof renewal	✓	✗	✗	✗
Unit heaters 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 49, 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 49: 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]	[\$]	[\$]	[\$]	[\$]	[\$]	[\$/tCO2e]	[yr]
Comprehensive cluster	Combined	-125,078	-96.9	50,666	100.0	409,791	61.7	94	92.5	5,661	18.3	-	5,516,500	1,085,191	4,431,309	3,654,191	-2,925,153	47,078	783
Comprehensive cluster	Wall upgrade to high performance	1,568	1.2	4,238	8.4	46,304	7.0	8	8.1	1,667	5.4	75	2,541,100	508,220	2,032,880	1,362,728	-633,690	246,826	1,220
Comprehensive cluster	Windows and doors to high performance	1,390	1.1	7,530	14.9	80,886	12.2	15	14.3	2,823	9.1	40	653,600	130,720	522,880	1,006,468	-277,430	35,830	185
Comprehensive cluster	Roof upgrade to high performance	634	0.5	2,147	4.2	23,295	3.5	4	4.1	828	2.7	20	1,111,700	222,340	889,360	1,656,557	-927,519	213,420	1,074
Comprehensive cluster	DHW heaters to ASHP	-2,537	-2.0	603	1.2	3,829	0.6	1	1.1	-37	-0.1	15	29,300	151	29,149	767,190	-38,152	26,775	-796
Comprehensive cluster	Unit heaters conversion	-294,978	-228.6	37,578	74.2	101,722	15.3	64	62.6	-15,861	-51.4	15	675,300	135,060	540,240	1,982,092	-1,253,054	8,480	-34
Comprehensive cluster	Radiant heaters to electric	-65,609	-50.8	11,348	22.4	54,193	8.2	20	19.6	-2,461	-8.0	15	118,500	23,700	94,800	962,001	-232,963	4,752	-39
Comprehensive cluster	Compressor schedule optimization	4,448	3.4	-311	-0.6	1,164	0.2	-0	-0.5	330	1.1	15	0	0	0	718,955	10,083	-0	0
Comprehensive cluster	Exterior LED lighting upgrade	131	0.1	0	0.0	131	0.0	0	0.0	13	0.0	20	1,500	0	1,500	730,256	-1,218	379,843	116
Comprehensive cluster	Interior LED lighting upgrade	9,358	7.3	-390	-0.8	5,239	0.8	-0	-0.5	789	2.6	20	21,000	0	21,000	728,377	661	-44,553	27
Comprehensive cluster	Solar PV rooftop	116,719	90.4	0	0.0	116,719	17.6	4	3.5	11,579	37.5	30	325,000	65,000	260,000	635,470	93,568	73,760	22
Comprehensive cluster	Install a mini split system in the lunchroom	3,750	2.9	911	1.8	13,368	2.0	2	1.8	697	2.3	15	39,500	0	39,500	761,516	-32,478	21,081	57
Control optimization	Combined	13,934	10.8	-703	-1.4	6,512	1.0	-1	-0.9	1,132	3.7	-	949,500	0	949,500	1,536,688	-807,650	-1,012,633	839
Control optimization	Compressor schedule optimization	4,448	3.4	-311	-0.6	1,164	0.2	-0	-0.5	330	1.1	15	0	0	0	718,955	10,083	-0	0
Control optimization	Exterior LED lighting upgrade	131	0.1	0	0.0	131	0.0	0	0.0	13	0.0	20	1,500	0	1,500	730,256	-1,218	379,843	116
Control optimization	Interior LED lighting upgrade	9,358	7.3	-390	-0.8	5,239	0.8	-0	-0.5	789	2.6	20	21,000	0	21,000	728,377	661	-44,553	27
Control optimization	Exterior walls renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	75	11,000	0	11,000	732,600	-3,562	-	-
Control optimization	Roof renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	565,000	0	565,000	1,316,318	-587,280	-	-
Control optimization	Windows and doors renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	243,000	0	243,000	876,574	-147,536	-	-
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	733,762	-4,724	-	-
Control optimization	Unit heaters renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	88,000	0	88,000	824,389	-95,350	-	-
Control optimization	Infrared renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	16,000	0	16,000	746,375	-17,336	-	-
Envelope upgrades	Combined	4,428	3.4	13,877	27.4	150,928	22.7	27	26.5	5,388	17.5	-	4,442,400	861,280	3,581,120	2,602,974	-1,873,936	132,880	665
Envelope upgrades	Wall upgrade to high performance	1,568	1.2	4,238	8.4	46,304	7.0	8	8.1	1,667	5.4	75	2,541,100	508,220	2,032,880	1,362,728	-633,690	246,826	1,220
Envelope upgrades	Windows and doors to high performance	1,390	1.1	7,530	14.9	80,886	12.2	15	14.3	2,823	9.1	40	653,600	130,720	522,880	1,006,468	-277,430	35,830	185
Envelope upgrades	Roof upgrade to high performance	634	0.5	2,147	4.2	23,295	3.5	4	4.1	828	2.7	20	1,111,700	222,340	889,360	1,656,557	-927,519	213,420	1,074
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	733,762	-4,724	-	-
Envelope upgrades	Unit heaters renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	88,000	0	88,000	824,389	-95,350	-	-
Envelope upgrades	Infrared renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	16,000	0	16,000	746,375	-17,336	-	-
Envelope upgrades	Exterior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	1,000	0	1,000	730,078	-1,039	-	-
Envelope upgrades	Interior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	27,000	0	27,000	757,103	-28,065	-	-
Load minimization	Combined	18,325	14.2	13,165	26.0	157,301	23.7	26	25.5	6,513	21.1	-	4,436,900	861,280	3,575,620	2,566,554	-1,837,515	137,565	549
Load minimization	Wall upgrade to high performance	1,568	1.2	4,238	8.4	46,304	7.0	8	8.1	1,667	5.4	75	2,541,100	508,220	2,032,880	1,362,728	-633,690	246,826	1,220
Load minimization	Windows and doors to high performance	1,390	1.1	7,530	14.9	80,886	12.2	15	14.3	2,823	9.1	40	653,600	130,720	522,880	1,006,468	-277,430	35,830	185
Load minimization	Roof upgrade to high performance	634	0.5	2,147	4.2	23,295	3.5	4	4.1	828	2.7	20	1,111,700	222,340	889,360	1,656,557	-927,519	213,420	1,074
Load minimization	Compressor schedule optimization	4,448	3.4	-311	-0.6	1,164	0.2	-0	-0.5	330	1.1	15	0	0	0	718,955	10,083	-0	0
Load minimization	Exterior LED lighting upgrade	131	0.1	0	0.0	131	0.0	0	0.0	13	0.0	20	1,500	0	1,500	730,256	-1,218	379,843	116
Load minimization	Interior LED lighting upgrade	9,358	7.3	-390	-0.8	5,239	0.8	-0	-0.5	789	2.6	20	21,000	0	21,000	728,377	661	-44,553	27
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	733,762	-4,724	-	-
Load minimization	Unit heaters renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	88,000	0	88,000	824,389	-95,350	-	-
Load minimization	Infrared renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	16,000	0	16,000	746,375	-17,336	-	-

Utility use comparison

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

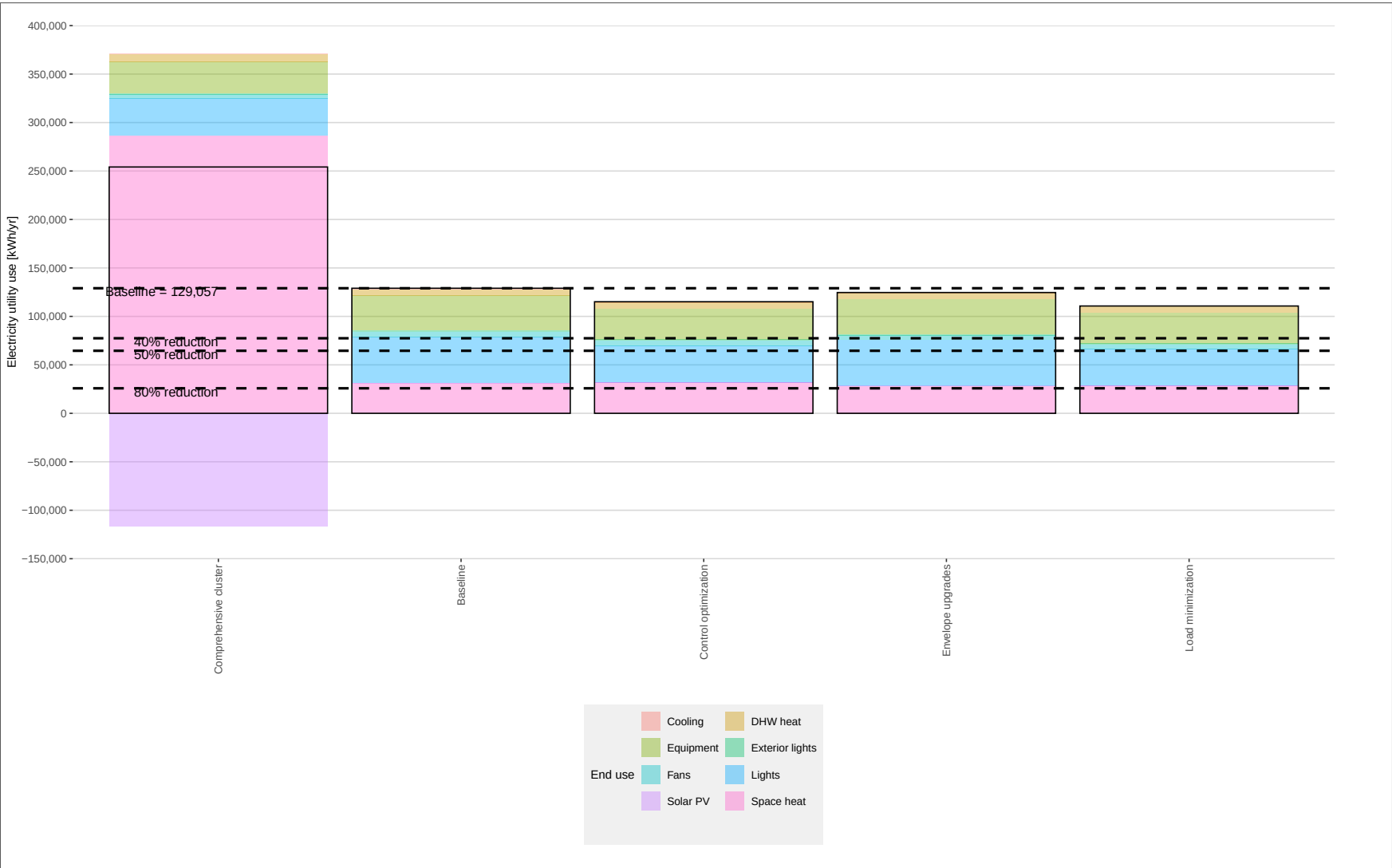


Figure 183: Electricity utility use expected yearly for each scenario by end use

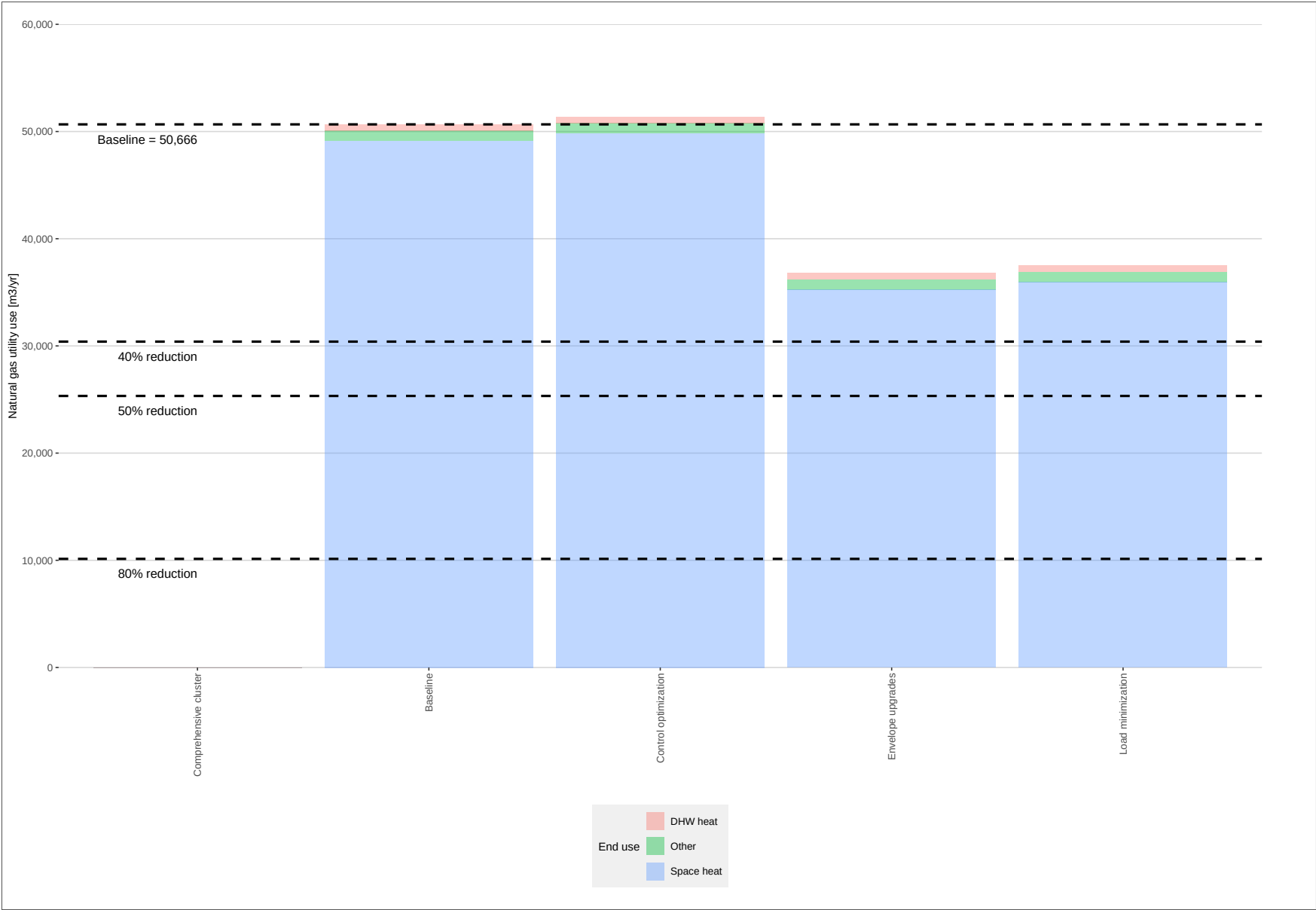


Figure 184: Natural gas utility use expected yearly for each scenario by end use

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.

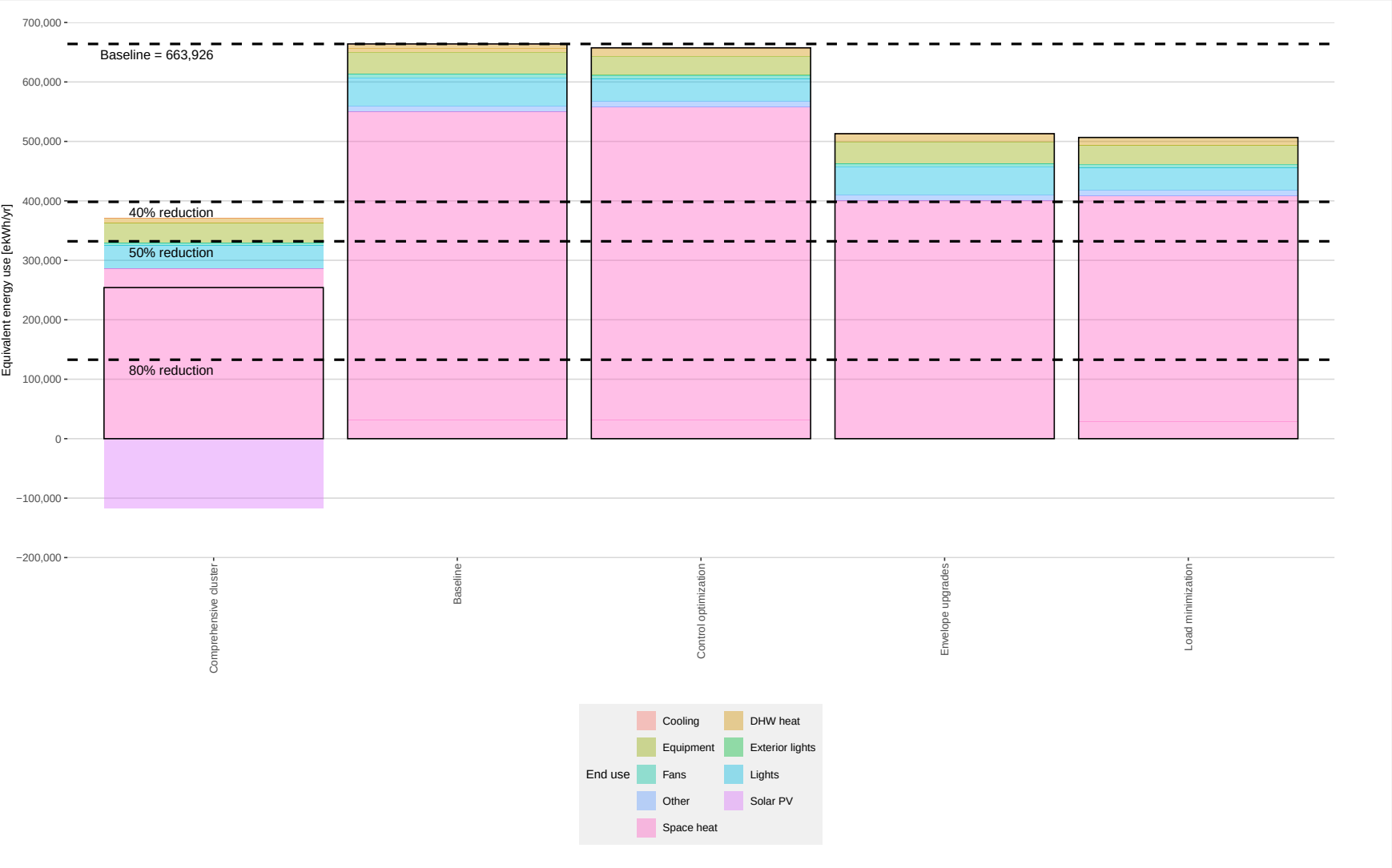


Figure 185: Equivalent energy use expected yearly for each scenario by end use

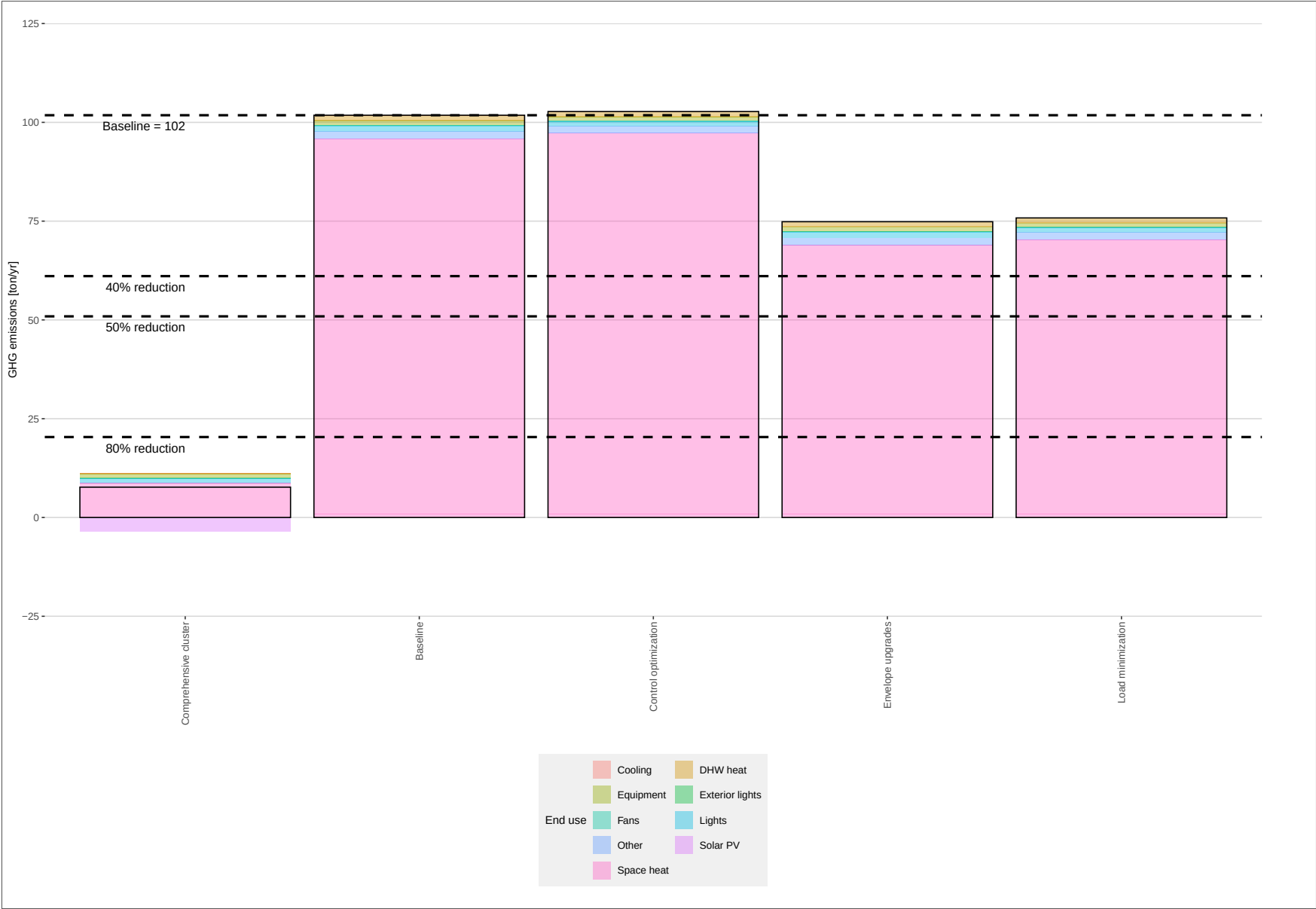


Figure 186: GHG emissions expected yearly for each scenario by end use

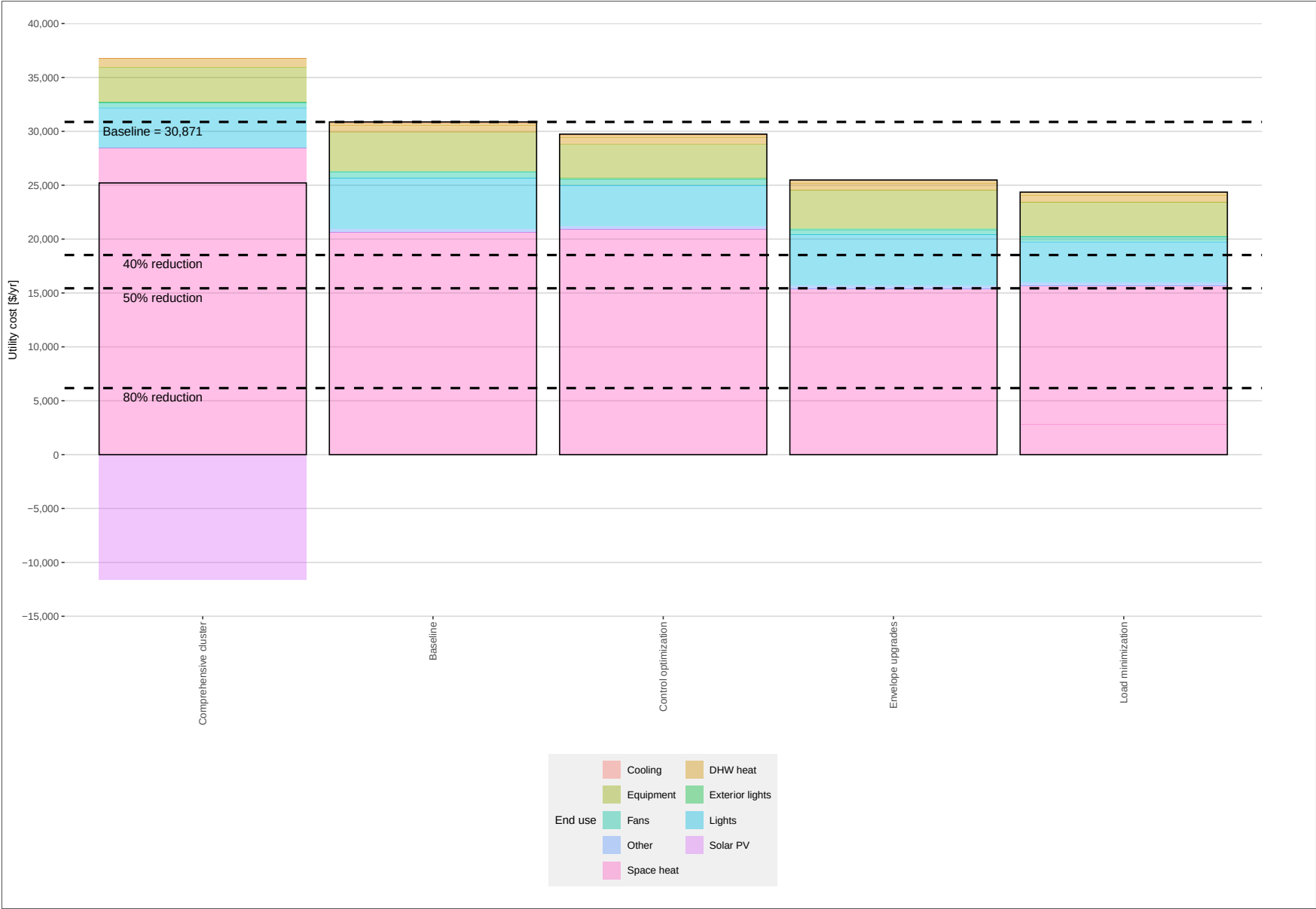


Figure 187: Utility costs expected yearly for each scenario by end use

Financial performance comparison

The following figures compare the financial performance between each scenario.

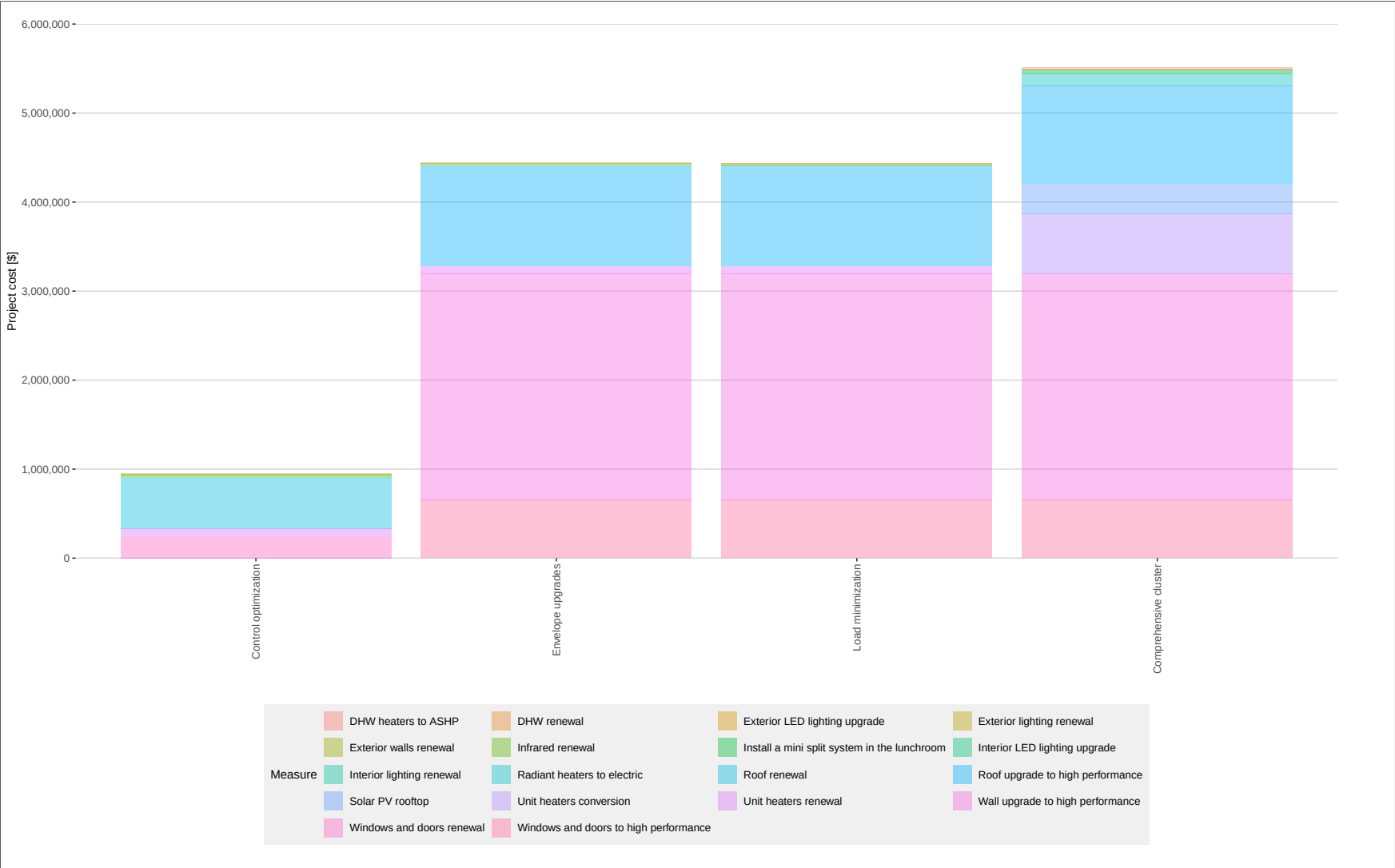


Figure 188: Project cost expected for each scenario by measure

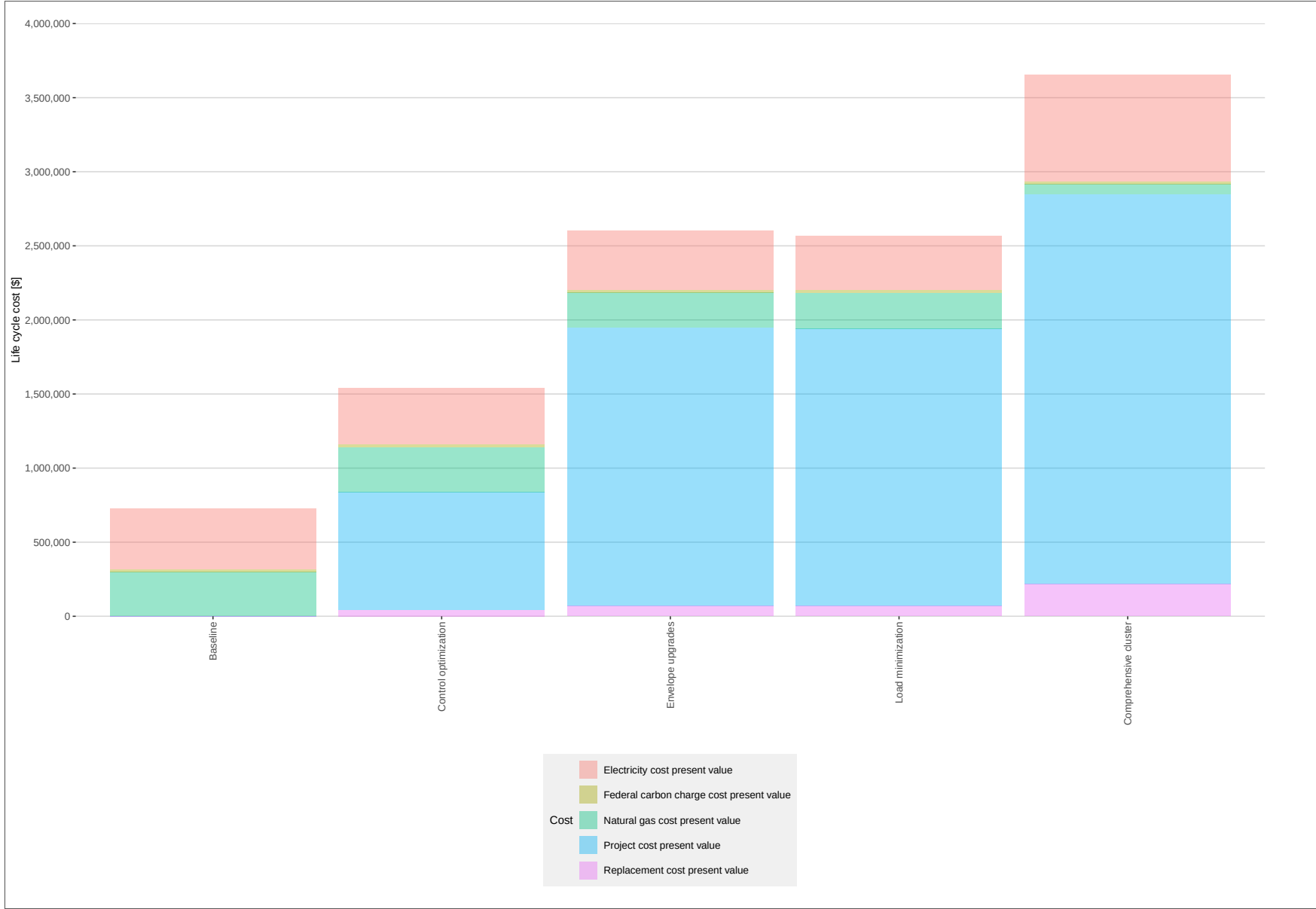


Figure 189: Life cycle cost expected for each scenario by cost item

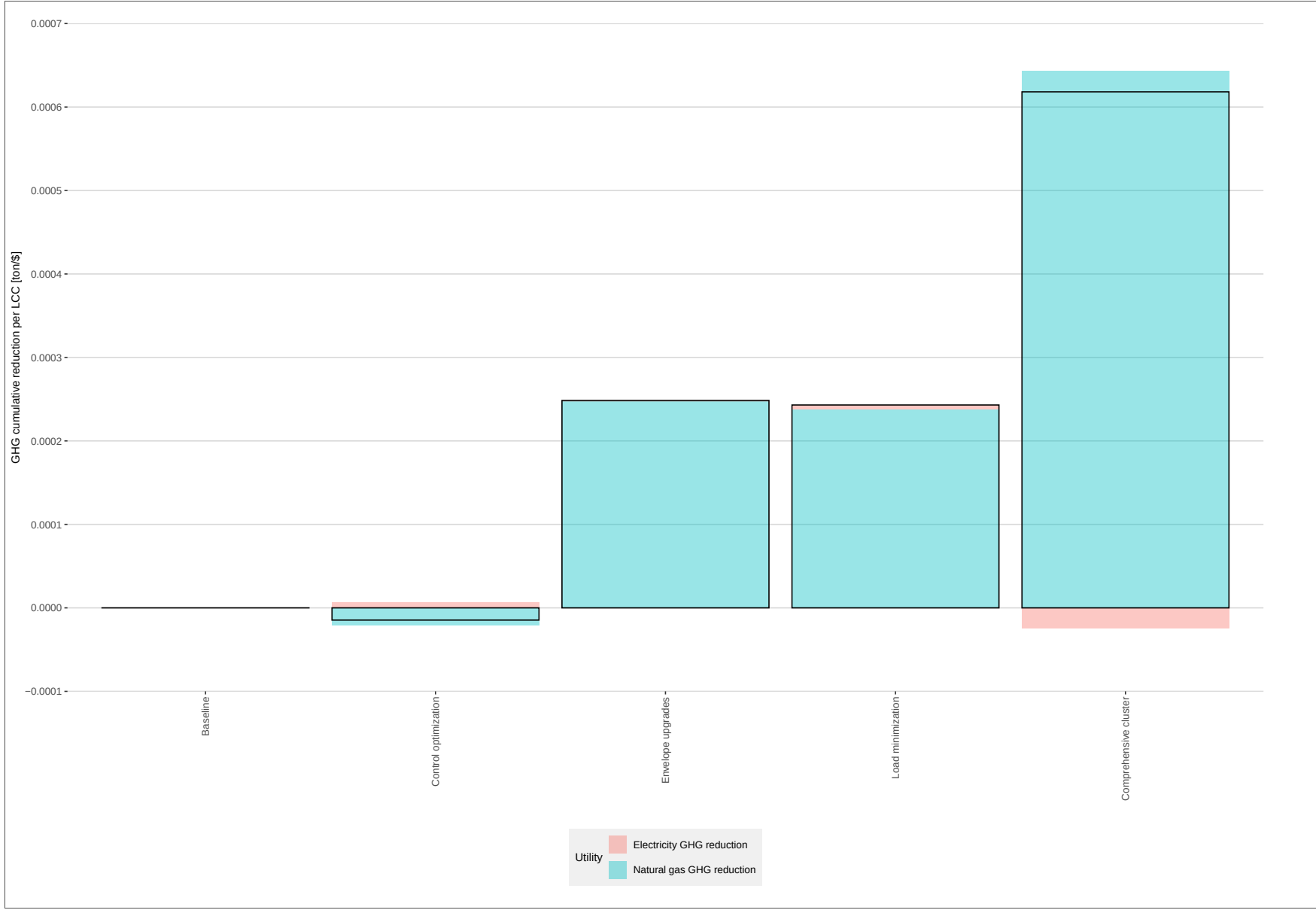


Figure 190: GHG cumulative reduction per life cycle cost (LCC) dollar expected for each scenario by utility

6.5 Plan scenario development

Plan scenario identification and objectives

The plan scenarios that were analyzed and their objectives are summarized in Table 50.

Table 50: 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 50. Results of the plan scenario composition are presented in Figure 191, 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 51 to 56.

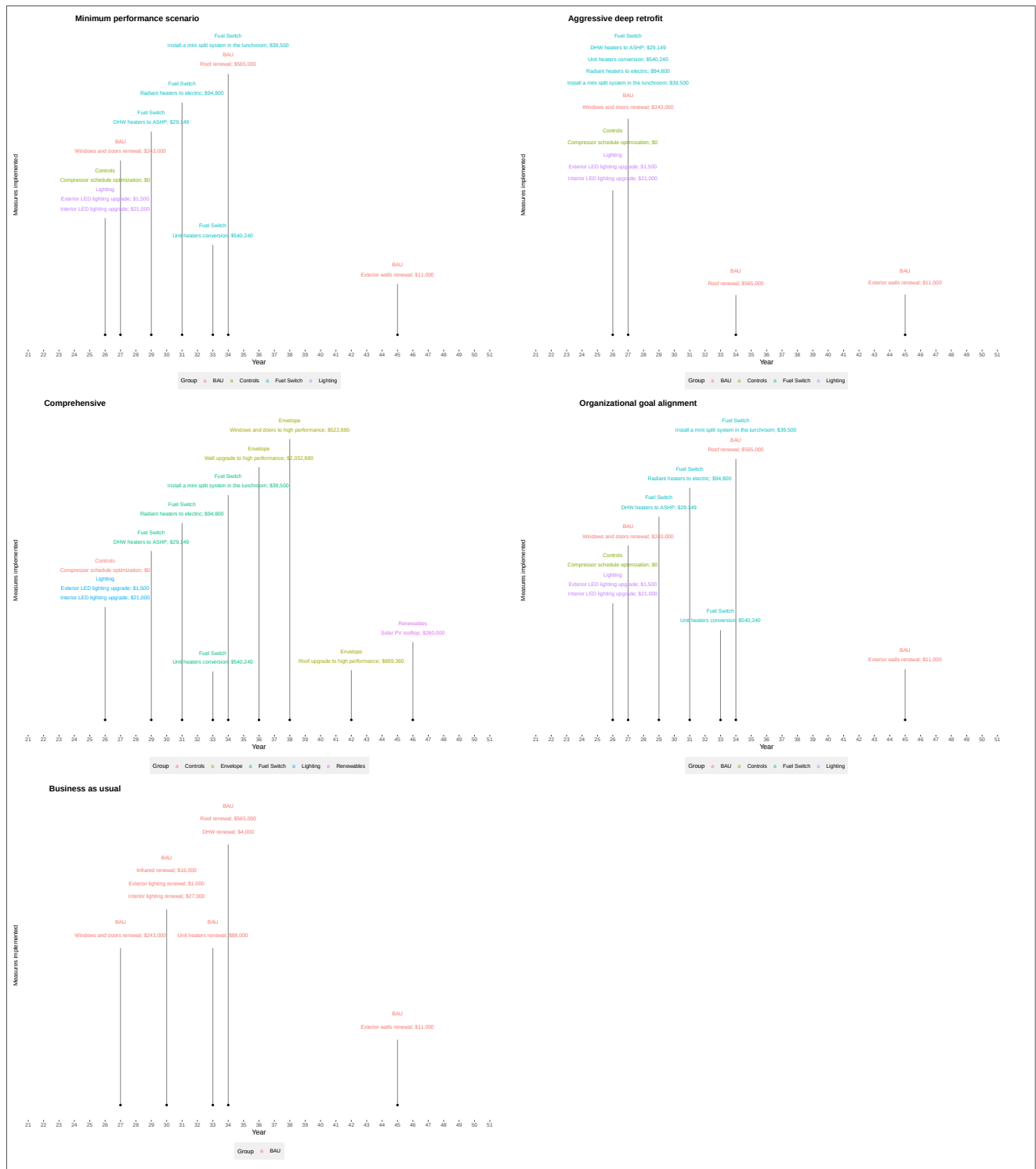


Figure 191: Plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

Table 51: Scenario composition summary

Measure	Minimum performance scenario	Aggressive deep retrofit	Comprehensive	Organizational goal alignment
Carbon offsets 20	✗	✗	✗	✗
Compressor schedule optimization	✓	✓	✓	✓
DHW heaters to ASHP	✓	✓	✓	✓
Exterior LED lighting upgrade	✓	✓	✓	✓
Install a mini split system in the lunchroom	✓	✓	✓	✓
Interior LED lighting upgrade	✓	✓	✓	✓
Radiant heaters to electric	✓	✓	✓	✓
Roof upgrade to high performance	✗	✗	✓	✗
Solar PV rooftop	✗	✗	✓	✗
Unit heaters conversion	✓	✓	✓	✓
Wall upgrade to high performance	✗	✗	✓	✗
Windows and doors to high performance	✗	✗	✓	✗
DHW renewal	✗	✗	✗	✗
Exterior lighting renewal	✗	✗	✗	✗
Exterior walls renewal	✓	✓	✗	✓
Infrared renewal	✗	✗	✗	✗
Interior lighting renewal	✗	✗	✗	✗
Roof renewal	✓	✓	✗	✓
Unit heaters renewal	✗	✗	✗	✗
Windows and doors renewal	✓	✓	✗	✓

Table 52: Minimum performance scenario measure implementation timeline

Measure	Year
Compressor schedule optimization	2026
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Windows and doors renewal	2027
DHW heaters to ASHP	2029
Radiant heaters to electric	2031
Unit heaters conversion	2033
Install a mini split system in the lunchroom	2034
Roof renewal	2034
Exterior walls renewal	2045

Table 53: Aggressive deep retrofit measure implementation timeline

Measure	Year
Compressor schedule optimization	2026
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
DHW heaters to ASHP	2027
Install a mini split system in the lunchroom	2027
Radiant heaters to electric	2027
Unit heaters conversion	2027
Windows and doors renewal	2027
Roof renewal	2034
Exterior walls renewal	2045

Table 54: Comprehensive measure implementation timeline

Measure	Year
Compressor schedule optimization	2026
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
DHW heaters to ASHP	2029
Radiant heaters to electric	2031
Unit heaters conversion	2033
Install a mini split system in the lunchroom	2034
Wall upgrade to high performance	2036
Windows and doors to high performance	2038
Roof upgrade to high performance	2042
Solar PV rooftop	2046

Table 55: Organizational goal alignment measure implementation timeline

Measure	Year
Compressor schedule optimization	2026
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Windows and doors renewal	2027
DHW heaters to ASHP	2029
Radiant heaters to electric	2031
Unit heaters conversion	2033
Install a mini split system in the lunchroom	2034
Roof renewal	2034
Exterior walls renewal	2045

Table 56: Business as usual measure implementation timeline

Measure	Year
Windows and doors renewal	2027
Exterior lighting renewal	2030
Infrared renewal	2030
Interior lighting renewal	2030
Unit heaters renewal	2033
DHW renewal	2034
Roof renewal	2034
Exterior walls renewal	2045

6.6 Plan performance analysis

Figures 192 through 195 present the projected yearly electricity use, natural gas use, GHG emissions and life cycle costs associated with each plan scenario.

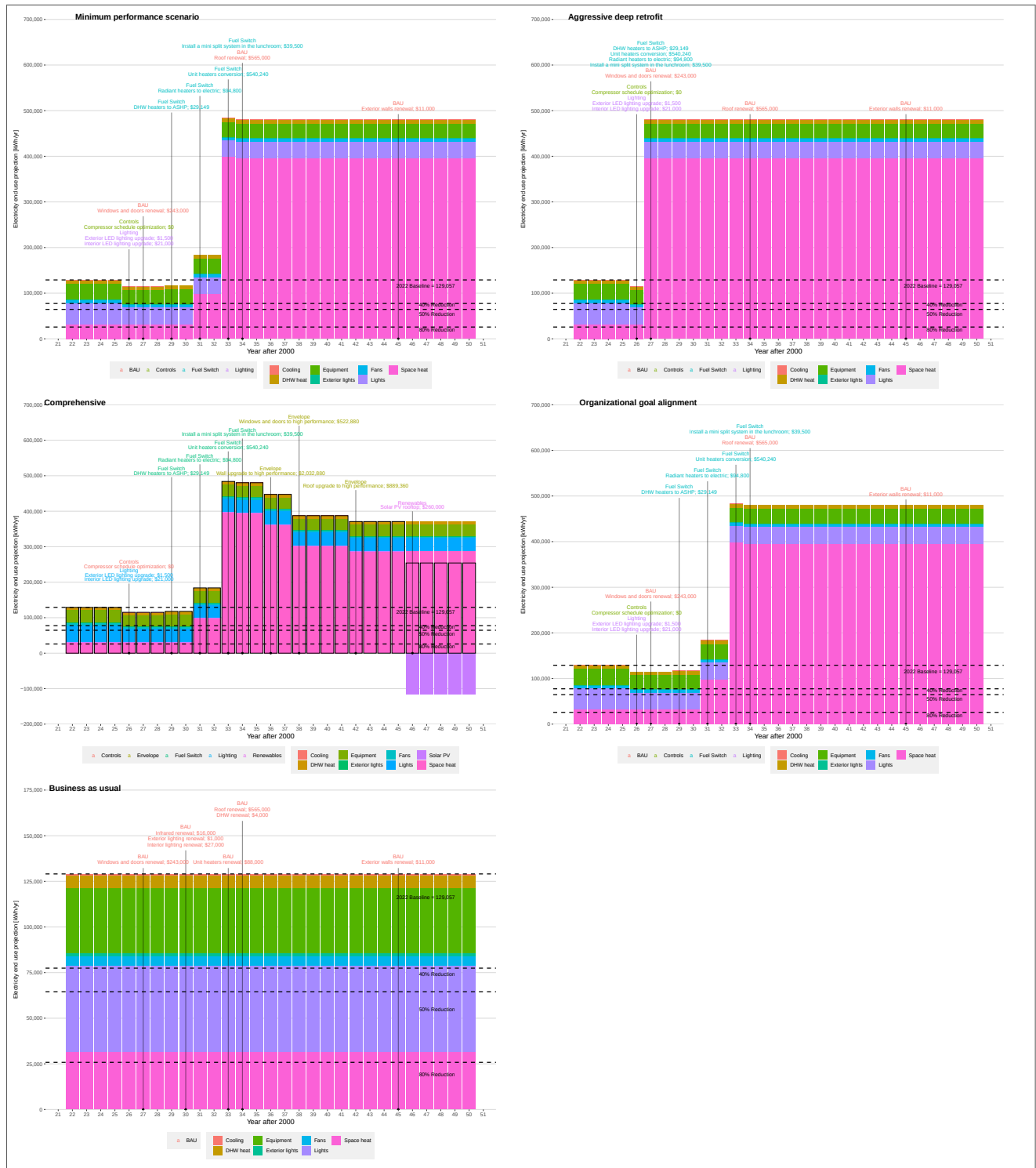


Figure 192: Electricity yearly utility use projection for each scenario



Figure 193: Natural gas yearly utility use projection for each scenario



Figure 194: GHG yearly emissions projection for each scenario

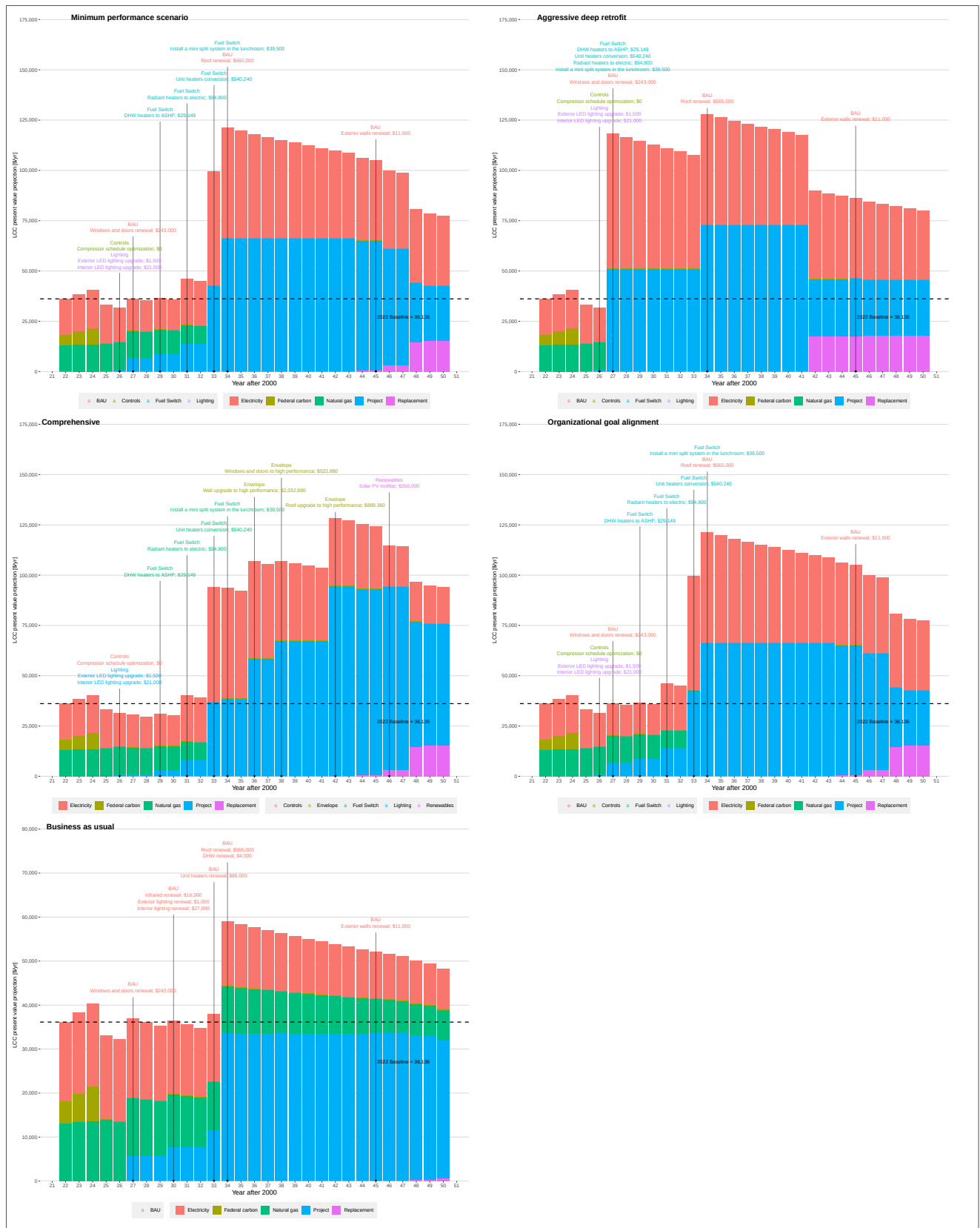


Figure 195: Life cycle yearly cost (after discounting to present value) projection for each scenario

6.7 Plan performance summary

Plan performance summary

Table 57 summarizes the performance of each plan scenario with respect to utility use, GHG emissions, utility cost, and financial metrics. The first half of Table 57 represents the estimated performance in the final year (2050) of the evaluation period. The second half of Table 57 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 57 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 195).

Table 57: 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]	480,302	480,302	254,135	480,302	129,057
	Electricity monthly peak (av)	[kW]	164	164	133	164	38
	Electricity yearly peak (max)	[kW]	249	249	197	249	55
	Natural gas use	[m3/yr]	0	0	0	0	50,666
GHG emissions final	Electricity GHGs	[tCO2e/yr]	4.6	4.6	2.4	4.6	1.2
	Natural gas GHGs	[tCO2e/yr]	0.0	0.0	0.0	0.0	97.9
	Carbon offsets GHGs	[tCO2e/yr]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e/yr]	4.6	4.6	2.4	4.6	99.1
Utility cost final	Electricity utility cost	[\$/yr]	117,098	117,098	61,958	117,098	31,464
	Natural gas utility cost	[\$/yr]	0	0	0	0	22,932
	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]	117,098	117,098	61,958	117,098	54,396
Utility use cumulative	Electricity use	[kWh]	10,113,914	12,158,611	8,108,714	10,113,914	3,742,663
	Natural gas use	[m3]	537,919	254,034	537,919	537,919	1,469,319
GHG emissions cumulative	Electricity GHGs	[tCO2e]	308	419	273	308	136
	Natural gas GHGs	[tCO2e]	1,039	491	1,039	1,039	2,839
	Carbon offsets GHGs	[tCO2e]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e]	1,347	910	1,313	1,347	2,976
Utility cost cumulative	Electricity utility cost	[\$]	2,019,664	2,351,130	1,574,989	2,019,664	701,091
	Natural gas utility cost	[\$]	154,142	68,749	154,142	154,142	510,943
	Carbon offsets utility cost	[\$]	0.00	0.00	0.00	0.00	0.00
	Federal carbon charge	[\$]	19,091	19,091	19,091	19,091	19,091
	Total utility cost	[\$]	2,192,898	2,438,971	1,748,223	2,192,898	1,231,125
Financial cumulative	Project cost	[\$]	1,970,933	1,864,789	7,080,823	1,970,933	1,100,856
	Replacement cost	[\$]	692,403	620,975	692,403	692,403	38,801
	Life cycle cost	[\$]	2,307,641	2,713,635	2,312,182	2,307,641	1,349,175

6.8 Scenario analysis discussion

Baseline

- This scenario reflects existing conditions.

Minimum performance scenario

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

Aggressive deep retrofit

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

Organizational goal alignment

- To achieve the organizational goal alignment of 80% reduction in GHG emissions without carbon offsets, the heating systems must be electrified.

Comprehensive

- The comprehensive scenario demonstrates the upper limit of energy-efficiency that the New Liskeard Public Works Site could achieve, based on the measures that were analyzed under this Pathway to Decarbonization Feasibility Study.

7 END