

PATHWAY TO DECARBONIZATION FEASIBILITY STUDY

CITY OF TEMISKAMING SHORES

NEW LISKEARD FIRE HALL
30 Wellington Street South, New Liskeard, ON

WalterFedy Project No: 2023-0734-11

July 21, 2025



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Project Number: 2023-0734-11

July 21, 2025

Mathew Bahm
Director of Recreation
City of Temiskaming Shores
325 Farr Drive
Haileybury, ON 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 Fire Hall, which is located at 30 Wellington Street South 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



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Contents

	Page
EXECUTIVE SUMMARY	1
1 INTRODUCTION	5
1.1 Overview	5
1.2 Background	5
1.2.1 Corporate Greenhouse Gas Reduction Plan	5
1.2.2 Asset Management Plan	5
1.3 Contact information	6
2 FACILITY DESCRIPTION	7
2.1 Facility description methodology	7
2.2 Facility overview	7
2.3 Building information	8
2.4 Space use	9
2.5 Building Envelope	11
2.6 HVAC	15
2.7 Domestic hot water	18
2.8 Lighting	19
2.9 Process and plug loads	21
2.10 Water fixtures	22
2.11 Utility services	24
2.12 Onsite energy sources	25
2.13 Electrical infrastructure	26
3 UTILITY USE ANALYSIS	27
3.1 Utility analysis methodology	27
3.2 Utility analysis assumptions	29
3.3 Electricity metered utility use	30
3.4 Natural gas metered utility use	32
3.5 Utility use baseline	33
3.6 Benchmarking analysis	34
3.7 ENERGY STAR Portfolio Manager benchmarking analysis	36
3.8 Utility use analysis discussion	37
4 ENERGY MODEL DEVELOPMENT	38
4.1 Energy model development methodology	38
4.2 Hourly utility use profiles	39
4.3 Monthly utility use profiles	42
4.4 Calibration analysis	43
4.5 End use analysis	47
5 MEASURE ANALYSIS	48
5.1 Measure analysis methodology	48
5.2 Measure analysis assumptions	50
5.3 Measure identification	53
5.4 Carbon offsets 20	54
5.5 DHW heater to ASHP	56
5.6 Exterior LED lighting upgrade	58
5.7 Furnace conversion to ASHP with electric backup	60
5.8 Furnace conversion to ASHP with natural gas backup	63
5.9 Interior LED lighting upgrade	66

5.10	Roof upgrade to high performance	68
5.11	Solar PV rooftop	70
5.12	Unit heater conversion	73
5.13	Wall upgrade to high performance	75
5.14	Windows and doors to high performance	77
5.15	Measure risk analysis	80
5.16	Measure analysis summary	82
6	SCENARIO ANALYSIS	83
6.1	Cluster scenario analysis methodology	83
6.2	Cluster scenario objectives	83
6.3	Cluster scenario composition	84
6.4	Cluster scenario performance analysis	85
6.5	Plan scenario development	95
6.6	Plan performance analysis	99
6.7	Plan performance summary	103
6.8	Scenario analysis discussion	104
7	END	105

List of Figures

1	Recommended plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario	2
2	Recommended scenario performance	3
3	New Liskeard Fire Hall aerial view	7
4	floor plans	10
5	3 elevations	13
6	4 typical sections	13
7	Concrete block for the firehall	13
8	Concrete block wall along the south elevation	13
9	Hollow metal door	13
10	Hose tower	13
11	Nameplate information for typical window	13
12	North elevation	13
13	Overhead bay doors	13
14	Pooling water on the roof above the firehall	13
15	Rear entry door	13
16	Roof above the firehall	13
17	Roof assembly above the firehall	13
18	Roof assembly above the hose tower	13
19	Roof assembly above the second floor	13
20	Wall assembly on office side	14
21	West elevation	14
22	Window seal fail	14
23	Wood framing around window on south elevation in poor condition	14
24	8 heating	16
25	Ceiling fan in the firehall	16
26	Condenser 1	16
27	Condenser 2	16
28	Electric baseboard heat on the second floor	16
29	Exhaust fan in the upstairs washroom	16
30	F1	16

31	F2	16
32	F2 nameplate	16
33	Fan control in the firehall	16
34	Thermostat assumed to control F2	16
35	Thermostat controlling F1	16
36	Thermostat controlling the unit heater in the firehall	17
37	Unit heater in the firehall	17
38	DHW tank information	18
39	DHW tank in the mechanical room	18
40	DHW temperature setting	18
41	Manual switches for lights on the second floor	20
42	Original fixture no longer used	20
43	Type A - lamp info	20
44	Type A - suspended T8 fluorescent fixture	20
45	Type B - lamp info	20
46	Type B - second floor multi-purpose room	20
47	Type B - surface-mounted T8 fluorescent fixture	20
48	Type C - hose tower fixture	20
49	Type D - lamp	20
50	Type D - pot lights with CFL lamps	20
51	Type E - lamp info	20
52	Type E - surface-mounted T12 fixture with magnetic ballast	20
53	Type F1 - incandescent lamp	20
54	Type F - lamp info	20
55	Type F - incandescent lamp	20
56	Type G - HPS fixture	20
57	Type H - LED wall pack	20
58	Type I - canopy light	20
59	Air compressor in the firehall	21
60	Breathable air compressor	21
61	Computer in the firehall	21
62	Door opener for a bay door	21
63	Exhaust hose	21
64	Kitchen appliances	21
65	Projector	21
66	Sump pump at bottom of the hose tower	21
67	TV	21
68	6 plumbing and drainage	22
69	Faucets in the upstairs washroom	22
70	Sink in the first floor kitchen area	22
71	Sink in the second floor kitchen area	22
72	Sink in washroom adjacent to the firehall	22
73	Toilet in the upstairs washroom	22
74	Toilet in washroom adjacent to the firehall	23
75	Urinals in the upstairs washroom	23
76	Electric meter	24
77	Natural gas meter	24
78	Portable generator	25
79	7 electrical	26
80	Panel A - located in the firehall	26
81	Panel B - located beside panel A	26
82	Transfer switch	26
83	Hourly electricity use	30
84	Hourly electricity use hairball plot	30

85	Monthly electricity use	31
86	Monthly natural gas use	32
87	Electricity use intensity benchmarking analysis comparison	34
88	Natural gas use intensity benchmarking analysis comparison	34
89	Total energy use intensity benchmarking analysis comparison	35
90	GHG emissions intensity benchmarking analysis comparison	35
91	Energy Star energy performance scorecard.	36
92	Hourly electricity utility use by end use (made by calibrated energy model)	40
93	Hourly natural gas utility use by end use (made by calibrated energy model)	41
94	Monthly utility use profiles for each modelled utility	42
95	Electricity calibration analysis (metered vs modelled utility use)	43
96	Natural gas calibration analysis (metered vs modelled utility use)	44
97	Electricity end use breakdown (calculated by calibrated energy model)	47
98	Natural gas end use breakdown (calculated by calibrated energy model)	47
99	Utility cumulative use sensitivity analysis	80
100	GHG cumulative emissions and life cycle cost sensitivity analysis	81
101	Scenario composition	84
102	Electricity utility use expected yearly for each scenario by end use	87
103	Natural gas utility use expected yearly for each scenario by end use	88
104	Equivalent energy use expected yearly for each scenario by end use	89
105	GHG emissions expected yearly for each scenario by end use	90
106	Utility costs expected yearly for each scenario by end use	91
107	Project cost expected for each scenario by measure	92
108	Life cycle cost expected for each scenario by cost item	93
109	GHG cumulative reduction per life cycle cost (LCC) dollar expected for each scenario by utility	94
110	Plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario	96
111	Electricity yearly utility use projection for each scenario	99
112	Natural gas yearly utility use projection for each scenario	100
113	GHG yearly emissions projection for each scenario	101
114	Life cycle yearly cost (after discounting to present value) projection for each scenario	102

List of Tables

1	Recommended plan scenario performance summary	4
2	Asset management summary for this facility	6
3	Contact information	6
4	Facility overview	7
5	Space use summary	9
6	Building envelope summary	11
7	Air distribution systems summary	15
8	Heating systems summary	15
9	Cooling systems summary	15
10	Lighting systems summary	19
11	Water fixture summary	22
12	Baseline performance data source for each utility	27
13	GHG emissions factor assumptions	29
14	Utility cost rate assumptions for the baseline year (2022)	29
15	Baseline utility use performance	33
16	Utility and end use summary and definitions	38
17	Statistical calibration analysis summary	45
18	Utility cost rate future assumptions	50
19	Financial incentive assumptions	51

20	Life cycle cost analysis assumptions	51
21	Risk parameter and case definitions	51
22	Measure identification and triaging summary	53
23	Carbon offsets 20 analysis results summary	55
24	Project cost estimate (DHW heater to ASHP)	57
25	DHW heater to ASHP analysis results summary	57
26	Project cost estimate (Exterior LED lighting upgrade)	59
27	Exterior LED lighting upgrade analysis results summary	59
28	Project cost estimate (Furnace conversion to ASHP with electric backup)	61
29	Furnace conversion to ASHP with electric backup analysis results summary	62
30	Project cost estimate (Furnace conversion to ASHP with natural gas backup)	64
31	Furnace conversion to ASHP with natural gas backup analysis results summary	65
32	Project cost estimate (Interior LED lighting upgrade)	67
33	Interior LED lighting upgrade analysis results summary	67
34	Project cost estimate (Roof upgrade to high performance)	69
35	Roof upgrade to high performance analysis results summary	69
36	Project cost estimate (Solar PV rooftop)	72
37	Solar PV rooftop analysis results summary	72
38	Project cost estimate (Unit heater conversion)	74
39	Unit heater conversion analysis results summary	74
40	Project cost estimate (Wall upgrade to high performance)	76
41	Wall upgrade to high performance analysis results summary	76
42	Project cost estimate (Windows and doors to high performance)	78
43	Windows and doors to high performance analysis results summary	79
44	Measure analysis summary	82
45	Scenario objectives	83
46	Cluster composition	85
47	Scenario analysis summary	86
48	Plan scenario identification and objectives	95
49	Scenario composition summary	97
50	Minimum performance scenario measure implementation timeline	97
51	Aggressive deep retrofit measure implementation timeline	98
52	Comprehensive measure implementation timeline	98
53	Organizational goal alignment measure implementation timeline	98
54	Business as usual measure implementation timeline	98
55	Plan performance summary	103

EXECUTIVE SUMMARY

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

1. **Facility description.** The existing conditions of the facility were reviewed through available documentation and a site survey completed on 2024-04-18 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 Fire Hall. Findings are documented in Section 3.
3. **Energy model development.** A calibrated energy model was developed from a bottom-up hourly analysis considering historical weather patterns, and the insight gained from reviewing the facility's existing conditions and historical utility use data. Findings are documented in Section 4.
4. **Measure analysis.** Measures intended to achieve the City of Temiskaming Shores's goals were identified and analyzed. Analysis includes conceptual design development and utility analysis quantifying utility use impacts, GHG emissions and utility costs for each measure. Findings are documented in Section 5.
5. **Scenario analysis.** Scenario analysis was completed to estimate the costs and benefits expected from implementing various combinations (i.e. scenarios) of the measures that were individually analyzed in Section 5, accounting for the interactive effects between measures within each scenario. Findings are documented in Section 6.

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

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

- **Organizational goal alignment**

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

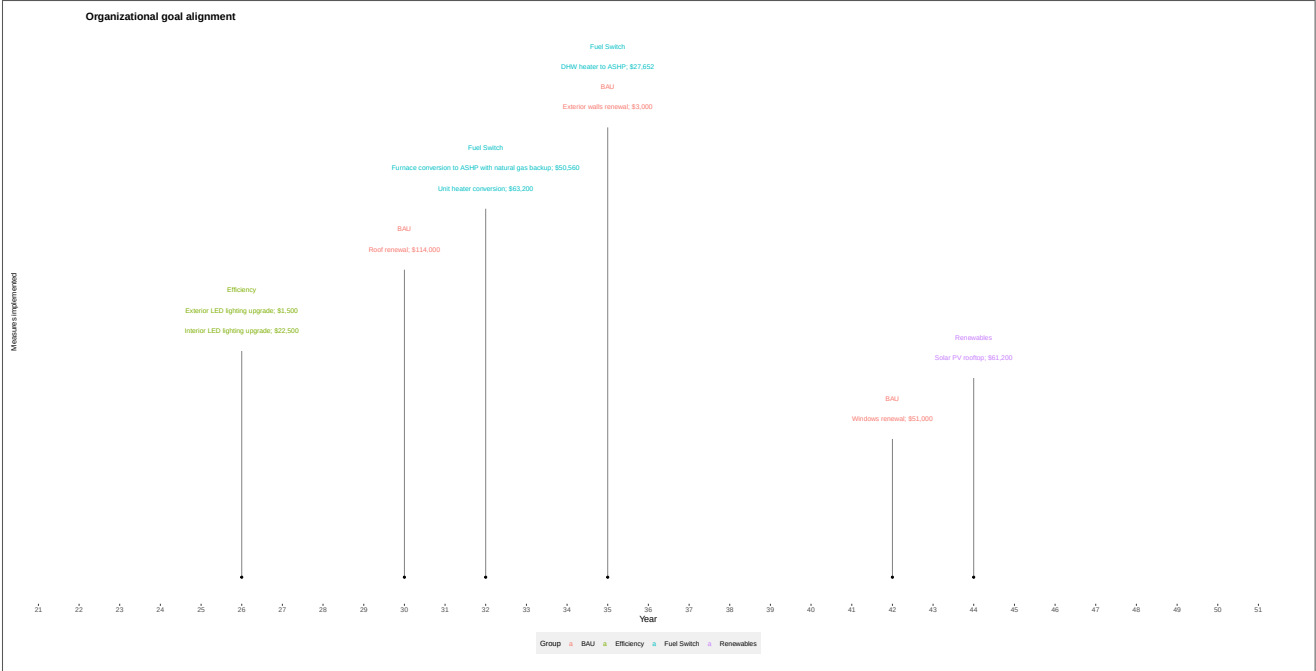


Figure 1: Recommended plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

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

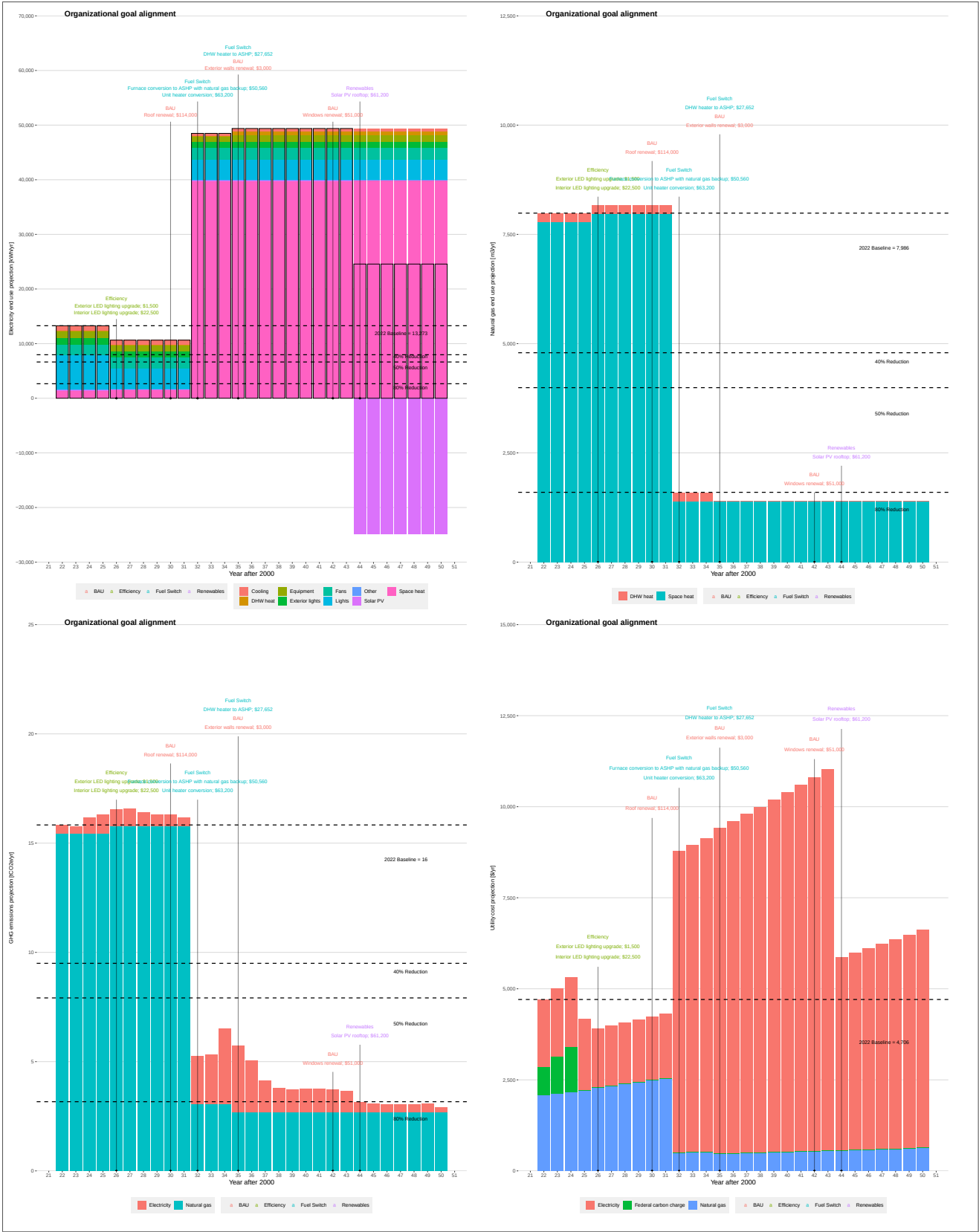


Figure 2: Recommended scenario performance

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

Table 1: Recommended plan scenario performance summary

Section	Description	Unit	Minimum performance scenario	Aggressive deep retrofit	Comprehensive	Organizational goal alignment	Business as usual
Utility use final	Electricity use	[kWh/yr]	36,325	36,325	18,294	24,563	13,273
	Electricity monthly peak (av)	[kW]	12.7	12.7	9.1	9.0	2.7
	Electricity yearly peak (max)	[kW]	25.9	25.9	19.6	15.0	4.5
	Natural gas use	[m3/yr]	0	0	0	1,389	7,986
GHG emissions final	Electricity GHGs	[tCO2e/yr]	0.35	0.35	0.17	0.23	0.13
	Natural gas GHGs	[tCO2e/yr]	0.0	0.0	0.0	2.7	15.4
	Carbon offsets GHGs	[tCO2e/yr]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e/yr]	0.3	0.3	0.2	2.9	15.6
Utility cost final	Electricity utility cost	[\$/yr]	8,856	8,856	4,460	5,988	3,236
	Natural gas utility cost	[\$/yr]	0	0	0	629	3,614
	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]	8,856	8,856	4,460	6,617	6,850
Utility use cumulative	Electricity use	[kWh]	1,102,227	952,159	865,692	878,747	384,906
	Natural gas use	[m3]	81,473	50,523	80,808	107,865	231,580
GHG emissions cumulative	Electricity GHGs	[tCO2e]	35.8	33.2	30.7	29.6	14.0
	Natural gas GHGs	[tCO2e]	157	98	156	208	447
	Carbon offsets GHGs	[tCO2e]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e]	193	131	187	238	462
Utility cost cumulative	Electricity utility cost	[\$]	215,823	182,849	165,057	169,963	72,102
	Natural gas utility cost	[\$]	23,226	13,874	23,021	33,280	80,530
	Carbon offsets utility cost	[\$]	0.00	0.00	0.00	0.00	0.00
	Federal carbon charge	[\$]	3,009	3,009	3,009	3,009	3,009
	Total utility cost	[\$]	242,058	199,732	191,088	206,252	155,641
Financial cumulative	Project cost	[\$]	922,800	855,700	1,974,082	533,970	246,756
	Replacement cost	[\$]	193,777	507,746	506,886	193,777	122,479
	Life cycle cost	[\$]	608,128	691,952	934,466	381,600	240,742

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 Fire Hall. This engagement aims to identify a recommended Greenhouse gas (GHG) reduction pathway by examining GHG reduction measures and various scenario developments. Based on a review of the Request For Proposal Document, the City's Corporate Greenhouse Gas Reduction Plan (GHGRP), and the Federation of Canadian Municipalities (FCM) Community Buildings Retrofit (CBR) funding program, the following scenarios will be developed:

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

1.2 Background

1.2.1 Corporate Greenhouse Gas Reduction Plan

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

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

This study will contribute to the decarbonization studies of its buildings. The New Liskeard Fire Hall is one of fourteen buildings being examined. Of these fourteen buildings, they represent over 77% of the buildings and facilities GHG emissions. In particular, the New Liskeard Fire Hall represented 18 tCO₂e in 2019, or 0.9% 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 Fire Hall.

Table 2: Asset management summary for this facility

Group	Metric	Unit	Value
Financial	Content Value Estimated	[\$]	443,268
	Building Land Tank	[\$]	1,477,560
	Replacement Cost	[\$]	1,920,828
Information	Install Date	[yr]	1966
	Age	[yrs]	59
Condition Rating	Structure Condition Score	[-]	3.9
	Final Condition Score	[-]	3.9
Risk	Probability of Failure	[-]	2
	Consequence of Failure	[-]	5
	Risk Score	[-]	2.6

1.3 Contact information

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

Table 3: Contact information

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

2 FACILITY DESCRIPTION

2.1 Facility description methodology

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

1. **Facility document review.** Facility documents from the following list were reviewed, if available. Further information on available documentation are available in Section 2.3.
 - Building drawings.
 - Building automation system graphics and points lists.
 - Previously completed Engineering studies, including Energy Audits, Feasibility Studies, and Building Condition Assessments.
 - Historical utility use data.
 - Other documentation made available by the City of Temiskaming Shores.
2. **Site survey.** A site survey was completed on 2024-04-18 to review the energy systems applicable to the desired retrofit scenario.

2.2 Facility overview

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

Table 4: Facility overview

Description	Unit	Value
Name	[-]	New Liskeard Fire Hall
Address	[-]	30 Wellington Street South
Location	[-]	New Liskeard, ON
Type	[-]	Fire station
Construction year	[-]	1966
Gross floor area	[m2]	340
Gross floor area	[ft2]	3,660

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



Figure 3: New Liskeard Fire Hall aerial view

2.3 Building information

Renovations

The following renovations are known:

- **Roof replacement (2016):** The facility underwent a roof replacement in 2016. However, no information on the new roof was provided. It is assumed that was replaced "like-for-like".
- **Window replacement (2002):** Based on a nameplate sticker on a window, the windows are assumed to have been replaced circa 2002.

Additions

There have been no additions to this building.

Energy use not within the gross floor area

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

- Building-mounted exterior light fixtures

Utility bill responsibility

Utility bill responsibility is as follows:

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

Commissioning history

No commissioning history has been documented.

Previous studies

The following is a summary of known previous studies:

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

Documentation availability

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

- Original drawings (dated June 1964), including structural, architectural, mechanical, and electrical. No schedules were listed in the drawings.

2.4 Space use

Type summary

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

- Meeting room
- Electrical/Mechanical room
- Office, enclosed
- Washroom
- Lunchroom
- Multi-purpose room
- Kitchen
- Storage

This building used to house both the police and the fire department. However, the police are no longer present. The first floor still has the jail cells, which are now used for storage.

Occupancy scheduling

The facility operation hours are as follows:

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

Based on the firefighter uniform storage room, this building is assumed to have a peak occupancy of 24 people.

Space use breakdown

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

Table 5: Space use summary			
Space name	Floor area of space	HVAC System	Data source
-	[m2]	-	-
Fire hall	169	UH	Site visit.
1st floor	147	F1	Site visit.
2nd floor	121	F2	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.

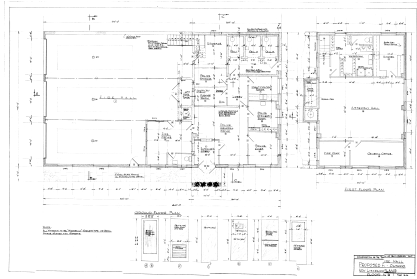


Figure 4: floor plans

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]
437	484	417	25	42

Overview

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

Roof

There were a total of three roof assembly types identified. R1, above the fire hall had the following composition (exterior to interior layer):

- 4 ply tar and gravel roof
- 1.5 inch rigid insulation
- 2 inch wood deck

R2, above the hose tower:

- 4 ply asphalt and gravel roof
- 3/4 inch T and G decking

R3, above the second floor:

- 4 ply asphalt and gravel roof
- 1.5 inch rigid insulation
- 2 x 10 wood joists at 16 inches OC
- 1/2 inch gyproc ceiling

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

- R1: 0.182 W/m2K
- R2: 2.561 W/m2K
- R3: 0.290 W/m2K
- The roof was in good condition. There were signs of pooling on the roof. However, it was raining during the site visit.

Opaque Walls (above ground)

There were a total of three notable wall assembly types identified. W1, in the fire hall had the following composition (exterior to interior layer):

- 8 inch concrete block
- No insulation
- There is a section midway up the wall that has brick veneer

W2, on the office side:

- 8 inch concrete block
- 2 x2 inch strapping
- 2 inches of insulation
- 2 mil poly vapour barrier
- 3/8 inch gyproc

W3, above the overhead doors:

- Brick veneer
- Concrete block
- 3 inch batt insulation
- 1/8 inch asbestos cement board

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

- W1: 0.0667 W/m²K
- W2: 0.602 W/m²K
- W3: 0.573 W/m²K
- The wall condition was fair.

Fenestration

Windows

- The facility has vinyl-framed, double-pane windows (picture and casement) that appear to have been replaced in 2002. A label on one of the windows indicated an ER of 4, which is well below ENERGY STAR minimum of 40.
- Based on the ER of the window and the composition observed while on site, the U-Value is assumed to be 3.24 W/m²K with a SHGC of 0.35.
- Windows appeared to be in good to poor condition. There were signs of seals failing around windows and some sills require replacement.

Doors

- The facility has three overhead bay doors, two swing doors with glazing, and one hollow metal door.
- The bay overhead doors appeared to be in good condition. However, the framing around the entry doors was in poor condition.
- The overall fenestration-to-wall ratio is estimated to be 14%.

Overall Enclosure Tightness

It is difficult to determine a building's infiltration rate without performing a blower door test. However, an infiltration rate is required for energy modelling purposes. Based on the site survey, an infiltration rate of 0.25 Lps/m² of the above-grade building envelope area will be assumed here.

Building Envelope documentation

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

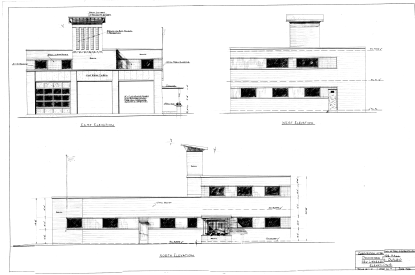


Figure 5: 3 elevations

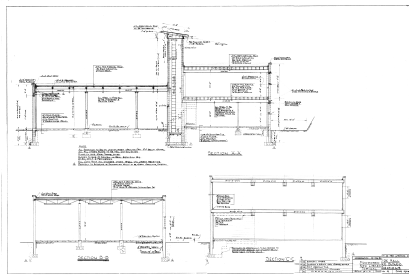


Figure 6: 4 typical sections

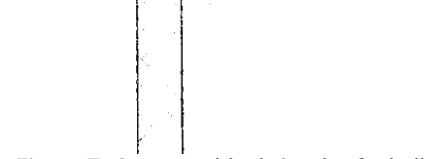


Figure 7: Concrete block for the firehall



Figure 8: Concrete block wall along the south elevation

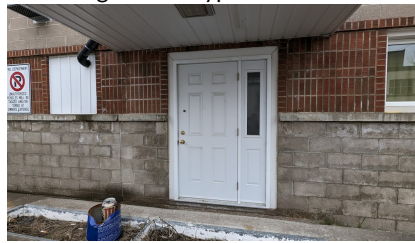


Figure 9: Hollow metal door



Figure 10: Hose tower



Figure 11: Nameplate information for typical window



Figure 12: North elevation



Figure 13: Overhead bay doors



Figure 14: Pooling water on the roof above the firehall



Figure 15: Rear entry door



Figure 16: Roof above the firehall

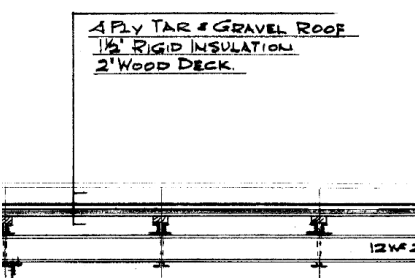


Figure 17: Roof assembly above the firehall



Figure 18: Roof assembly above the hose tower

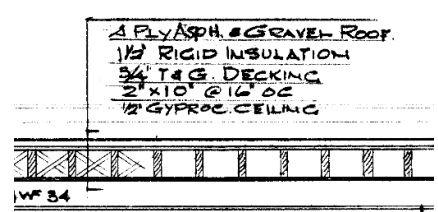


Figure 19: Roof assembly above the second floor

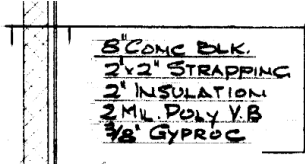


Figure 20: Wall assembly on office side



Figure 21: West elevation



Figure 22: Window seal fail

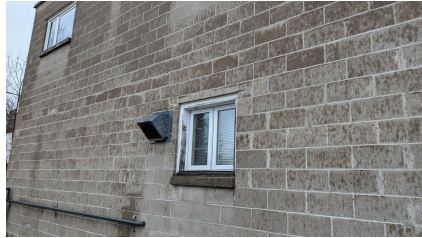


Figure 23: Wood framing around window on south elevation in poor condition

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]	-
F1	Payne Heating and Cooling	PG95SA S48080B	1st floor	1,325	0.75	Nameplate.
F2	Duomatic Olsen	WSS2-130/120B	2nd floor	900	0.50	Nameplate.

Table 8: Heating systems summary

Tag	Serves	Utility	Efficiency	Output	Data source
-	-	-	[decimal]	[btuh]	-
F1_HEAT	1st floor	Natural gas	0.97	78,000	Nameplate.
F2_HEAT	2nd floor	Natural gas	0.76	91,200	Nameplate.
UH1	Unit heater in the fire hall	Natural gas	0.83	207,500	Nameplate.
BB1	Electric baseboard on second floor	Electricity	1.00	1,365	Assumption.
DHW1	DHW	Natural gas	0.80	32,000	Nameplate.

Table 9: Cooling systems summary

Tag	Serves	Efficiency	Output	Data source
-	-	[decimal]	[ton]	-
COND_1	1st floor	3.5	2.0	Nameplate
COND_2	2nd floor	3.5	2.5	Nameplate

System type

The facility utilizes two gas-fired furnaces coupled with two condensers located on the roof. F1, which is located in the rear of the mechanical room, serves the first floor, and F2, which is in front of F1, serves the second floor. A gas-fired unit heater is installed in the fire hall.

Distribution system

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

Controls

The two furnaces and the unit heater are controlled by dedicated thermostats. Information on each thermostat is as follows:

- The thermostat serving the unit heater is located in the fire hall. It is non-programmable and was set to 69F during the site visit.

- The thermostat serving F1 is located in the open space on the first floor. It is non-programmable and was set to 18C (hold) during the site visit.
- The thermostat serving F2 is located in the open space on the second floor. It is programmable and was set to 65F (hold) during the site visit.

HVAC system documentation

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

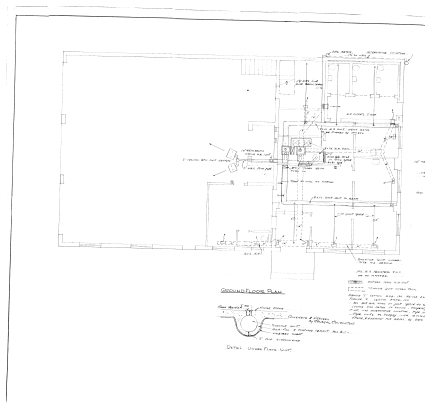


Figure 24: 8 heating

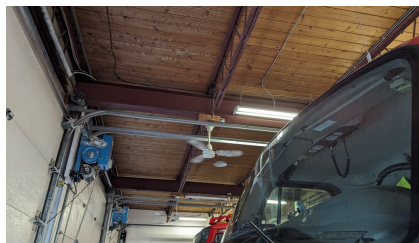


Figure 25: Ceiling fan in the firehall

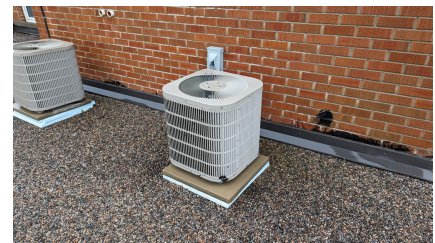


Figure 26: Condenser 1



Figure 27: Condenser 2

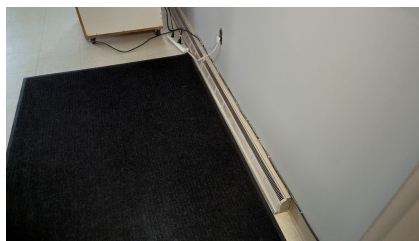


Figure 28: Electric baseboard heat on the second floor



Figure 29: Exhaust fan in the upstairs washroom



Figure 30: F1



Figure 31: F2

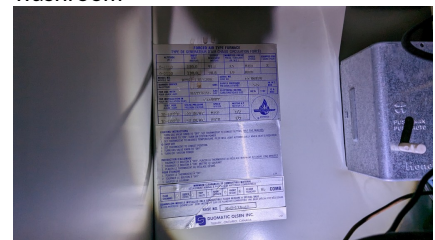


Figure 32: F2 nameplate



Figure 33: Fan control in the firehall



Figure 34: Thermostat assumed to control F2



Figure 35: Thermostat controlling F1



Figure 36: Thermostat controlling the unit heater in the firehall



Figure 37: Unit heater in the firehall

2.7 Domestic hot water

Overview

One gas-fired DHW heater serves the whole building. Based on the site survey, the unit only serves sinks and handwashing faucets. No showers were present at the time of the site visit. Showers are planned to be added in the upstairs washrooms in 2025, although they are not anticipated to add much DHW use. DHW1 capacity is 50 USG.

Domestic Hot Water documentation

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



Figure 38: DHW tank information



Figure 39: DHW tank in the mechanical room

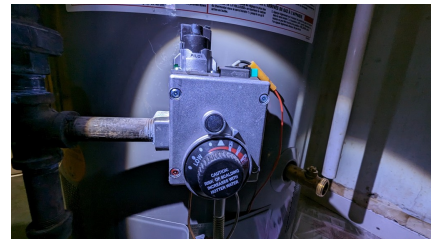


Figure 40: DHW temperature setting

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]	-
Fire hall	169	10.8	1,825	Assumption.
1st floor	147	10.8	1,588	Assumption.
2nd floor	121	10.8	1,307	Assumption.

Interior lighting

Fixtures

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

- Type A: 1'x4' suspended, 2 lamp, 120V, T8
- Type B: 1'x4' surface-mounted, 2 lamp, 120V, T8
- Type C: LED flood light, nameplate information was not obtained
- Type D: Recessed CFL downlight, 1 lamp, 120V
- Type E: 2'x4' surface-mounted, 4 lamp, 120V, T12, magnetic ballast
- Type F and F1: incandescent lamp
- Type I: canopy light

Controls

Interior lighting control is done through manual switches. It appears that the fixtures in the fire hall are left on continuously.

Exterior lighting

Fixtures

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

- Type G: original HPS downlight
- Type H: LED wall pack

Controls

It was not confirmed how the lighting is controlled. It's assumed that it is controlled by a timer.

Lighting system documentation

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



Figure 41: Manual switches for lights on the second floor



Figure 42: Original fixture no longer used

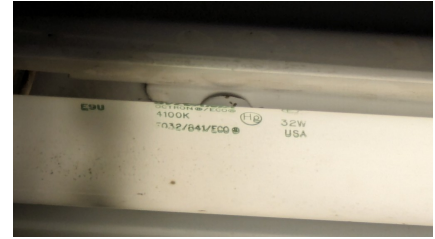


Figure 43: Type A - lamp info

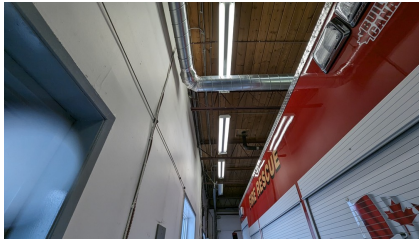


Figure 44: Type A - suspended T8 fluorescent fixture



Figure 45: Type B - lamp info



Figure 46: Type B - second floor multi-purpose room



Figure 47: Type B - surface-mounted T8 fluorescent fixture



Figure 48: Type C - hose tower fixture



Figure 49: Type D - lamp



Figure 50: Type D - pot lights with CFL lamps

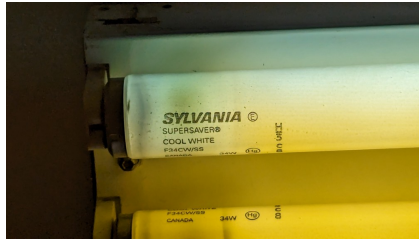


Figure 51: Type E - lamp info



Figure 52: Type E - surface-mounted T12 fixture with magnetic ballast



Figure 53: Type F1 - incandescent lamp



Figure 54: Type F - lamp info



Figure 55: Type F - incandescent lamp

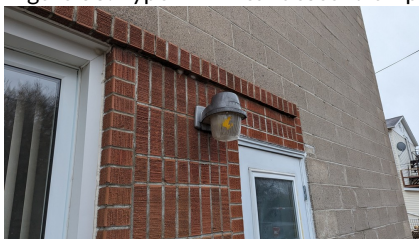


Figure 56: Type G - HPS fixture



Figure 57: Type H - LED wall pack



Figure 58: Type I - canopy light

2.9 Process and plug loads

Process

Various process loads are present at the facility, including:

- Air compressor
- Breathable air compressor
- Exhaust hose

Plug loads

Various plug loads are present at the facility, including:

- Computer
- Televisions
- Appliances (e.g., refrigerator, stove, etc.)
- Projector

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 59: Air compressor in the firehall



Figure 60: Breathable air compressor



Figure 61: Computer in the firehall

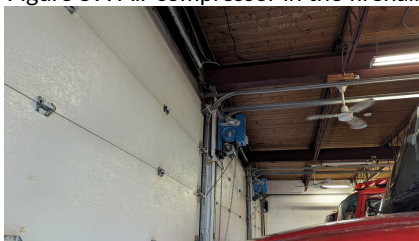


Figure 62: Door opener for a bay door



Figure 63: Exhaust hose



Figure 64: Kitchen appliances



Figure 65: Projector

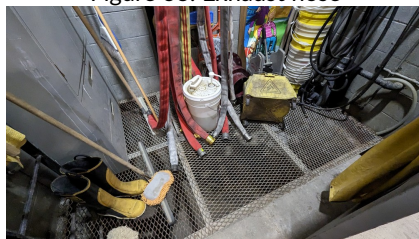


Figure 66: Sump pump at bottom of the hose tower



Figure 67: TV

2.10 Water fixtures

Water fixture summary

Water fixtures at New Liskeard Fire Hall are summarized in Table 11.

Table 11: Water fixture summary

Serves	Unit count	Flow	Volume	Data source
-	-	[gpm]	[gpc]	-
Kitchen faucets	2	2.2	-	Assumption.
Washroom faucets	3	2.0	-	Assumption.
Toilets	2	-	1.6	Assumption.
Urinals	2	-	1.0	Assumption.

Overview

A summary of water fixtures is as follows:

- Three handwashing faucets that are manually active and appear to not be low flow.
- Two kitchen sinks.
- 2 toilets.
- 2 urinals.

Water fixture documentation

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

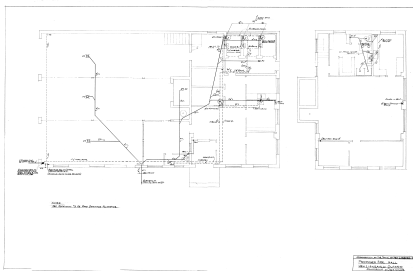


Figure 68: 6 plumbing and drainage



Figure 69: Faucets in the upstairs washroom



Figure 70: Sink in the first floor kitchen area



Figure 71: Sink in the second floor kitchen area



Figure 72: Sink in washroom adjacent to the firehall



Figure 73: Toilet in the upstairs washroom



Figure 74: Toilet in washroom adjacent to the firehall



Figure 75: Urinals in the upstairs washroom

2.11 Utility services

Utility services summary

Overview

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

- The one electricity meter operates on a General Energy rate structure.
- There is one natural gas meter at this facility.

Utility services documentation

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



Figure 76: Electric meter



Figure 77: Natural gas meter

2.12 Onsite energy sources

Overview

There is a portable generator that was located in the fire hall during the site survey. Furthermore, there was a transfer switch that allowed the building to switch over to a portable generator.

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 78: Portable generator

2.13 Electrical infrastructure

Overview

The existing systems is 200A at 240V running at a maximum load of 7.4 kW, which is approximately 20% of the full load of 38.4 kW of the building. The panel has 13 available breaker spaces.

Panel summary

Only one panel was observed during the site visit. However, there are two additional panels. The following summary is based on the drawings:

- Panel Main, 120/240V, single ph, 200A service
- Panel Firehall, 120/240V, single ph, 60A service
- Panel Police, 120/240V, single ph, 50A service

Electrical infrastructure documentation

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

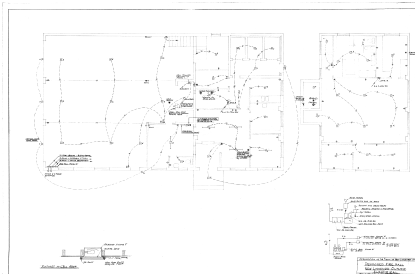


Figure 79: 7 electrical

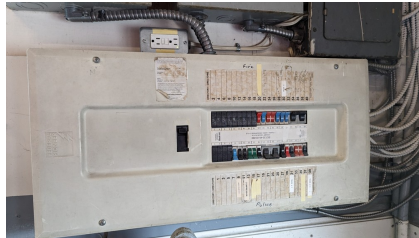


Figure 80: Panel A - located in the firehall

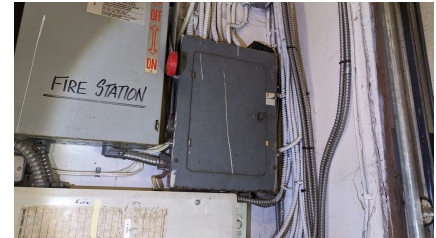


Figure 81: Panel B - located beside panel A



Figure 82: Transfer switch

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 Fire Hall.
 - Electricity; see Section 3.3.
 - Natural gas; see Section 3.4.
3. **Utility use baseline.** The utility use baseline was summarized in Section 3.5, and includes the following.
 - **Baseline year:** A baseline year was determined as the most recent year with the fewest anomalies in facility operations and utility metering. The baseline year was used to establish the historical weather data used for the energy model development, as explained in Section 4.1. If valid metered utility data was available for the baseline year, then the metered utility use data for the baseline year was used to establish baseline performance and for energy model calibration.
 - **Baseline performance:** Yearly utility use, GHG emissions and utility costs. For each utility, the baseline performance was derived from the metered utility use for the baseline year if available for that utility, or from the energy model described in Section 4 if metered data were unavailable or invalid for that utility. Table 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 Fire Hall was compared with those of similar facilities in Section 3.6. Data for similar facilities were obtained from the Government of Ontario's website, made available for the Broader Public Sector (BPS) through O. Reg. 25/23. The list below includes all municipalities considered for the benchmarking process. If this building is the only one presented, it indicates that similar buildings are not being reported to the database.
 - City of Greater Sudbury
 - City of North Bay
 - City of Temiskaming Shores
 - City of Timmins
 - Municipality of Temagami
 - Municipality of West Nipissing
 - Town of Iroquois Falls
 - Town of Kirkland Lake
 - Township of Armstrong
 - Township of Black River-Matheson
 - Township of Brethour
 - Township of Casey

- Township of Chamberlain
 - Township of Gauthier
 - Township of Harley
 - Township of Harris
 - Township of Hilliard
 - Township of Hudson
 - Township of James
 - Township of Kerns
 - Township of Larder Lake
 - Township of Matachewan
 - Township of McGarry
5. **Portfolio benchmarking analysis.** A portfolio benchmarking analysis was also performed, where Energy Star Portfolio Manager was used to benchmark the energy analysis of New Liskeard Fire Hall.
6. **Utility use analysis discussion.** Results of the utility use analysis were studied and discussed in Section 3.8.

3.2 Utility analysis assumptions

Assumptions applied throughout the methodology are summarized as follows.

- GHG emissions factors were assumed as per Table 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 83.

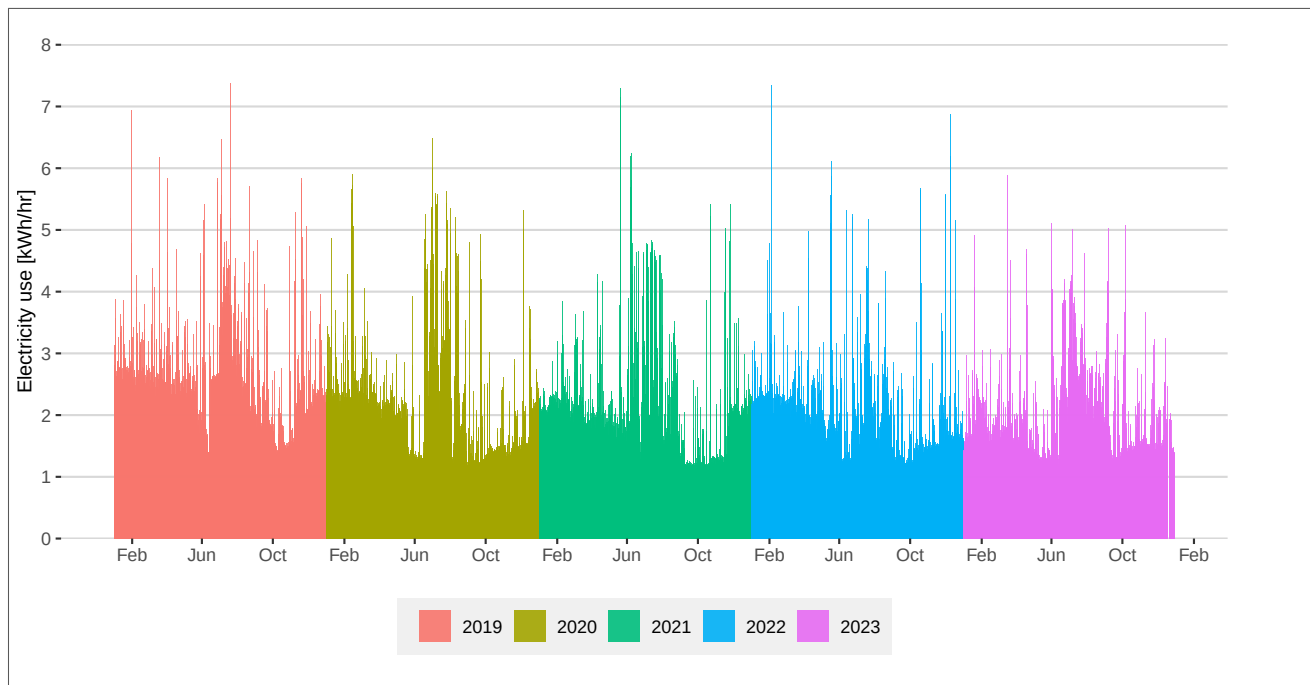


Figure 83: Hourly electricity use

The same hourly electricity use data is plotted in Figure 84, which highlights how electricity use is influenced by year, season, day of week and hour of day. The vertical axis on Figure 84 may be rescaled relative to in Figure 83 for greater resolution.

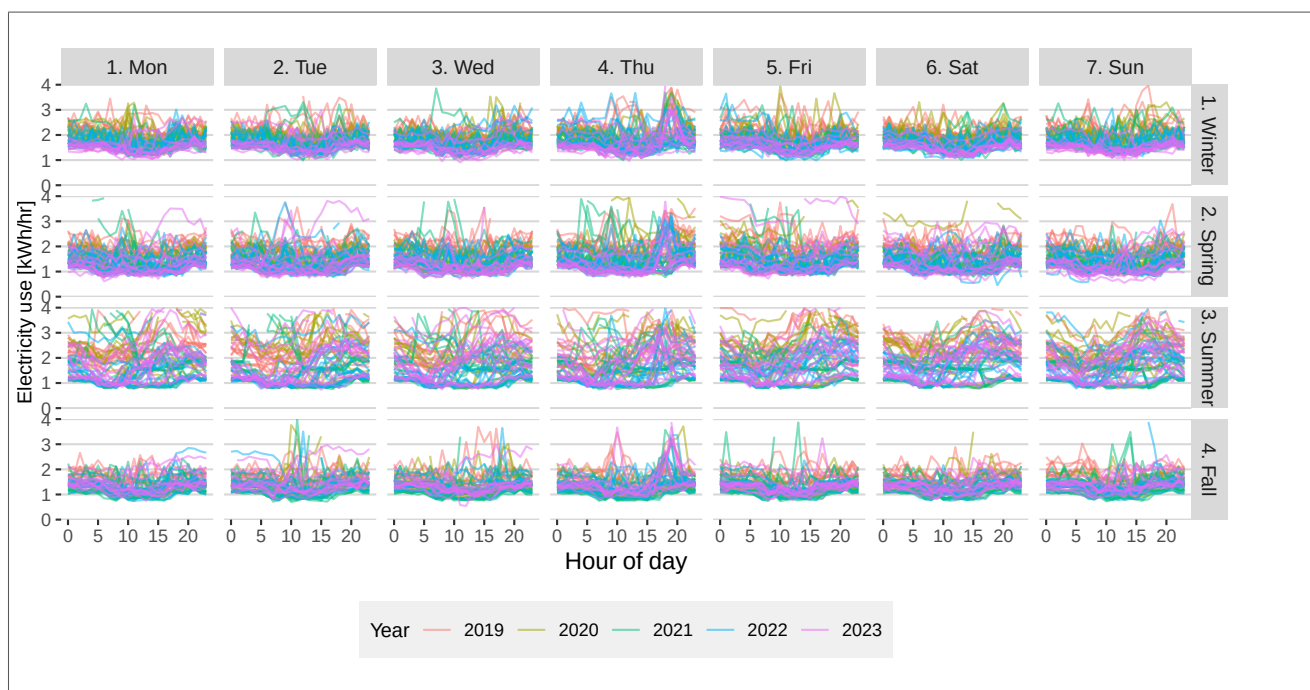


Figure 84: Hourly electricity use hairball plot

Monthly electricity use is plotted in Figure 85.

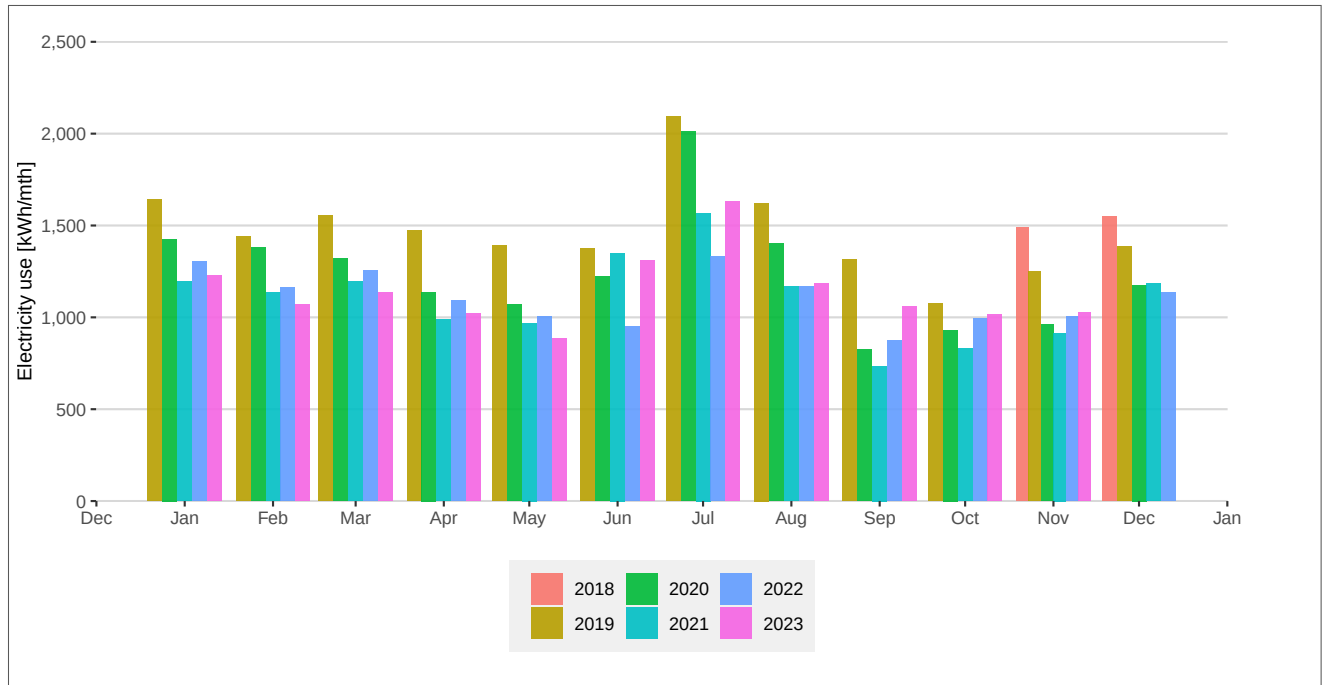


Figure 85: Monthly electricity use

3.4 Natural gas metered utility use

Monthly natural gas use is plotted in Figure 86.

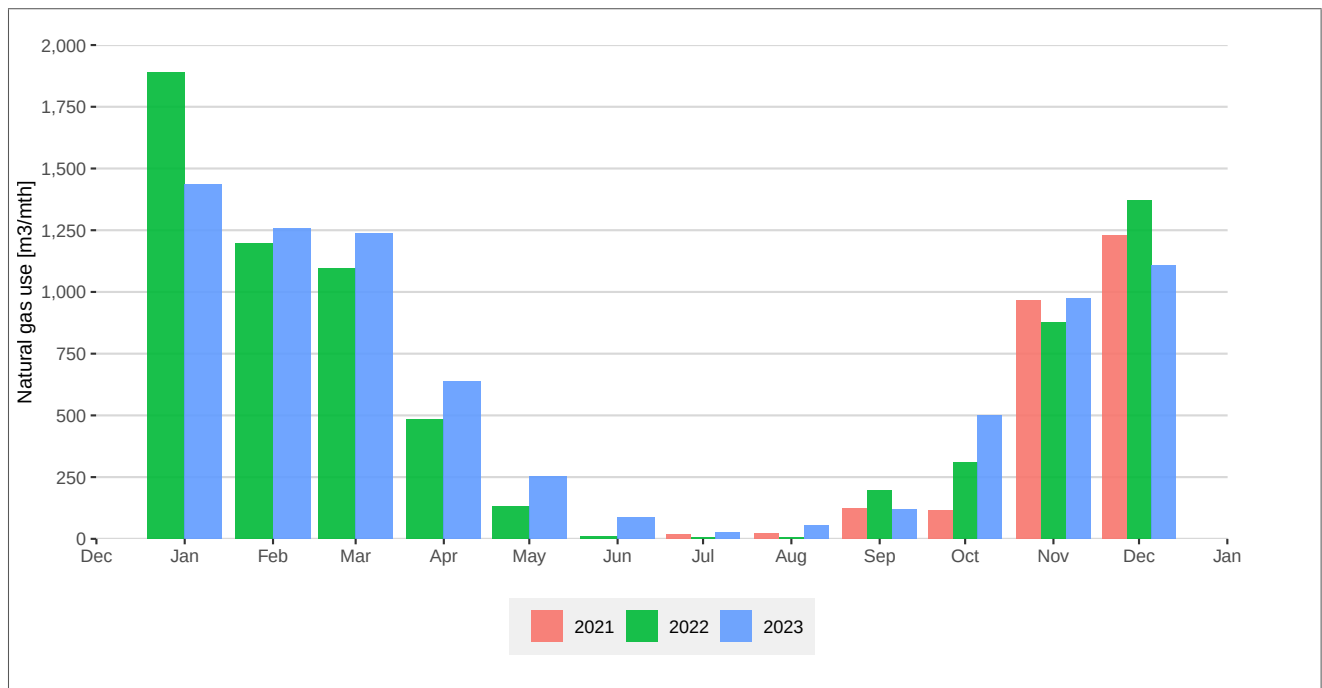


Figure 86: Monthly natural gas use

3.5 Utility use baseline

Baseline year

The baseline year for New Liskeard Fire Hall, 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]	13,273
	Natural gas use	[m3/yr]	7,986
	Carbon offset use	[tCO2e/yr]	0
Equivalent energy use	Electricity energy	[kWh/yr]	13,273
	Natural gas energy	[kWh/yr]	84,301
	Total energy	[kWh/yr]	97,574
GHG emissions	Electricity GHGs	[tCO2e/yr]	0
	Natural gas GHGs	[tCO2e/yr]	15
	Carbon offsets GHGs	[tCO2e/yr]	0
	Total GHGs	[tCO2e/yr]	16
Utility cost	Electricity utility cost	[\$/yr]	1,317
	Natural gas utility cost	[\$/yr]	2,076
	Carbon offsets utility cost	[\$/yr]	0
	Federal carbon charge	[\$/yr]	772
	Total utility cost	[\$/yr]	4,164

3.6 Benchmarking analysis

Benchmarking analysis results are presented in the following figures.

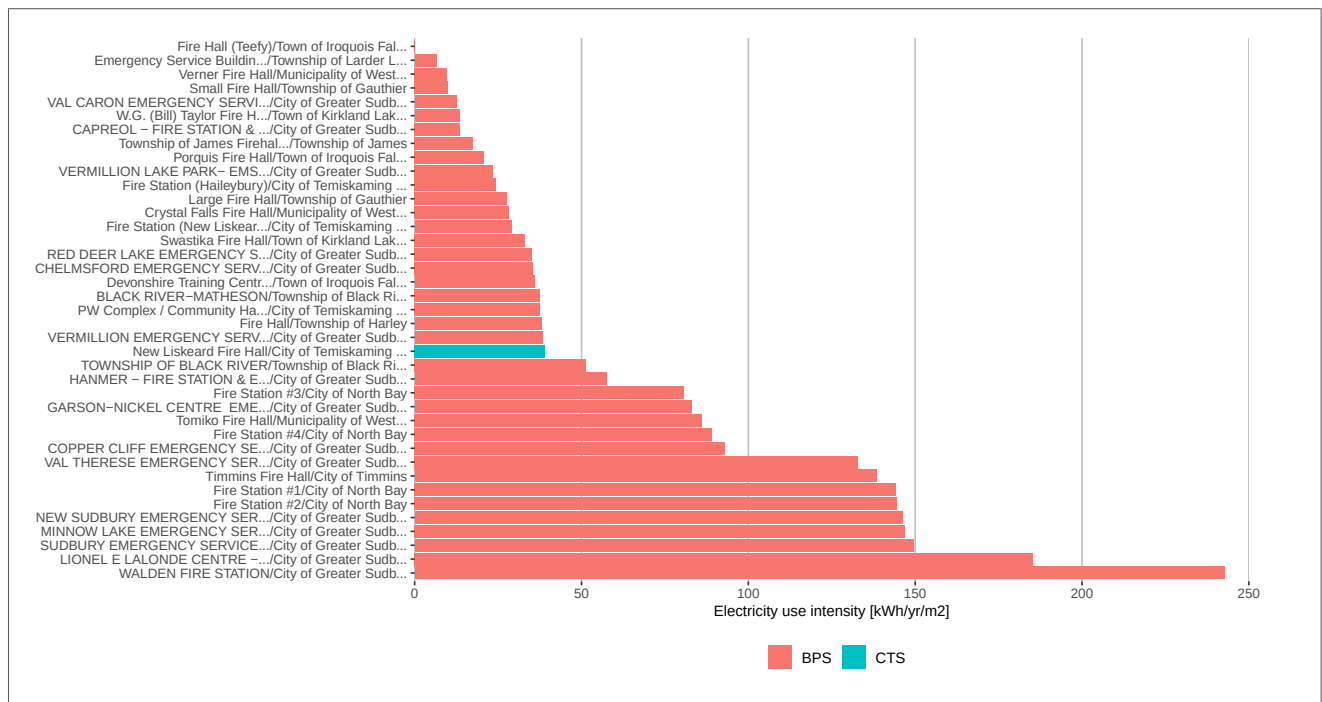


Figure 87: Electricity use intensity benchmarking analysis comparison

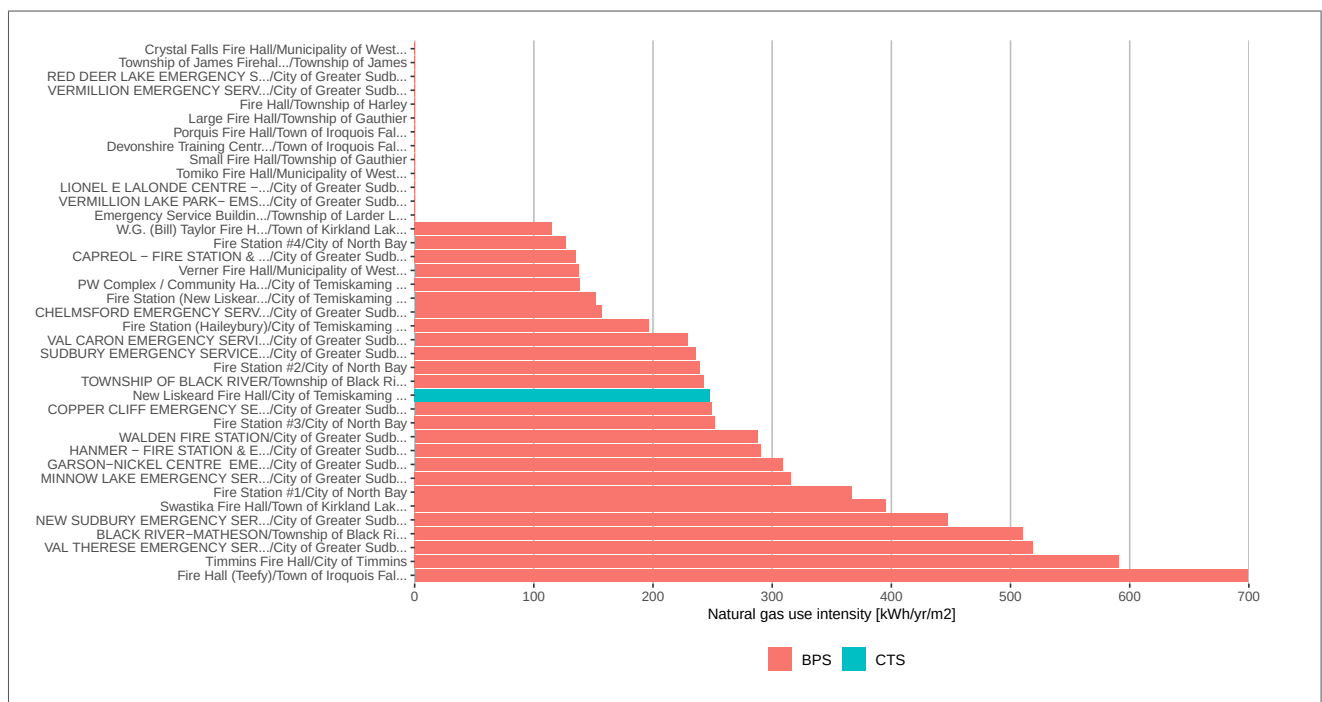


Figure 88: Natural gas use intensity benchmarking analysis comparison

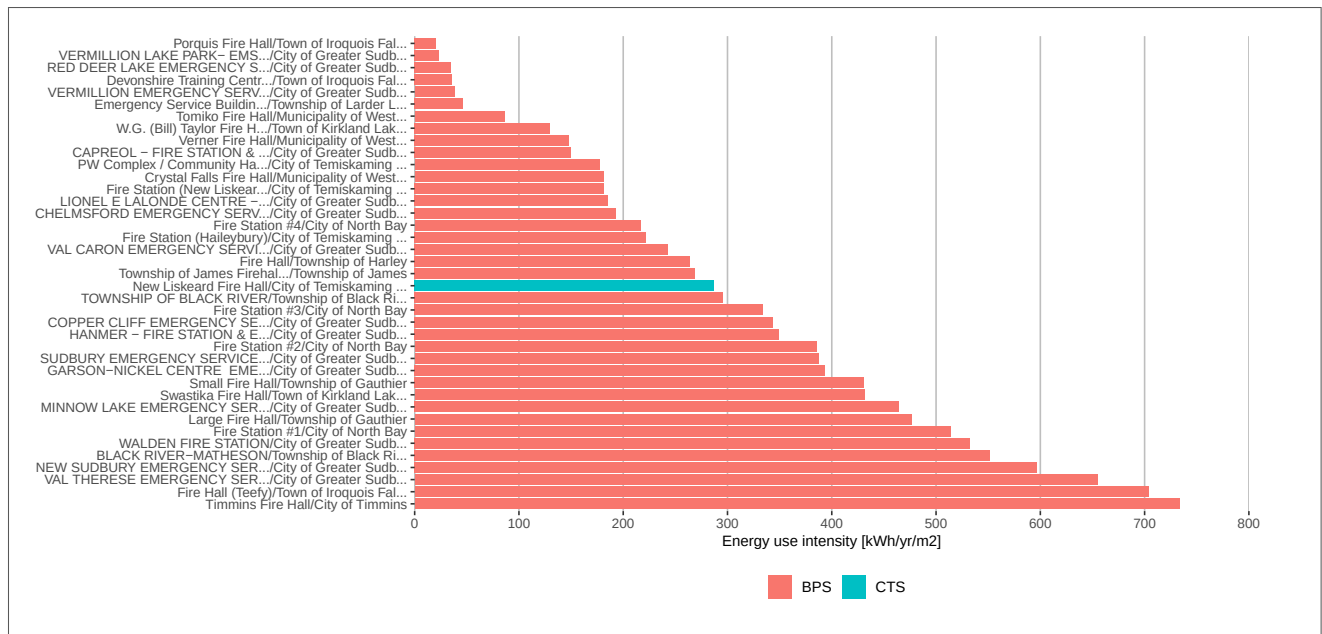


Figure 89: Total energy use intensity benchmarking analysis comparison

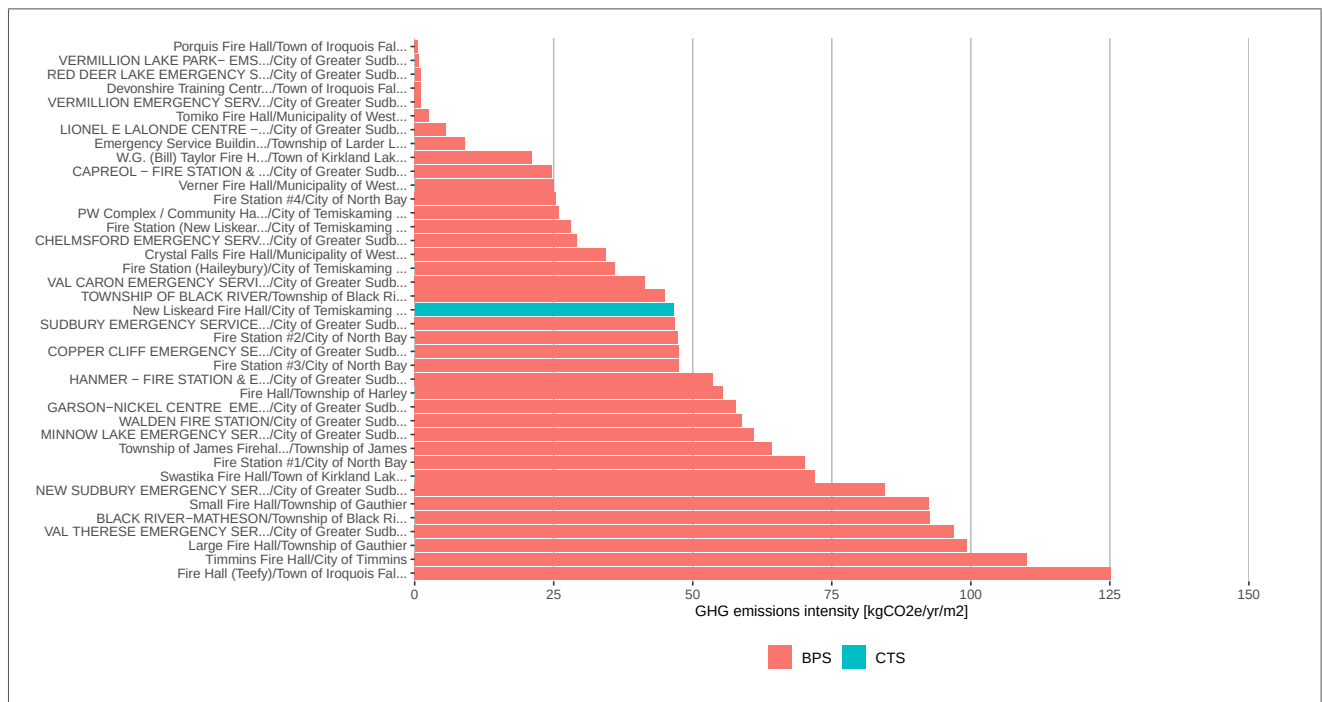


Figure 90: GHG emissions intensity benchmarking analysis comparison

3.7 ENERGY STAR Portfolio Manager benchmarking analysis

The scorecard is shown in Figure 91.

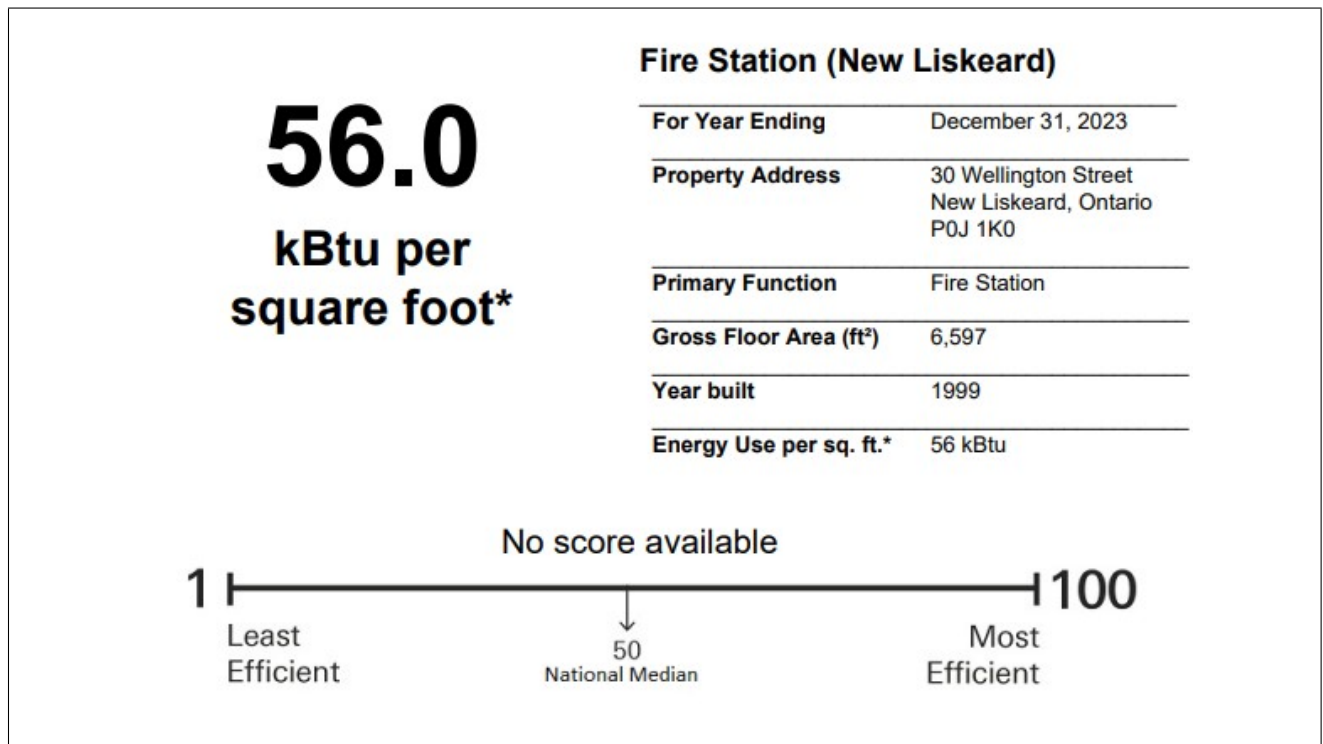


Figure 91: Energy Star energy performance scorecard.

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 summer, most likely due to cooling, with spikes in the winter, likely due to electric baseboard heating.
- Hourly consumption is typically under 7 kWh and above 1 kWh.
- Peaks in the winter and summer suggests heating in the winter and cooling in the summer.

Electricity - Monthly

- **2018:** The dataset provided started in November 2018 and did not allow for a full year of comparison. However, November and December for this year were notably higher than in future years.
- **2019:** Peak consumption in January and July with high overall consumption compared to future years.
- **2020:** There is a decrease in the monthly electricity use from 2019 to 2020. Because this trend continues to the present, and fire halls are necessary services which would have remained operational, it is not believed that there were any operational changes due to the pandemic.
- **2021:** Similar electricity profile to 2020, with a lower peak in July.
- **2022:** Similar electricity use to 2021.
- **2023:** Similar electricity use profile to 2022, with no data available for December.

Natural gas

- Natural gas consumption has maintained a consistent profile year over year. It is highest during the heating season and very low during the cooling season.
- This building has two natural gas end uses: space heating and domestic hot water.
- Of the thirty data points available for monthly natural gas consumption, only 12 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.
	Equipment	Equipment energy use.
	Exterior lights	Exterior lighting energy use.
	Fans	Fan motor energy use.
	Lights	Lighting energy use.
	Other	Metered use less modelled use.
	Space heat	Space heating energy use.
Natural gas	DHW heat	Domestic hot water heating energy use.
	Space heat	Space heating energy use.

- (b) *Weather data.* Hourly weather data was obtained from the Earleton-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).

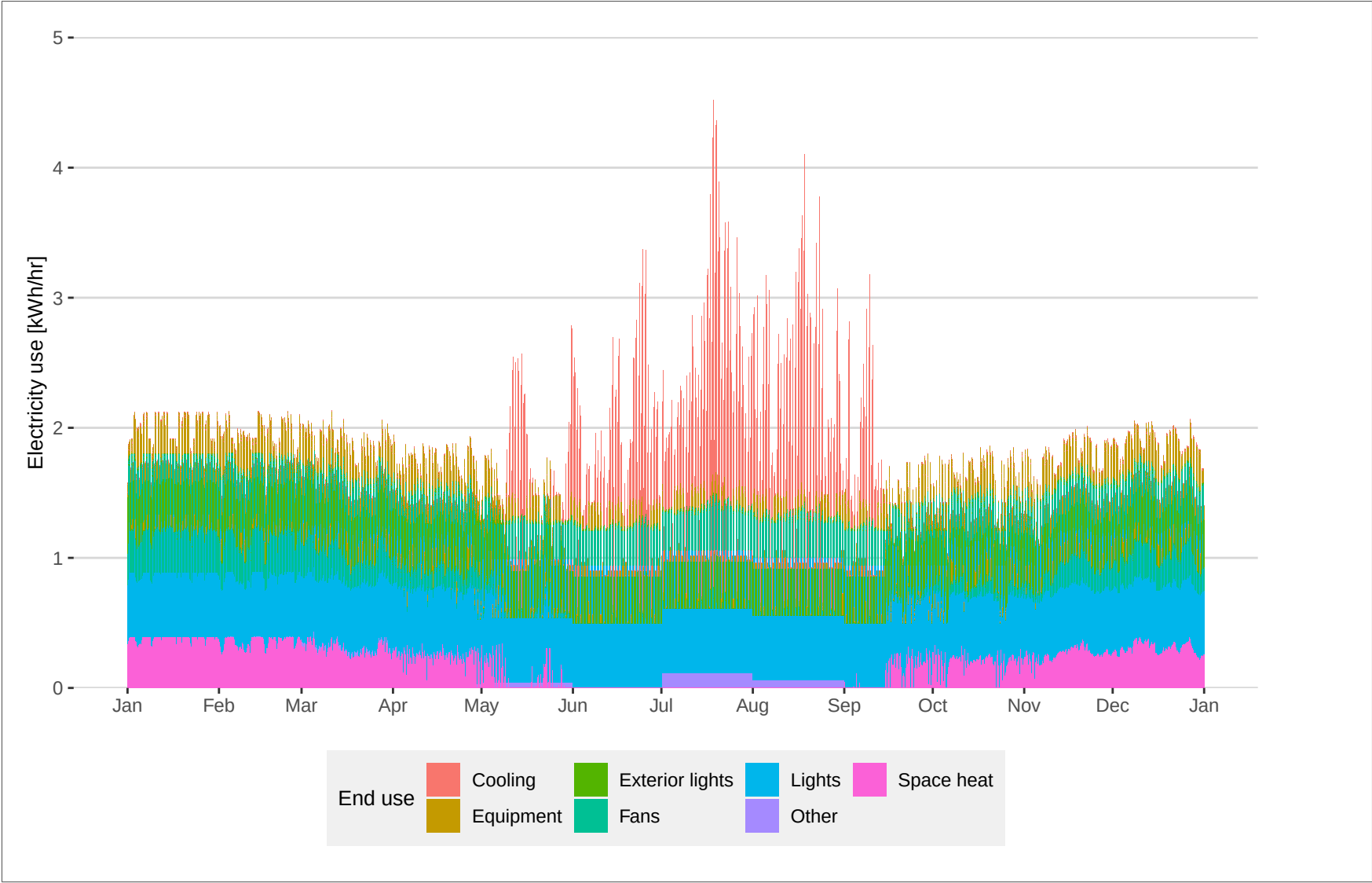
- (f) *Generators*. The utility use and generation of on-site systems that generate energy or utilities was modelled based on the assumed capacities and operations of those systems according to findings documented in Section 2; examples include solar PV, CHP, etc. Utilities generated on site were treated 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 92. See Table 16 for end use definitions.



Natural gas

The hourly natural gas utility use profile by end use made by the energy model is plotted in Figure 93. See Table 16 for end use definitions.

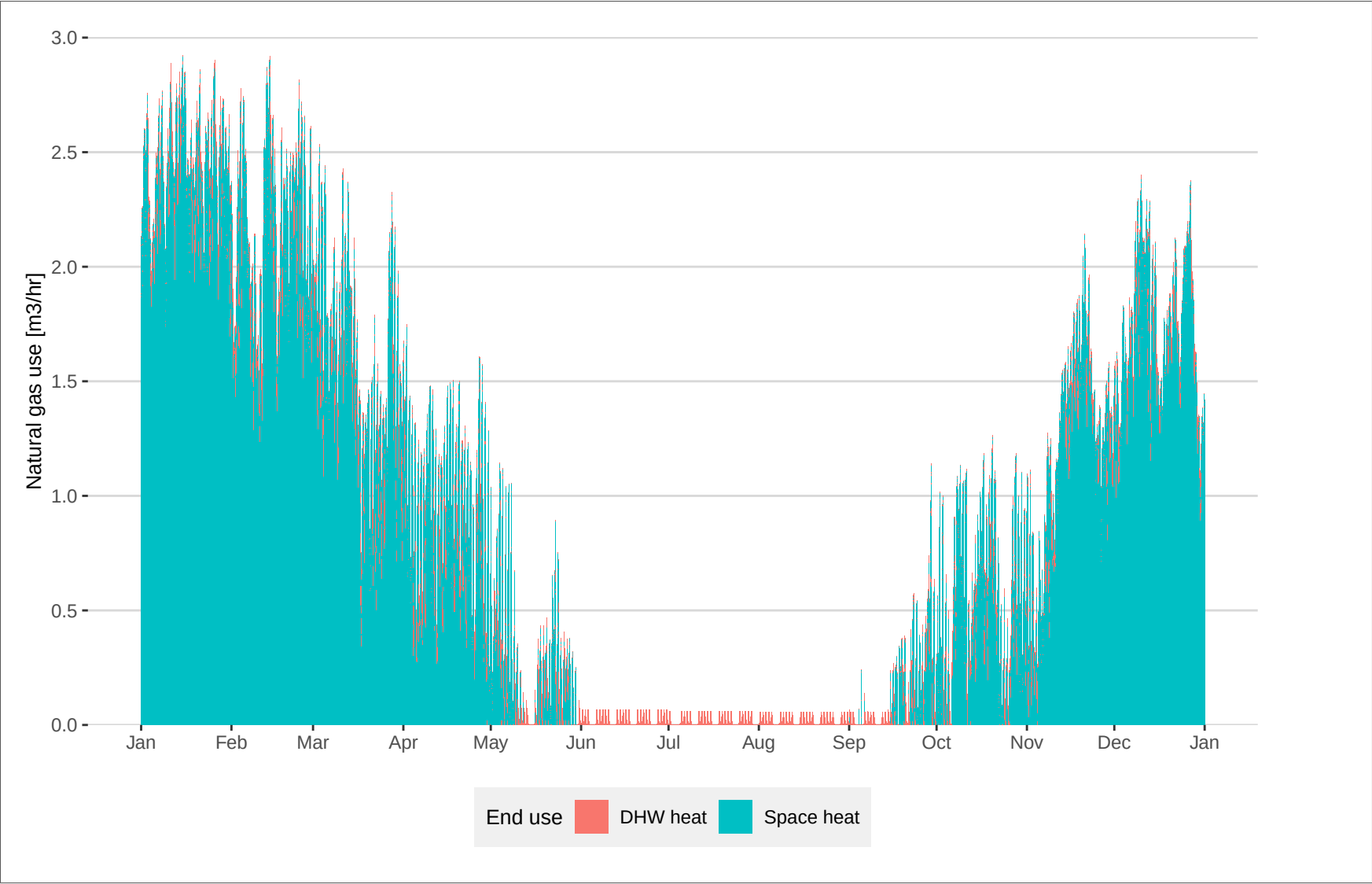


Figure 93: Hourly natural gas utility use by end use (made by calibrated energy model)

4.3 Monthly utility use profiles

Monthly utility use profiles for each modelled utility are presented in Figure 94.

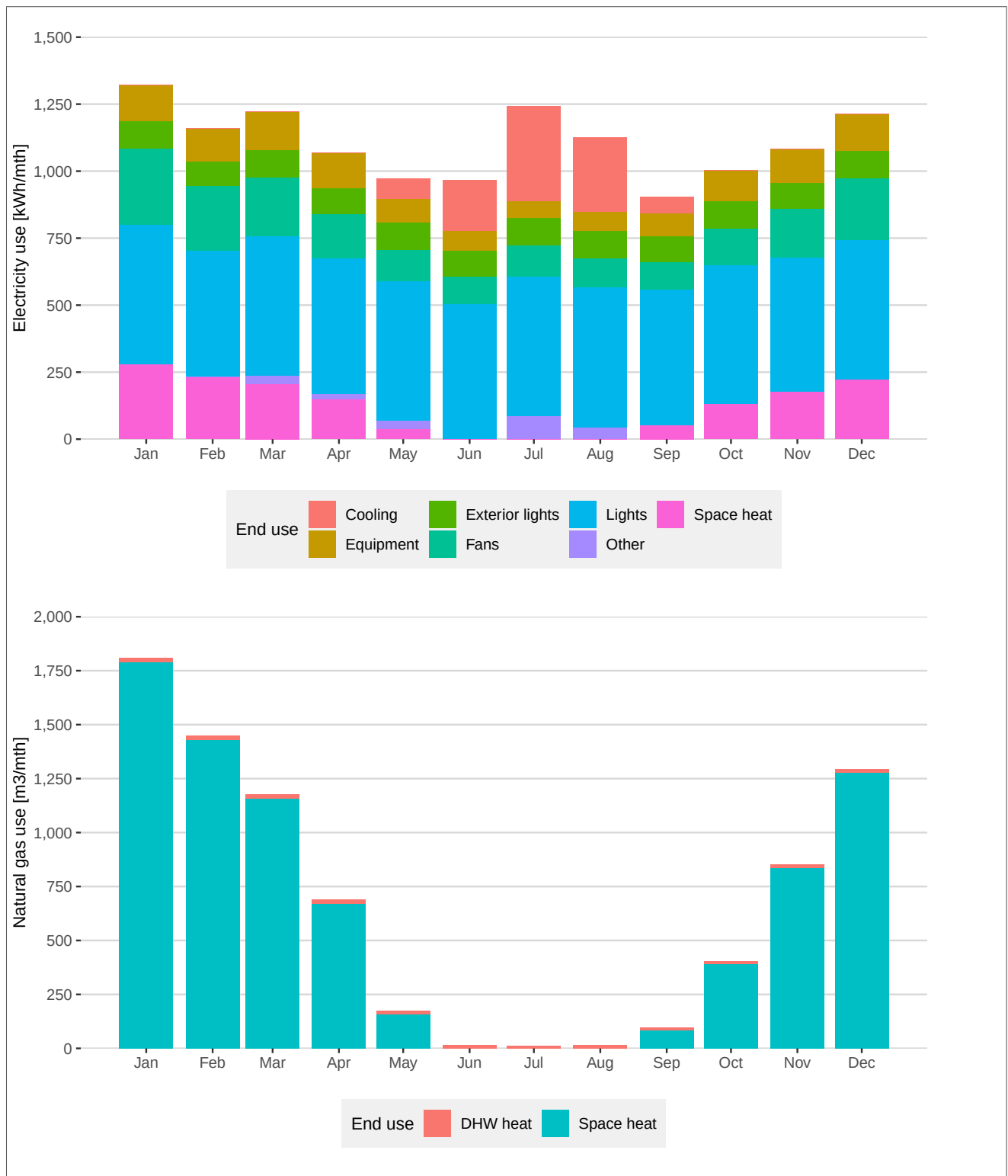


Figure 94: Monthly utility use profiles for each modelled utility

4.4 Calibration analysis

Electricity

Figure 95 compares the metered utility use with the modelled use to check how well the model is calibrated.

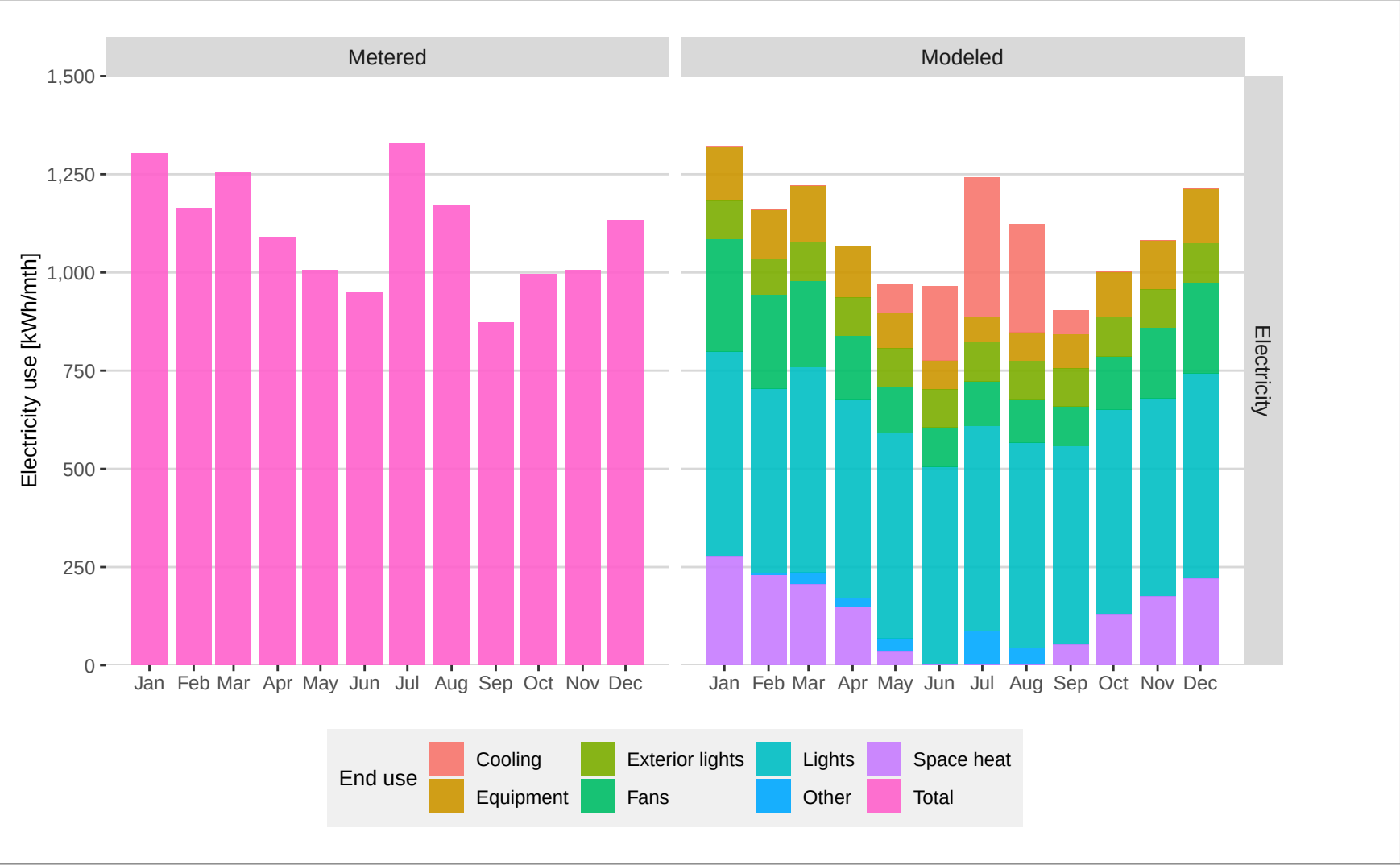


Figure 95: Electricity calibration analysis (metered vs modelled utility use)

Natural gas

Figure 96 compares the metered utility use with the modelled use to check how well the model is calibrated.

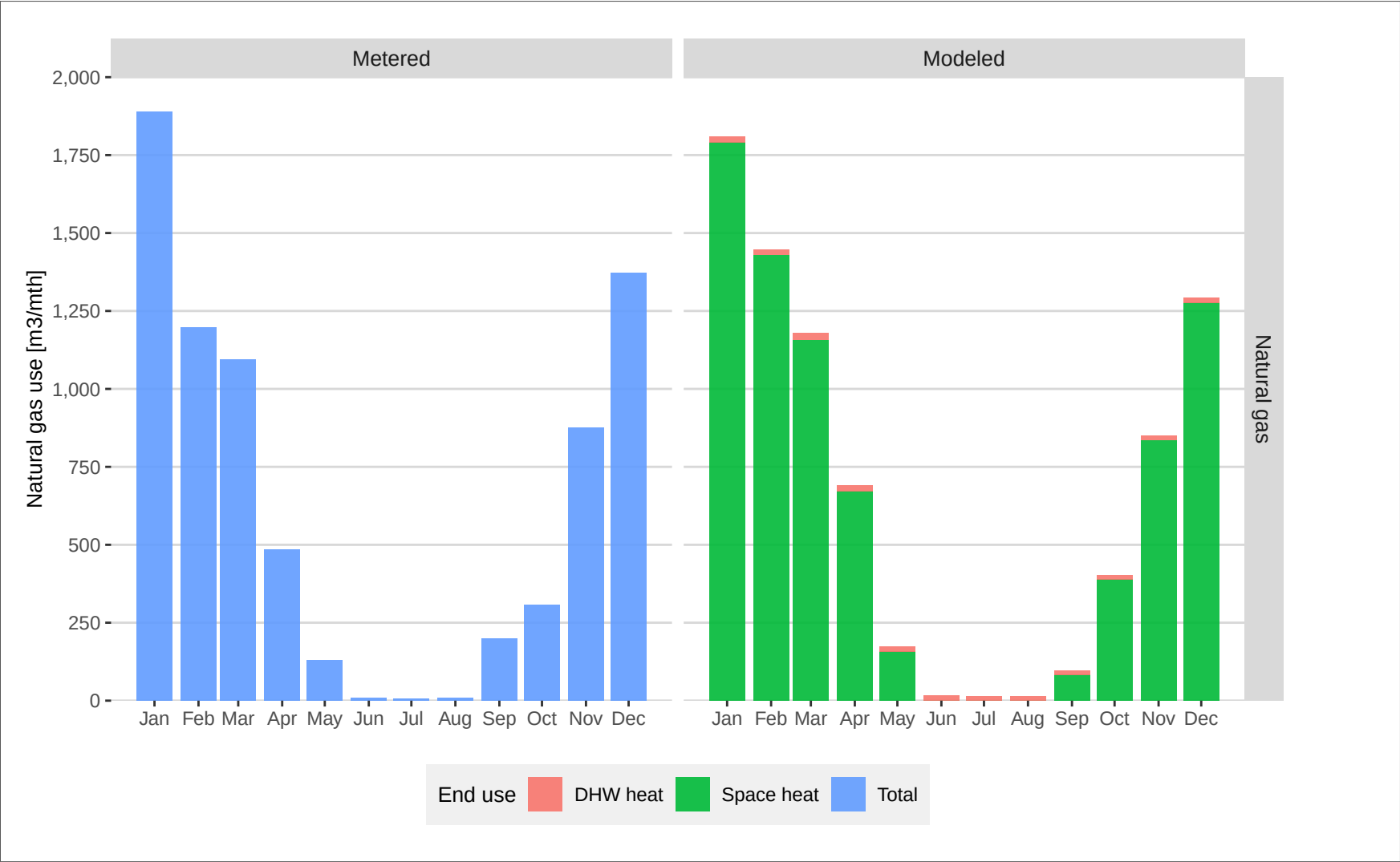


Figure 96: Natural gas calibration analysis (metered vs modelled utility use)

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	0.0	Pass
	Root mean square error	[%]	< 15	4.4	Pass
Natural gas	Mean bias error	[%]	< +/- 5	-5.9	Fail
	Root mean square error	[%]	< 15	18.3	Fail

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

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

- Figure 95 demonstrates a strong agreement between monthly trends observed in the metered utility use data and the monthly utility use predicted by the calibrated energy model. Figure 96 demonstrates a similar trend in the monthly utility use, although the modelled natural gas consumption is higher than the metered utility use.
- Electricity use was successfully calibrated according to the standards of ASHRAE Guideline 14. Note that the mean bias error is zero for electricity and natural gas because the Other end-use ensures that the yearly modelled utility use matches the yearly metered utility use. This process also maintains consistency between the baseline utility use derived from the metered utility data and all measure and scenario analyses.
- Natural gas consumption fails to follow Guideline 14 on the mean bias error and the root mean square error. Some notable issues are that consumption is higher in the model from February through March and October. Another note is that only 5 of 12 natural gas readings are actual readings. This issue makes it difficult to calibrate the model, especially against estimated data that the LDC typically underestimates.
- The successful energy model calibration is largely due to the methodology used in developing the calibrated energy model. Under this methodology, the major systems affecting utility use were studied in detail (see Section 2), including their operations from information gained during the site survey, so that these systems could be explicitly modelled one-to-one, precisely reflecting the unique operations associated with each system. Examples of such major systems include both furnaces (F1 and F2) and the natural gas unit heater.

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

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

Electricity

- Figure 95 indicates strong agreement between modelled and metered data.
- The peak and trough hourly consumption align with the metered interval data.

Natural gas

- Figure 96 indicates higher modelled natural gas use than the metered natural gas consumption.
- To achieve better alignment between the modelled and metered natural gas use, a relatively low infiltration rate was assumed for the building (0.25 lps/m² envelope). In addition, although the unit heater temperature was observed to be 69F during the site survey, it was assumed that this temperature is varied and kept at an average of 62F throughout the year.

4.5 End use analysis

Electricity

The yearly electricity end use breakdown calculated by the energy model is plotted in Figure 97. See Table 16 for end use definitions.

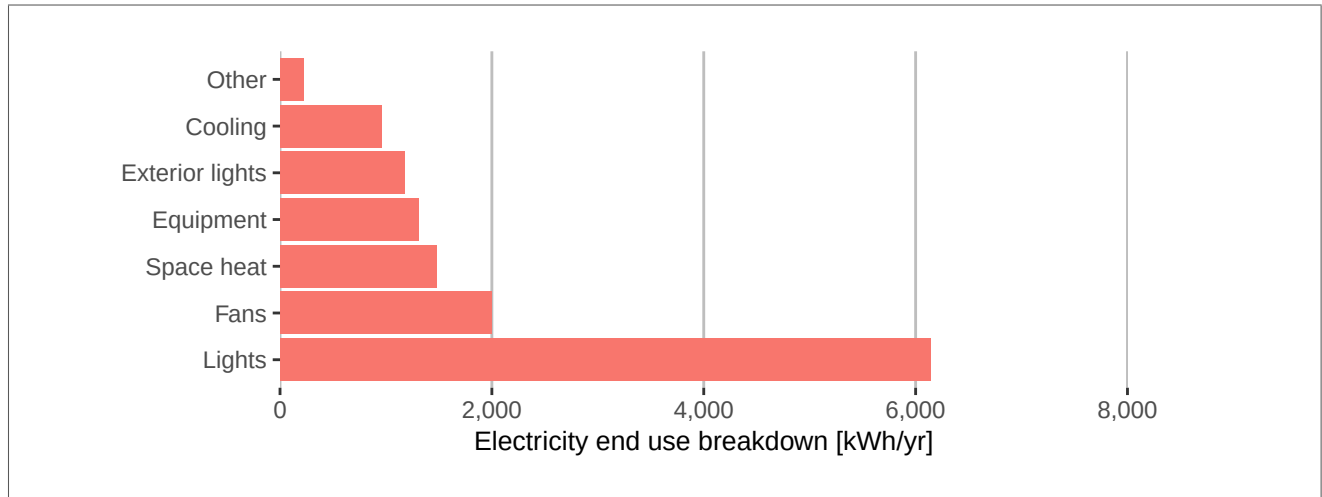


Figure 97: Electricity end use breakdown (calculated by calibrated energy model)

Natural gas

The yearly natural gas end use breakdown calculated by the energy model is plotted in Figure 98. See Table 16 for end use definitions.

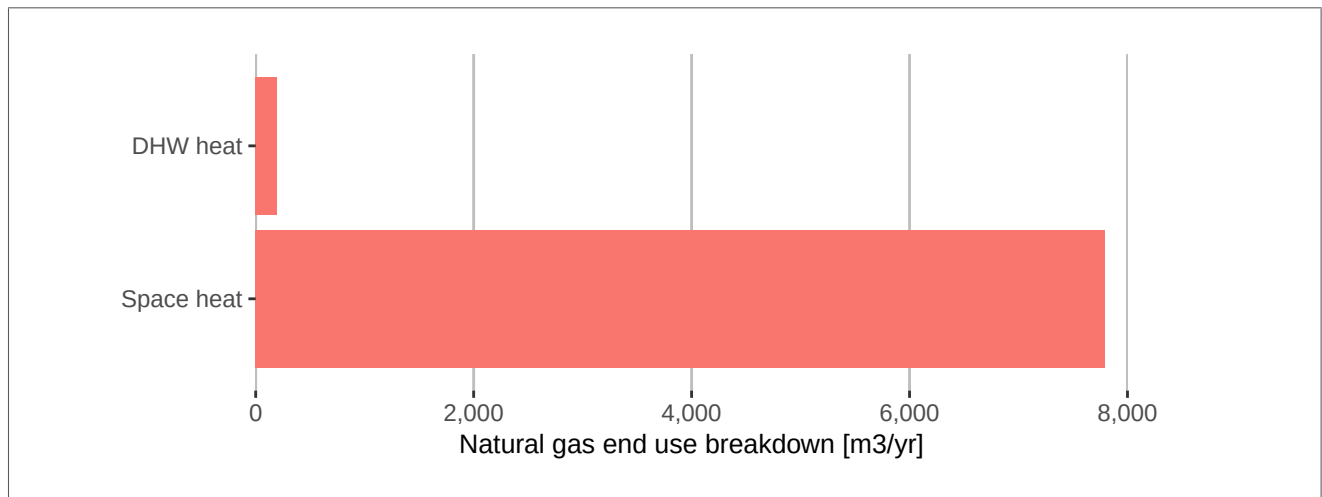


Figure 98: Natural gas end use breakdown (calculated by calibrated energy model)

5 MEASURE ANALYSIS

5.1 Measure analysis methodology

The measure analysis was completed according to the following methodology.

1. **Measure identification and triaging.** Measures that could be implemented to help achieve City of Temiskaming Shores's goals were identified based on the findings documented in Sections 2 and 3. Identified measures were triaged by labeling each one as either 'Analyzed' or 'Not analyzed'. The intent of triaging was to focus efforts on analyzing measures for which analysis was considered most valuable (typically for measures that are more complex or more impactful). Results are summarized in Section 5.3.
2. **Measure analysis.** For each 'Analyzed' measure, the analysis completed for that measure was summarized in a dedicated sub-section named after that measure (see Sections 5.4 through 5.14). In each sub-section, the following was documented.
 - *Measure description.* The relevant existing condition was summarized, an opportunity for improving the stated existing condition was described, and the intended utility-savings mechanism associated with the opportunity was described.
 - *Design description.* A conceptual design description was provided, including a written description of the proposed design concept and the associated project cost estimate.
 - *Utility analysis.* A utility analysis was completed using the energy model introduced in Section 4. Measure-specific assumptions applied in calculating the impacts on utility use were provided for each measure. For each measure, the expected GHG emissions, utility costs and financial incentives associated with implementing the measure were calculated based on utility use, using the assumptions outlined in Section 5.2. A life cycle cost analysis was completed, applying the assumptions summarized in Tables 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 2025 for each measure. The life cycle cost for each measure was calculated as the sum of the following future financial cost expenditures, discounted back to present value using the discount rate from Table 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 5.15.

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

5.2 Measure analysis assumptions

Assumptions general to all measures are as follows.

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

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

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

5.3 Measure identification

Results of the measure identification and triaging process are summarized in Table 22.

Table 22: Measure identification and triaging summary

Measure name	Triage for analysis
Baseline	
Carbon offsets 20	Analyzed.
DHW heater to ASHP	Analyzed.
Exterior LED lighting upgrade	Analyzed.
Furnace conversion to ASHP with electric backup	Analyzed.
Furnace conversion to ASHP with natural gas backup	Analyzed.
Interior LED lighting upgrade	Analyzed.
Roof upgrade to high performance	Analyzed.
Solar PV rooftop	Analyzed.
Unit heater 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.
F1 renewal	Business as usual.
F2 renewal	Business as usual.
Interior lighting renewal	Business as usual.
Roof renewal	Business as usual.
UH renewal	Business as usual.
Windows renewal	Business as usual.

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]	13,273	13,273	0	0
	Natural gas use	[m3/yr]	7,986	7,986	0	0
	Carbon offset use	[tCO ₂ e/yr]	0	3.2	-3.2	—
Equivalent energy use	Electricity energy	[kWh/yr]	13,273	13,273	0	0
	Natural gas energy	[kWh/yr]	84,301	84,301	0	0
	Total energy	[kWh/yr]	97,574	97,574	0	0
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	0.40	0.40	0	0
	Natural gas GHGs	[tCO ₂ e/yr]	15.4	15.4	0	0
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	-3.2	3.2	—
	Total GHGs	[tCO ₂ e/yr]	15.8	12.7	3.2	20
Utility cost	Electricity utility cost	[\$/yr]	1,317	1,317	0	0
	Natural gas utility cost	[\$/yr]	2,076	2,076	0	0
	Carbon offsets utility cost	[\$/yr]	0	95.0	-95.0	—
	Federal carbon charge	[\$/yr]	772	772	0	0
	Total utility cost	[\$/yr]	4,164	4,259	-95.0	-2.3
Financial	Assumed life	[yrs]	—	20	—	—
	Project cost	[\$]	0	—	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	—	—	—
	Life cycle cost	[\$]	92,413	94,244	—	—
	Net present value	[\$]	0	-1,831	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	—	—	—
	Simple payback period	[yr]	—	—	—	—

5.5 DHW heater to ASHP

Measure description

Existing condition

A natural gas-fired DHW heater serves DHW heating.



Opportunity

Replace the gas-fired DHW heater with an 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

It is recommended that the gas-fired domestic hot water (DHW) heater be replaced with a hybrid air-source heat pump (ASHP) option that extracts heat from the surrounding air to heat water. The hybrid ASHP water heater will be operated in a hybrid mode, such that its electric resistance heating elements only operate when the space temperature drops below 50F.

Replace the existing 50USG tank with an 80USG Rheem Proterra DHW HP.

Electrical

The ASHP will add approximately 4kW of power to the existing system, which will put the system at 12.4 kW, which is approximately 33% of the full load of the electrical capacity of the building.

Project cost estimate

Table 24: Project cost estimate (DHW heater to ASHP)

Category	Line item	Unit	Value
Materials and labour	Supply	[\$]	4,500
	Install	[\$]	2,000
	Electrical contingency	[\$]	12,000
Contingency	Subtotal after Materials and labour	[\$]	18,500
	General Contingency (50%)	[\$]	9,200
Total	Total	[\$]	27,700

Utility analysis

Utility analysis methodology

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

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

Utility analysis results

Table 25: DHW heater to ASHP analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	13,273	14,166	-894	-6.7
	Natural gas use	[m3/yr]	7,986	7,792	194	2.4
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	13,273	14,166	-894	-6.7
	Natural gas energy	[kWh/yr]	84,301	82,256	2,045	2.4
	Total energy	[kWh/yr]	97,574	96,422	1,151	1.2
GHG emissions	Electricity GHGs	[tCO2e/yr]	0.40	0.43	-0.03	-6.7
	Natural gas GHGs	[tCO2e/yr]	15.4	15.1	0.37	2.4
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	15.8	15.5	0.35	2.2
Utility cost	Electricity utility cost	[\$/yr]	1,317	1,405	-88.7	-6.7
	Natural gas utility cost	[\$/yr]	2,076	2,026	50.4	2.4
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	772	753	18.7	2.4
	Total utility cost	[\$/yr]	4,164	4,184	-19.6	-0.47
Financial	Assumed life	[yrs]	—	15	—	—
	Project cost	[\$]	0	27,700	—	—
	Incentive amount	[\$]	0	48.4	—	—
	Incremental project cost	[\$]	0	27,652	—	—
	Life cycle cost	[\$]	92,413	128,111	—	—
	Net present value	[\$]	0	-35,697	—	—
	Project cost per GHG reduction	[\$/yr/tCO2e]	—	79,603	—	—
	Simple payback period	[yr]	—	—	—	—

5.6 Exterior LED lighting upgrade

Measure description

Existing condition

The exterior lighting consists of LED wall packs and HPS fixtures.



Opportunity

Replace all non-LED fixtures with LED equivalent fixtures.

Utility-savings mechanism

Reduced lighting energy use through more energy-efficient lamps. Given that 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 Fire Hall 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 IESO's 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 G fixtures should be replaced.

Project cost estimate

Table 26: 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:** The HPS downlight is assumed to consume 70 W.
- **Proposed:** It is assumed that the HPS downlight is replaced with an LED equivalent which consumes 42 W.

Utility analysis results

Table 27: Exterior LED lighting upgrade analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	13,273	13,155	117	0.88
	Natural gas use	[m3/yr]	7,986	7,986	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	13,273	13,155	117	0.88
	Natural gas energy	[kWh/yr]	84,301	84,301	0	0
	Total energy	[kWh/yr]	97,574	97,456	117	0.12
GHG emissions	Electricity GHGs	[tCO2e/yr]	0.40	0.40	0.00	0.88
	Natural gas GHGs	[tCO2e/yr]	15.4	15.4	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	15.8	15.8	0.00	0.02
Utility cost	Electricity utility cost	[\$/yr]	1,317	1,305	11.7	0.88
	Natural gas utility cost	[\$/yr]	2,076	2,076	0	0
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	772	772	0	0
	Total utility cost	[\$/yr]	4,164	4,153	11.6	0.28
Financial	Assumed life	[yrs]	—	15	—	—
	Project cost	[\$]	0	1,500	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	1,500	—	—
	Life cycle cost	[\$]	92,413	93,946	—	—
	Net present value	[\$]	0	-1,533	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	422,928	—	—
	Simple payback period	[yr]	—	>20	—	—

5.7 Furnace conversion to ASHP with electric backup

Measure description

Existing condition

Two furnaces serve the first floor (F1) and second floor (F2), excluding the apparatus bay. Both furnaces have natural gas-fired burners and DX cooling.



Opportunity

Replace the furnaces and use air-source heat pumps with electric back up as the heating and cooling source.

Utility-savings mechanism

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

Design description

Overview

Replace existing furnace/AC combos with cold climate ASHPs and backup electric resistance. A total of two units will be supplied for the building and will be connected to the existing ductwork.

- F1 - Moovair - Central-Moov 5T Capacity with 20kW backup electric
- F2 - Moovair - Central-Moov 4T Capacity with 10kW backup electric

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

Electrical

The ASHP with the electric backup will add approximately 43.5kW of power to the existing system, which will put the system at 50.9 kW, which is approximately 133% of the full load of the electrical capacity of the building. This measure will require a system upgrade to a 75kW transformer, or a 400A 208V-3PH service. The existing 200A 240A panel can be powered from the new 400A panel.

Project cost estimate

Table 28: Project cost estimate (Furnace conversion to ASHP with electric backup)

Category	Line item	Unit	Value
Construction	Supply	[\$]	22,500
	Install	[\$]	15,000
	Electrical contingency	[\$]	166,000
	General requirements (25%)	[\$]	50,900
Contingency	Subtotal after Construction	[\$]	254,400
	Design Contingency (25%)	[\$]	63,600
	Construction Contingency (10%)	[\$]	25,400
Design, Contractors, PM	Subtotal after Contingency	[\$]	343,400
	Engineering Design and Field Review (10%)	[\$]	34,300
	Contractor Fee (7%)	[\$]	24,000
Total	Total	[\$]	401,700

Utility analysis

Utility analysis methodology

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

- **Baseline:** These furnaces provide space heating and cooling through natural gas-fired burners and DX, respectively. The existing heating efficiencies are 97% (for F1) and 76% (for F2), and the cooling COPs are 3.5.
- **Proposed:** These furnaces provide space heating and cooling through air-source heat pumps. The proposed average heating and cooling COPs are 3 and 4.1 (14 EER), respectively. Backup heating is provided through electric resistance when the outdoor air temperature is below -15 C.

Utility analysis results

Table 29: Furnace conversion to ASHP with electric backup analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	13,273	41,477	-28,204	-212
	Natural gas use	[m3/yr]	7,986	2,903	5,083	63.7
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	13,273	41,477	-28,204	-212
	Natural gas energy	[kWh/yr]	84,301	30,641	53,660	63.7
	Total energy	[kWh/yr]	97,574	72,118	25,456	26.1
GHG emissions	Electricity GHGs	[tCO2e/yr]	0.40	1.3	-0.85	-212
	Natural gas GHGs	[tCO2e/yr]	15.4	5.6	9.8	63.7
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	15.8	6.9	9.0	56.7
Utility cost	Electricity utility cost	[\$/yr]	1,317	4,115	-2,798	-212
	Natural gas utility cost	[\$/yr]	2,076	755	1,322	63.7
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	772	280	491	63.7
	Total utility cost	[\$/yr]	4,164	5,150	-985	-23.7
Financial	Assumed life	[yrs]	—	20	—	—
	Project cost	[\$]	0	401,700	—	—
	Incentive amount	[\$]	0	80,340	—	—
	Incremental project cost	[\$]	0	321,360	—	—
	Life cycle cost	[\$]	92,413	499,198	—	—
	Net present value	[\$]	0	-406,785	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	35,825	—	—
	Simple payback period	[yr]	—	—	—	—

5.8 Furnace conversion to ASHP with natural gas backup

Measure description

Existing condition

Two furnaces serve the first floor (F1) and second floor (F2), excluding the apparatus bay. Both furnaces have natural gas-fired burners and DX cooling.



Opportunity

Replace the furnaces and use air-source heat pumps with natural gas back up as the heating and cooling source.

Utility-savings mechanism

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

Design description

Overview

Replace existing AC units with Cold Climate ASHPs, with the existing gas furnaces as backup heating. A total of two units will be supplied for the building and will be connected to the existing ductwork. The new ASHP condensing units will be sized to the maximum allowable airflow from the furnaces and ductwork.

- F1 - Moovair - Central-Moov Addon 4T Capacity
- F2 - Moovair - Central-Moov Addon 3T Capacity

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

Electrical

The ASHP will add approximately 10.5kW of power to the existing system, which will put the system at 17.9 kW, which is approximately 47% of the full load of the electrical capacity of the building.

Project cost estimate

Table 30: Project cost estimate (Furnace conversion to ASHP with natural gas backup)

Category	Line item	Unit	Value
Construction	Supply	[\$]	14,000
	Install	[\$]	10,000
	Electrical contingency	[\$]	8,000
	General requirements (25%)	[\$]	8,000
Contingency	Subtotal after Construction	[\$]	40,000
	Design Contingency (25%)	[\$]	10,000
	Construction Contingency (10%)	[\$]	4,000
Design, Contractors, PM	Subtotal after Contingency	[\$]	54,000
	Engineering Design and Field Review (10%)	[\$]	5,400
	Contractor Fee (7%)	[\$]	3,800
Total	Total	[\$]	63,200

Utility analysis

Utility analysis methodology

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

- **Baseline:** These furnaces provide space heating and cooling through natural gas-fired burners and DX, respectively. The existing heating efficiencies are 97% (for F1) and 76% (for F2), and the cooling COPs are 3.5.
- **Proposed:** These furnaces provide space heating and cooling through air-source heat pumps. The proposed average heating and cooling COPs are 3 and 4.1 (14 EER), respectively. Backup heating is provided from the existing gas-fired furnaces when the outdoor air temperature is below -15 C.

Utility analysis results

Table 31: Furnace conversion to ASHP with natural gas backup analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	13,273	29,996	-16,724	-126
	Natural gas use	[m3/yr]	7,986	4,257	3,728	46.7
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	13,273	29,996	-16,724	-126
	Natural gas energy	[kWh/yr]	84,301	44,943	39,358	46.7
	Total energy	[kWh/yr]	97,574	74,939	22,634	23.2
GHG emissions	Electricity GHGs	[tCO2e/yr]	0.40	0.91	-0.51	-126
	Natural gas GHGs	[tCO2e/yr]	15.4	8.2	7.2	46.7
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	15.8	9.1	6.7	42.3
Utility cost	Electricity utility cost	[\$/yr]	1,317	2,976	-1,659	-126
	Natural gas utility cost	[\$/yr]	2,076	1,107	969	46.7
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	772	411	360	46.7
	Total utility cost	[\$/yr]	4,164	4,494	-329	-7.9
Financial	Assumed life	[yrs]	—	20	—	—
	Project cost	[\$]	0	63,200	—	—
	Incentive amount	[\$]	0	12,640	—	—
	Incremental project cost	[\$]	0	50,560	—	—
	Life cycle cost	[\$]	92,413	175,275	—	—
	Net present value	[\$]	0	-82,862	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	7,547	—	—
	Simple payback period	[yr]	—	—	—	—

5.9 Interior LED lighting upgrade

Measure description

Existing condition

The interior lighting utilizes fluorescent fixtures, including T8 and T12 lamps.



Opportunity

Replace all non-LED fixtures with LED equivalent 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 Fire Hall 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 IESO's 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, B, D, E, F, F1, and I 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	[\$]	15,000
Contingency	Subtotal after Materials and labour	[\$]	15,000
	General Contingency (50%)	[\$]	7,500
Total	Total	[\$]	22,500

Utility analysis

Utility analysis methodology

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

- **Baseline:** It is assumed that there is an average lpd of 10.8 W/m².
- **Proposed:** It is assumed that the average lpd is reduced to 6.48 W/m². 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]	13,273	10,753	2,519	19.0
	Natural gas use	[m ³ /yr]	7,986	8,158	-173	-2.2
	Carbon offset use	[tCO ₂ e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	13,273	10,753	2,519	19.0
	Natural gas energy	[kWh/yr]	84,301	86,125	-1,824	-2.2
	Total energy	[kWh/yr]	97,574	96,878	695	0.71
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	0.40	0.32	0.08	19.0
	Natural gas GHGs	[tCO ₂ e/yr]	15.4	15.8	-0.33	-2.2
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	0	0	—
	Total GHGs	[tCO ₂ e/yr]	15.8	16.1	-0.26	-1.6
Utility cost	Electricity utility cost	[\$/yr]	1,317	1,067	250	19.0
	Natural gas utility cost	[\$/yr]	2,076	2,121	-44.9	-2.2
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	772	788	-16.7	-2.2
	Total utility cost	[\$/yr]	4,164	3,976	188	4.5
Financial	Assumed life	[yrs]	—	15	—	—
	Project cost	[\$]	0	22,500	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	22,500	—	—
	Life cycle cost	[\$]	92,413	114,200	—	—
	Net present value	[\$]	0	-21,787	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	-87,257	—	—
	Simple payback period	[yr]	—	>20	—	—

5.10 Roof upgrade to high performance

Measure description

Existing condition

A total of three roof assembly types were identified at the New Liskeard Fire Hall. The exterior finish included asphalt and gravel. The U-Values range from 0.182 W/m²K to 0.290 W/m²K.



Opportunity

Upgrade upon the end of useful life.

Utility-savings mechanism

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

Design description

Overview

The thermal performance of the flat roofs over the garage and offices currently relies on 1.5 inches of rigid insulation installed on wood decking, resulting in an overall thermal performance rating of approximately R9. This is significantly below the current code minimum requirements.

To improve this, we recommend increasing the amount of rigid insulation when the roof membrane is replaced. Specifically, we suggest adding an additional 10 inches of rigid insulation to the existing layer. This upgrade will necessitate adjusting the parapets and installing new parapet flashing, as well as transition membranes to connect to the air barrier in the wall assembly.

By following this approach, the thermal performance of the new assembly would reach R45, exceeding the current building code minimum requirement of R40.

Project cost estimate

Table 34: Project cost estimate (Roof upgrade to high performance)

Category	Line item	Unit	Value
Construction	Roof replacement	[\$]	251,000
	General requirements (25%)	[\$]	62,800
Contingency	Subtotal after Construction	[\$]	313,800
	Design Contingency (25%)	[\$]	78,400
	Construction Contingency (10%)	[\$]	31,400
Design, Contractors, PM	Subtotal after Contingency	[\$]	423,600
	Engineering Design and Field Review (10%)	[\$]	42,400
	Contractor Fee (7%)	[\$]	29,700
Total	Total	[\$]	495,700

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 0.0383 BTU/hr.ft².F (R26) was assumed.
- **Proposed.** An average roof U-value of 0.0222 BTU/hr.ft².F (R45) was assumed.

Utility analysis results

Table 35: Roof upgrade to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	13,273	13,170	102	0.77
	Natural gas use	[m3/yr]	7,986	7,652	333	4.2
	Carbon offset use	[tCO ₂ e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	13,273	13,170	102	0.77
	Natural gas energy	[kWh/yr]	84,301	80,783	3,518	4.2
	Total energy	[kWh/yr]	97,574	93,954	3,620	3.7
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	0.40	0.40	0.00	0.77
	Natural gas GHGs	[tCO ₂ e/yr]	15.4	14.8	0.64	4.2
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	0	0	—
	Total GHGs	[tCO ₂ e/yr]	15.8	15.2	0.65	4.1
Utility cost	Electricity utility cost	[\$/yr]	1,317	1,306	10.1	0.77
	Natural gas utility cost	[\$/yr]	2,076	1,990	86.6	4.2
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	772	739	32.2	4.2
	Total utility cost	[\$/yr]	4,164	4,035	129	3.1
Financial	Assumed life	[yrs]	—	20	—	—
	Project cost	[\$]	0	495,700	—	—
	Incentive amount	[\$]	0	99,140	—	—
	Incremental project cost	[\$]	0	396,560	—	—
	Life cycle cost	[\$]	92,413	528,630	—	—
	Net present value	[\$]	0	-436,217	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	612,951	—	—
	Simple payback period	[yr]	—	>20	—	—

5.11 Solar PV rooftop

Measure description

Existing condition

The facility has no solar PV on the roof.



Opportunity

Install a solar PV system on the remaining 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.

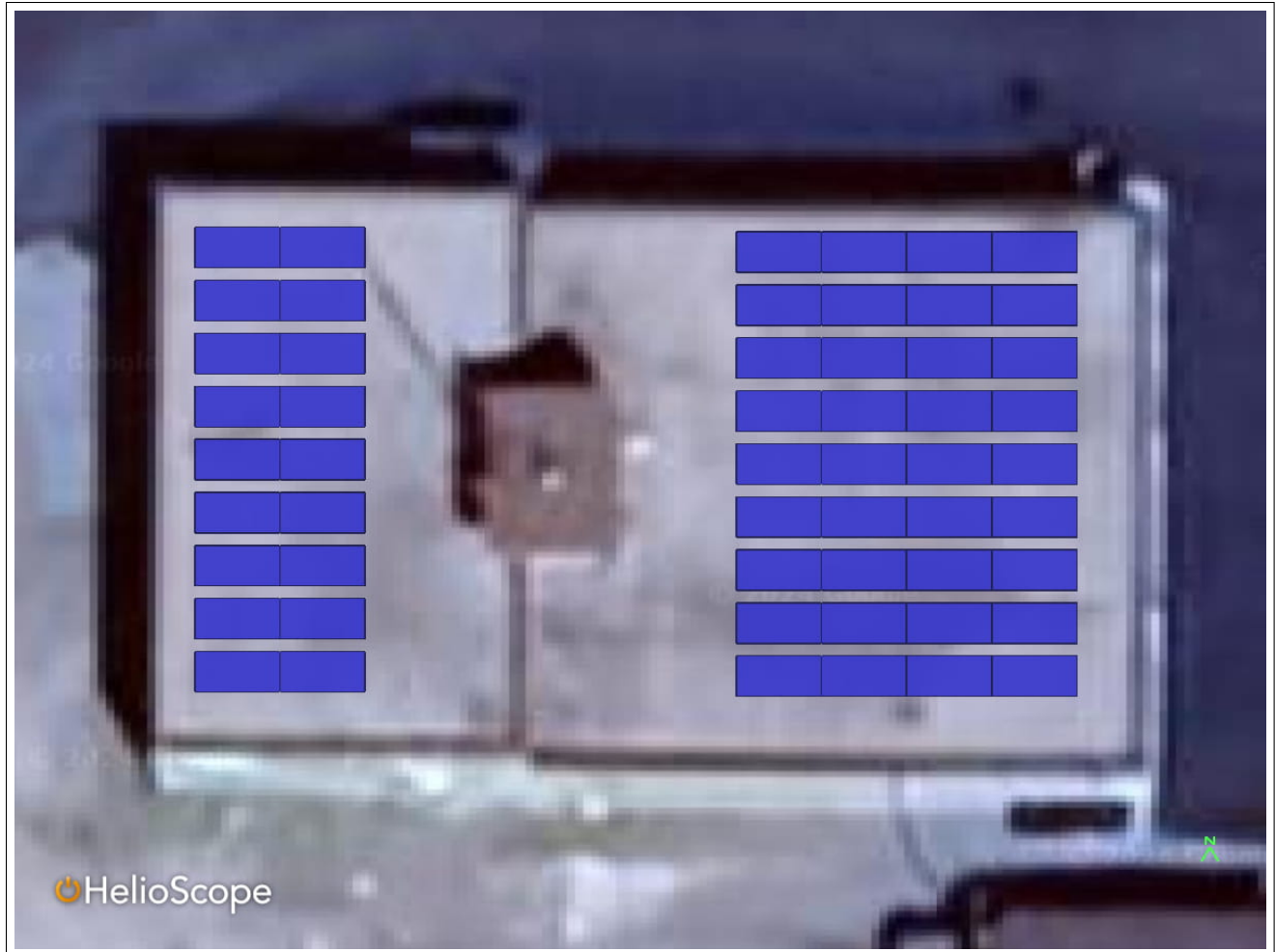
Utility-savings mechanism

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) = 23 kW.

Proposed scope

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

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

Electrical

With the existing system, the panel is rated high enough to accommodate the additional incoming load of the solar. No additional upgrades outside of the solar equipment will be required.

Project cost estimate

Table 36: Project cost estimate (Solar PV rooftop)

Category	Line item	Unit	Value
Materials and labour	Solar PV electricity system installed (assuming 23 kW at 2000 \$/kW)	[\$]	46,000
	Electrical	[\$]	5,000
Contingency	Subtotal after Materials and labour	[\$]	51,000
	General Contingency (50%)	[\$]	25,500
Total	Total	[\$]	76,500

Utility analysis

Utility analysis methodology

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

- **Baseline.** There is no solar PV present at this site.
- **Proposed.** The proposed solar PV electricity generation system described above was assumed to be implemented. Helioscope was used to model the hourly electricity output from the solar PV system. All electricity generated by the system was assumed to be used on-site, directly reducing grid electricity consumption, GHG emissions and utility costs. Note that if this measure is installed as a standalone measure then the solar PV system should be reduced in size to avoid exporting net annual electricity to the grid.

Utility analysis results

Table 37: Solar PV rooftop analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	13,273	-11,546	24,819	187
	Natural gas use	[m3/yr]	7,986	7,986	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	13,273	-11,546	24,819	187
	Natural gas energy	[kWh/yr]	84,301	84,301	0	0
	Total energy	[kWh/yr]	97,574	72,755	24,819	25.4
GHG emissions	Electricity GHGs	[tCO2e/yr]	0.40	-0.35	0.75	187
	Natural gas GHGs	[tCO2e/yr]	15.4	15.4	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	15.8	15.1	0.75	4.7
Utility cost	Electricity utility cost	[\$/yr]	1,317	0	1,317	100
	Natural gas utility cost	[\$/yr]	2,076	2,076	0	0
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	772	772	0	0
	Total utility cost	[\$/yr]	4,164	2,848	1,317	31.6
Financial	Assumed life	[yrs]	—	30	—	—
	Project cost	[\$]	0	76,500	—	—
	Incentive amount	[\$]	0	15,300	—	—
	Incremental project cost	[\$]	0	61,200	—	—
	Life cycle cost	[\$]	92,413	77,114	—	—
	Net present value	[\$]	0	15,299	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	81,651	—	—
	Simple payback period	[yr]	—	>20	—	—

5.12 Unit heater conversion

Measure description

Existing condition

A natural gas-fired unit heater serves the apparatus bay.



Opportunity

Replace the natural gas unit heater with a mini-split system to serve as the first stage of heating and an electric resistance unit heater as the second stage of heating.

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

Install two new 2-T wall-hung split cold climate heat pumps in the garage. Also, replace the existing unit heater with a 20kW unit heater to operate as a second-stage supplement to the heat pumps.

The basis of design for the wall-hung heat pump is the Moovair M21 heat pump. These units will provide first-stage heating and cooling for the space. A basic 20kW unit heater will be supplied to operate off the same thermostat and will be controlled to operate only as a second stage to the heat pump.

Electrical

The ASHP will add approximately 26 kW of power to the existing system, which will put the system at 33.4 kW, which is approximately 87% of the full load of the electrical capacity of the building.

Project cost estimate

Table 38: Project cost estimate (Unit heater conversion)

Category	Line item	Unit	Value
Construction	Supply	[\$]	18,000
	Install	[\$]	10,000
	Electrical contingency	[\$]	12,000
	General requirements (25%)	[\$]	10,000
Contingency	Subtotal after Construction	[\$]	50,000
	Design Contingency (25%)	[\$]	12,500
	Construction Contingency (10%)	[\$]	5,000
Design, Contractors, PM	Subtotal after Contingency	[\$]	67,500
	Engineering Design and Field Review (10%)	[\$]	6,800
	Contractor Fee (7%)	[\$]	4,700
Total	Total	[\$]	79,000

Utility analysis

Utility analysis methodology

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

- **Baseline.** Unit heater provides natural gas space heating to service corridors, the outdoor storage, and the boiler room. The average burner thermal efficiency is 83%.
- **Proposed.** Primary heating is provided from a mini-split with a COP of 2.8. Backup heating is provided by electric resistance, with an efficiency of 100%.

Utility analysis results

Table 39: Unit heater conversion analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	13,273	33,342	-20,069	-151
	Natural gas use	[m3/yr]	7,986	5,312	2,673	33.5
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	13,273	33,342	-20,069	-151
	Natural gas energy	[kWh/yr]	84,301	56,082	28,219	33.5
	Total energy	[kWh/yr]	97,574	89,424	8,150	8.4
GHG emissions	Electricity GHGs	[tCO2e/yr]	0.40	1.0	-0.61	-151
	Natural gas GHGs	[tCO2e/yr]	15.4	10.3	5.2	33.5
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	15.8	11.3	4.6	28.8
Utility cost	Electricity utility cost	[\$/yr]	1,317	3,308	-1,991	-151
	Natural gas utility cost	[\$/yr]	2,076	1,381	695	33.5
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	772	513	258	33.5
	Total utility cost	[\$/yr]	4,164	5,202	-1,038	-24.9
Financial	Assumed life	[yrs]	—	15	—	—
	Project cost	[\$]	0	79,000	—	—
	Incentive amount	[\$]	0	15,800	—	—
	Incremental project cost	[\$]	0	63,200	—	—
	Life cycle cost	[\$]	92,413	215,963	—	—
	Net present value	[\$]	0	-123,550	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	13,862	—	—
	Simple payback period	[yr]	—	—	—	—

5.13 Wall upgrade to high performance

Measure description

Existing condition

Three exterior wall assembly types were identified at the New Liskeard Fire Hall. The exterior finishes included concrete block or brick veneer. The U-Values range from 0.0667 W/m²K to 0.602 W/m²K.



Opportunity

Upgrade upon the end of useful life.

Utility-savings mechanism

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

Design description

Overview

Based on the assumptions outlined for the wall construction, we recommend adding an EIFS to the existing exterior. We believe that the current exterior consists of 10 inches of concrete block or brick veneer, and with the interior insulation, the thermal performance of most of the exterior wall is R9. This is significantly below the current code requirement of R20.

Adding 6 inches of an EIFS can enhance the thermal performance to R29 without disturbing the interior. The EIFS system includes an air barrier, which can help address air leakage issues in the existing building, provided that proper flashing is installed around doors and windows. Additionally, the air barrier can be connected to a new air barrier on the roof, creating a tight thermal envelope.

There are no structural requirements for adding an EIFS system of this thickness to an existing masonry wall.

Project cost estimate

Table 40: Project cost estimate (Wall upgrade to high performance)

Category	Line item	Unit	Value
Construction	Add EIFS system to existing exterior wall	[\$]	179,000
	General requirements (25%)	[\$]	44,800
Contingency	Subtotal after Construction	[\$]	223,800
	Design Contingency (25%)	[\$]	56,000
	Construction Contingency (10%)	[\$]	22,400
Design, Contractors, PM	Subtotal after Contingency	[\$]	302,200
	Engineering Design and Field Review (10%)	[\$]	30,200
	Contractor Fee (7%)	[\$]	21,200
Total	Total	[\$]	353,600

Utility analysis

Utility analysis methodology

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

- **Baseline.** An average wall U-value of 0.100 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 41: Wall upgrade to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	13,273	12,690	583	4.4
	Natural gas use	[m ³ /yr]	7,986	6,789	1,197	15.0
	Carbon offset use	[tCO ₂ e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	13,273	12,690	583	4.4
	Natural gas energy	[kWh/yr]	84,301	71,666	12,635	15.0
	Total energy	[kWh/yr]	97,574	84,356	13,218	13.5
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	0.40	0.38	0.02	4.4
	Natural gas GHGs	[tCO ₂ e/yr]	15.4	13.1	2.3	15.0
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	0	0	—
	Total GHGs	[tCO ₂ e/yr]	15.8	13.5	2.3	14.7
Utility cost	Electricity utility cost	[\$/yr]	1,317	1,259	57.8	4.4
	Natural gas utility cost	[\$/yr]	2,076	1,765	311	15.0
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	772	656	116	15.0
	Total utility cost	[\$/yr]	4,164	3,680	485	11.6
Financial	Assumed life	[yrs]	—	40	—	—
	Project cost	[\$]	0	353,600	—	—
	Incentive amount	[\$]	0	70,720	—	—
	Incremental project cost	[\$]	0	282,880	—	—
	Life cycle cost	[\$]	92,413	268,563	—	—
	Net present value	[\$]	0	-176,149	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	121,392	—	—
	Simple payback period	[yr]	—	>20	—	—

5.14 Windows and doors to high performance

Measure description

Existing condition

Windows consist mainly of vinyl-framed, double-pane windows. The U-Value assumed for all windows is 3.24 W/m²K. There are three types of doors: overhead bay doors, hollow metal, and swing doors with glazing. The U-Value assumed for all doors is 3.98 W/m²K.



Opportunity

Upgrade upon the end of useful life.

Utility-savings mechanism

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

Design description

Windows

We recommend replacing all windows with Passive House Certified triple-glazed, thermally broken windows. These could be framed in aluminum, vinyl or fibreglass. At the very least, we recommend double-glazed windows in thermally broken frames to meet 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 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 42: Project cost estimate (Windows and doors to high performance)

Category	Line item	Unit	Value
Construction	Window replacement	[\$]	59,000
	Door replacement	[\$]	40,000
	General requirements (25%)	[\$]	24,800
Contingency	Subtotal after Construction	[\$]	123,800
	Design Contingency (25%)	[\$]	31,000
	Construction Contingency (10%)	[\$]	12,400
Design, Contractors, PM	Subtotal after Contingency	[\$]	167,200
	Engineering Design and Field Review (10%)	[\$]	16,700
	Contractor Fee (7%)	[\$]	11,700
Total	Total	[\$]	195,600

Utility analysis

Utility analysis methodology

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

- **Baseline.** The average U-value of all windows and doors was assumed to be 0.571 BTU/hr.ft².F and 0.701 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 43: Windows and doors to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	13,273	13,097	175	1.3
	Natural gas use	[m3/yr]	7,986	6,741	1,244	15.6
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	13,273	13,097	175	1.3
	Natural gas energy	[kWh/yr]	84,301	71,164	13,137	15.6
	Total energy	[kWh/yr]	97,574	84,262	13,312	13.6
GHG emissions	Electricity GHGs	[tCO2e/yr]	0.40	0.40	0.01	1.3
	Natural gas GHGs	[tCO2e/yr]	15.4	13.0	2.4	15.6
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	15.8	13.4	2.4	15.2
Utility cost	Electricity utility cost	[\$/yr]	1,317	1,299	17.4	1.3
	Natural gas utility cost	[\$/yr]	2,076	1,753	324	15.6
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	772	651	120	15.6
	Total utility cost	[\$/yr]	4,164	3,703	461	11.1
Financial	Assumed life	[yrs]	—	40	—	—
	Project cost	[\$]	0	195,600	—	—
	Incentive amount	[\$]	0	39,120	—	—
	Incremental project cost	[\$]	0	156,480	—	—
	Life cycle cost	[\$]	92,413	187,282	—	—
	Net present value	[\$]	0	-94,869	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	64,933	—	—
	Simple payback period	[yr]	—	>20	—	—

5.15 Measure risk analysis

Utility use sensitivity

Figure 99 indicates how sensitive cumulative electricity and natural gas use are to variations in each risk parameter.

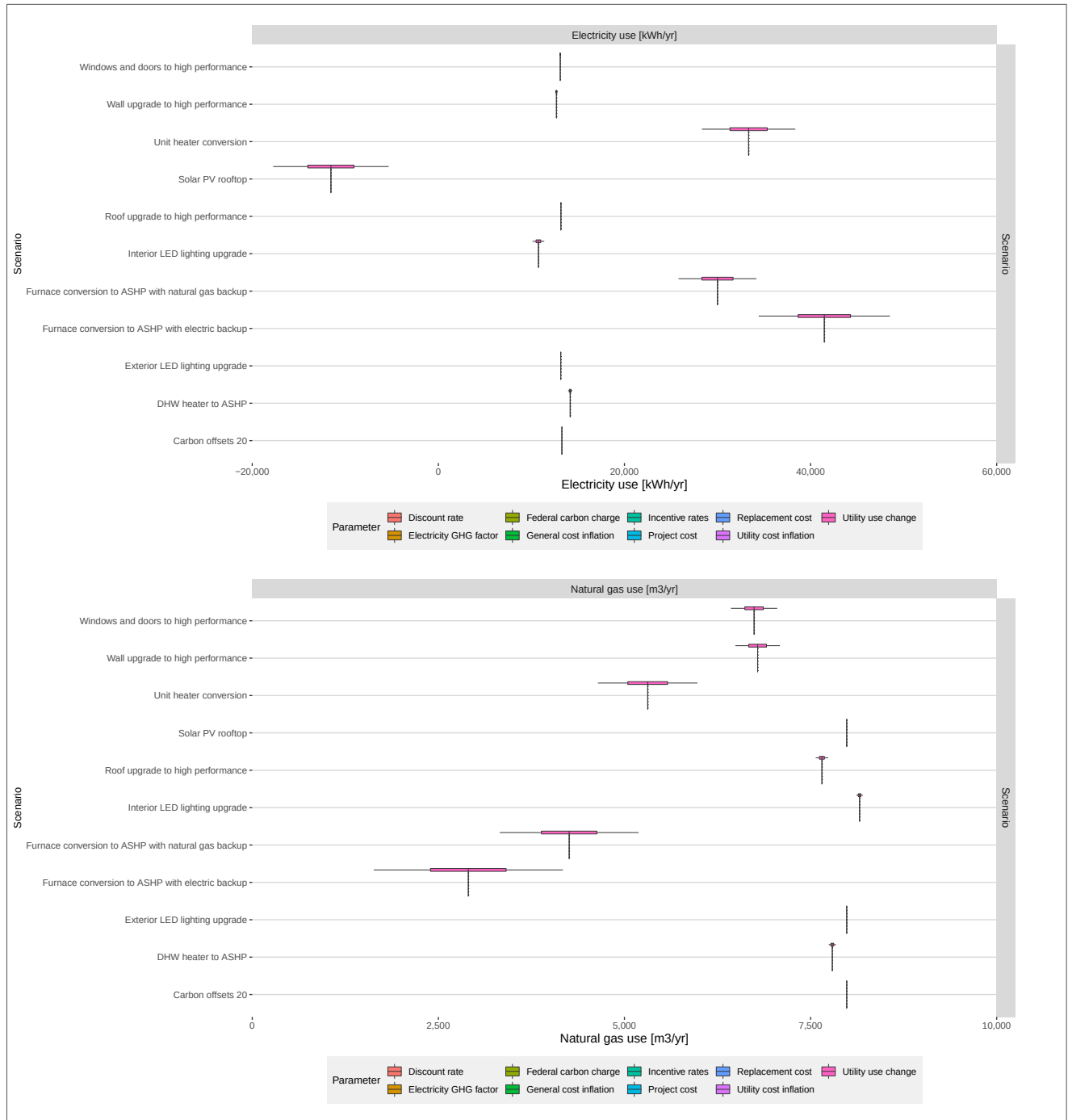


Figure 99: Utility cumulative use sensitivity analysis

GHG emissions and life cycle cost sensitivity

Figure 100 indicates how sensitive cumulative GHG emissions and life cycle costs are to variations in each risk parameter.

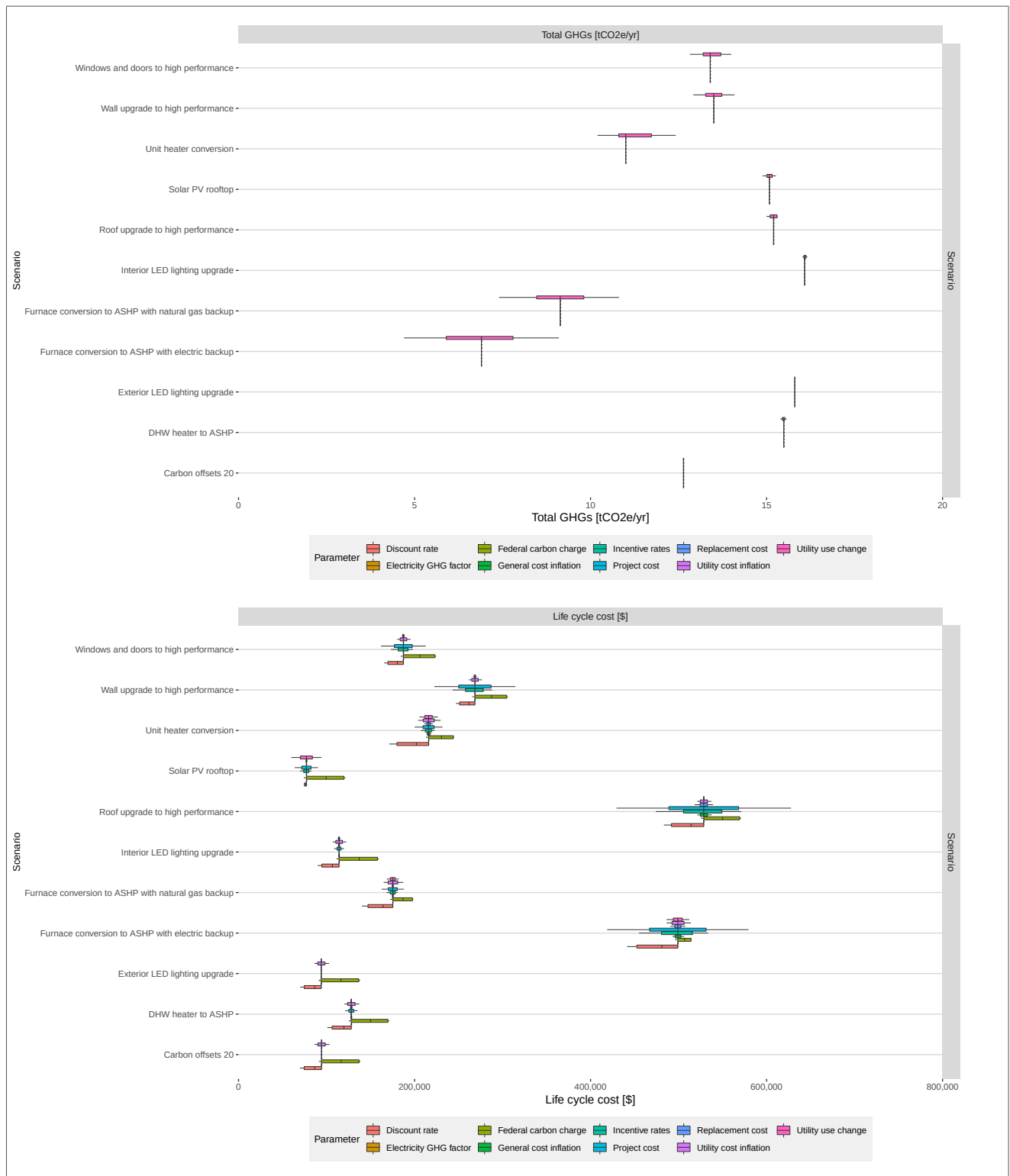


Figure 100: GHG cumulative emissions and life cycle cost sensitivity analysis

5.16 Measure analysis summary

For each analyzed measure, the analysis results are summarized in Table 44.

Table 44: 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	13,273	100.0	7,986	100.0	97,574	100.0	16	100.0	4,164	100.0	-	0	0	0	92,413	0	-	-
Carbon offsets 20	0	0.0	0	0.0	0	0.0	3	20.0	-95	-2.3	20	-	0	-	94,244	-1,831	-	-
DHW heater to ASHP	-894	-6.7	194	2.4	1,151	1.2	0	2.2	-20	-0.5	15	27,700	48	27,652	128,110	-35,697	79,603	-1,413
Exterior LED lighting upgrade	117	0.9	0	0.0	117	0.1	0	0.0	12	0.3	15	1,500	0	1,500	93,946	-1,533	422,928	129
Furnace conversion to ASHP with electric backup	-28,204	-212.5	5,083	63.7	25,456	26.1	9	56.7	-985	-23.7	20	401,700	80,340	321,360	499,198	-406,785	35,825	-326
Furnace conversion to ASHP with natural gas backup	-16,724	-126.0	3,728	46.7	22,634	23.2	7	42.3	-329	-7.9	20	63,200	12,640	50,560	175,275	-82,862	7,547	-153
Interior LED lighting upgrade	2,519	19.0	-173	-2.2	695	0.7	-0	-1.6	188	4.5	15	22,500	0	22,500	114,200	-21,787	-87,257	119
Roof upgrade to high performance	102	0.8	333	4.2	3,620	3.7	1	4.1	129	3.1	20	495,700	99,140	396,560	528,630	-436,217	612,951	3,075
Solar PV rooftop	24,819	187.0	0	0.0	24,819	25.4	1	4.7	1,317	31.6	30	76,500	15,300	61,200	77,114	15,299	81,651	46
Unit heater conversion	-20,069	-151.2	2,673	33.5	8,150	8.4	5	28.8	-1,038	-24.9	15	79,000	15,800	63,200	215,963	-123,550	13,862	-61
Wall upgrade to high performance	583	4.4	1,197	15.0	13,218	13.5	2	14.7	485	11.6	40	353,600	70,720	282,880	268,562	-176,149	121,392	584
Windows and doors to high performance	175	1.3	1,244	15.6	13,312	13.6	2	15.2	461	11.1	40	195,600	39,120	156,480	187,282	-94,869	64,933	339
Total project cost	-	-	-	-	-	-	-	-	-	-	-	1,717,000	-	-	-	-	-	-
DHW renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	4,000	0	4,000	97,363	-4,949	-	-
Exterior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	1,000	0	1,000	93,650	-1,237	-	-
Exterior walls renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	3,000	0	3,000	94,363	-1,950	-	-
F1 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	8,000	0	8,000	101,085	-8,672	-	-
F2 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	12,000	0	12,000	105,421	-13,008	-	-
Interior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	6,000	0	6,000	99,837	-7,424	-	-
Roof renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	114,000	0	114,000	215,990	-123,577	-	-
UH renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	11,000	0	11,000	106,024	-13,611	-	-
Windows renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	51,000	0	51,000	125,563	-33,150	-	-
BAU measure totals	-	-	-	-	-	-	-	-	-	-	-	210,000	-	-	-	-	-	-

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 45.
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 45.

Table 45: 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 101 and Table 46 present the results of this exercise, indicating which measures were assigned to which scenario.

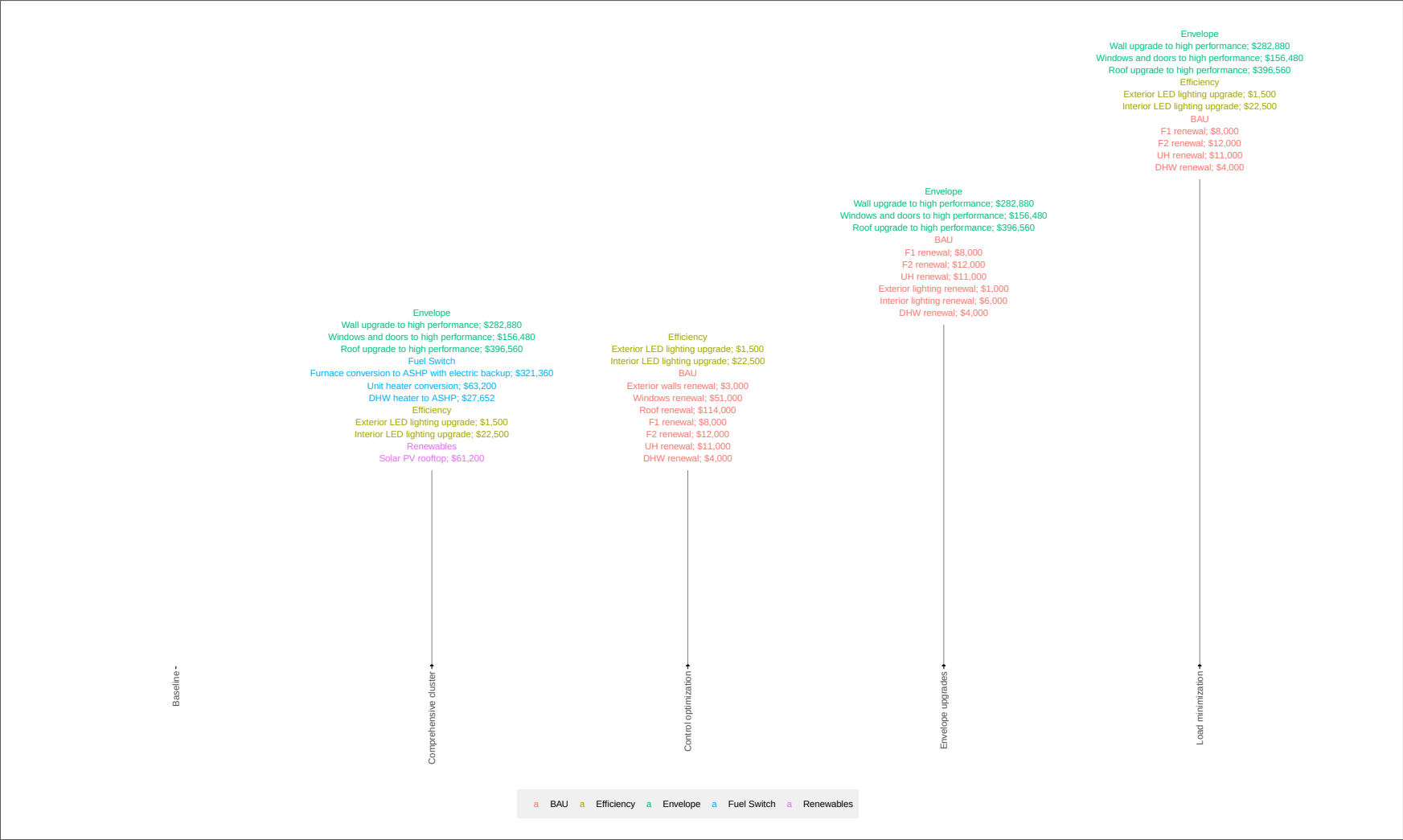


Figure 101: Scenario composition

Table 46: Cluster composition

Measure	Control optimization	Envelope upgrades	Load minimization	Comprehensive cluster
Carbon offsets 20	✗	✗	✗	✗
DHW heater to ASHP	✗	✗	✗	✓
Exterior LED lighting upgrade	✓	✗	✓	✓
Furnace conversion to ASHP with electric backup	✗	✗	✗	✓
Furnace conversion to ASHP with natural gas backup	✗	✗	✗	✗
Interior LED lighting upgrade	✓	✗	✓	✓
Roof upgrade to high performance	✗	✓	✓	✓
Solar PV rooftop	✗	✗	✗	✓
Unit heater conversion	✗	✗	✗	✓
Wall upgrade to high performance	✗	✓	✓	✓
Windows and doors to high performance	✗	✓	✓	✓
DHW renewal	✓	✓	✓	✗
Exterior lighting renewal	✗	✓	✗	✗
Exterior walls renewal	✓	✗	✗	✗
F1 renewal	✓	✓	✓	✗
F2 renewal	✓	✓	✓	✗
Interior lighting renewal	✗	✓	✗	✗
Roof renewal	✓	✗	✗	✗
UH renewal	✓	✓	✓	✗
Windows 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 47, 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 47: Scenario analysis summary

Scenario	Measure name	Utility use				Equivalent energy use				GHG emissions		Utility cost		Financial							
		Electricity use reduction	Electricity use reduction	Natural gas use reduction	Natural gas use reduction	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	-5,021	-37.8	7,986	100.0	79,280	81.3	15	96.5	2,350	56.4	-	1,653,800	320,468	1,333,332	1,220,510	-1,128,097	87,264	567		
Comprehensive cluster	Wall upgrade to high performance	583	4.4	1,197	15.0	13,218	13.5	2	14.7	485	11.6	40	353,600	70,720	282,880	268,562	-176,149	121,392	584		
Comprehensive cluster	Windows and doors to high performance	175	1.3	1,244	15.6	13,312	13.6	2	15.2	461	11.1	40	195,600	39,120	156,480	187,282	-94,869	64,933	339		
Comprehensive cluster	Roof upgrade to high performance	102	0.8	333	4.2	3,620	3.7	1	4.1	129	3.1	20	495,700	99,140	396,560	528,630	-436,217	612,951	3,075		
Comprehensive cluster	Furnace conversion to ASHP with electric backup	-28,204	-212.5	5,083	63.7	25,456	26.1	9	56.7	-985	-23.7	20	401,700	80,340	321,360	499,198	-406,785	35,825	-326		
Comprehensive cluster	Unit heater conversion	-20,069	-151.2	2,673	33.5	8,150	8.4	5	28.8	-1,038	-24.9	15	79,000	15,800	63,200	215,963	-123,550	13,862	-61		
Comprehensive cluster	Exterior LED lighting upgrade	117	0.9	0	0.0	117	0.1	0	0.0	12	0.3	15	1,500	0	1,500	93,946	-1,533	422,928	129		
Comprehensive cluster	Interior LED lighting upgrade	2,519	19.0	-173	-2.2	695	0.7	-0	-1.6	188	4.5	15	22,500	0	22,500	114,200	-21,787	-87,257	119		
Comprehensive cluster	DHW heater to ASHP	894	6.7	194	2.4	1,151	1.2	0	2.2	-20	-0.5	15	27,700	48	27,652	128,110	-35,697	79,603	-1,413		
Comprehensive cluster	Solar PV rooftop	24,819	187.0	0	0.0	24,819	25.4	1	4.7	1,317	31.6	30	76,500	15,300	61,200	77,114	15,299	81,651	46		
Control optimization	Combined	2,637	19.9	-173	-2.2	813	0.8	-0	-1.6	200	4.8	-	227,000	0	227,000	294,774	-202,361	-892,407	1,135		
Control optimization	Exterior LED lighting upgrade	117	0.9	0	0.0	117	0.1	0	0.0	12	0.3	15	1,500	0	1,500	93,946	-1,533	422,928	129		
Control optimization	Interior LED lighting upgrade	2,519	19.0	-173	-2.2	695	0.7	-0	-1.6	188	4.5	15	22,500	0	22,500	114,200	-21,787	-87,257	119		
Control optimization	Exterior walls renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	3,000	0	3,000	94,363	-1,950	-	-		
Control optimization	Windows renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	51,000	0	51,000	125,563	-33,150	-	-		
Control optimization	Roof renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	114,000	0	114,000	215,990	-123,577	-	-		
Control optimization	F1 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	8,000	0	8,000	101,085	-8,672	-	-		
Control optimization	F2 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	12,000	0	12,000	105,421	-13,008	-	-		
Control optimization	UH renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	11,000	0	11,000	106,024	-13,611	-	-		
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	97,363	-4,949	-	-		
Envelope upgrades	Combined	923	7.0	2,627	32.9	28,656	29.4	5	32.2	1,028	24.7	-	1,086,900	208,980	877,920	772,054	-679,641	171,997	854		
Envelope upgrades	Wall upgrade to high performance	583	4.4	1,197	15.0	13,218	13.5	2	14.7	485	11.6	40	353,600	70,720	282,880	268,562	-176,149	121,392	584		
Envelope upgrades	Windows and doors to high performance	175	1.3	1,244	15.6	13,312	13.6	2	15.2	461	11.1	40	195,600	39,120	156,480	187,282	-94,869	64,933	339		
Envelope upgrades	Roof upgrade to high performance	102	0.8	333	4.2	3,620	3.7	1	4.1	129	3.1	20	495,700	99,140	396,560	528,630	-436,217	612,951	3,075		
Envelope upgrades	F1 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	8,000	0	8,000	101,085	-8,672	-	-		
Envelope upgrades	F2 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	12,000	0	12,000	105,421	-13,008	-	-		
Envelope upgrades	UH renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	11,000	0	11,000	106,024	-13,611	-	-		
Envelope upgrades	Exterior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	1,000	0	1,000	93,650	-1,237	-	-		
Envelope upgrades	Interior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	6,000	0	6,000	99,837	-7,424	-	-		
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	97,363	-4,949	-	-		
Load minimization	Combined	3,552	26.8	2,449	30.7	29,402	30.1	5	30.6	1,226	29.4	-	1,103,900	208,980	894,920	785,559	-693,146	184,939	730		
Load minimization	Wall upgrade to high performance	583	4.4	1,197	15.0	13,218	13.5	2	14.7	485	11.6	40	353,600	70,720	282,880	268,562	-176,149	121,392	584		
Load minimization	Windows and doors to high performance	175	1.3	1,244	15.6	13,312	13.6	2	15.2	461	11.1	40	195,600	39,120	156,480	187,282	-94,869	64,933	339		
Load minimization	Roof upgrade to high performance	102	0.8	333	4.2	3,620	3.7	1	4.1	129	3.1	20	495,700	99,140	396,560	528,630	-436,217	612,951	3,075		
Load minimization	Exterior LED lighting upgrade	117	0.9	0	0.0	117	0.1	0	0.0	12	0.3	15	1,500	0	1,500	93,946	-1,533	422,928	129		
Load minimization	Interior LED lighting upgrade	2,519	19.0	-173	-2.2	695	0.7	-0	-1.6	188	4.5	15	22,500	0	22,500	114,200	-21,787	-87,257	119		
Load minimization	F1 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	8,000	0	8,000	101,085	-8,672	-	-		
Load minimization	F2 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	12,000	0	12,000	105,421	-13,008	-	-		
Load minimization	UH renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	11,000	0	11,000	106,024	-13,611	-	-		
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	97,363	-4,949	-	-		

Utility use comparison

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

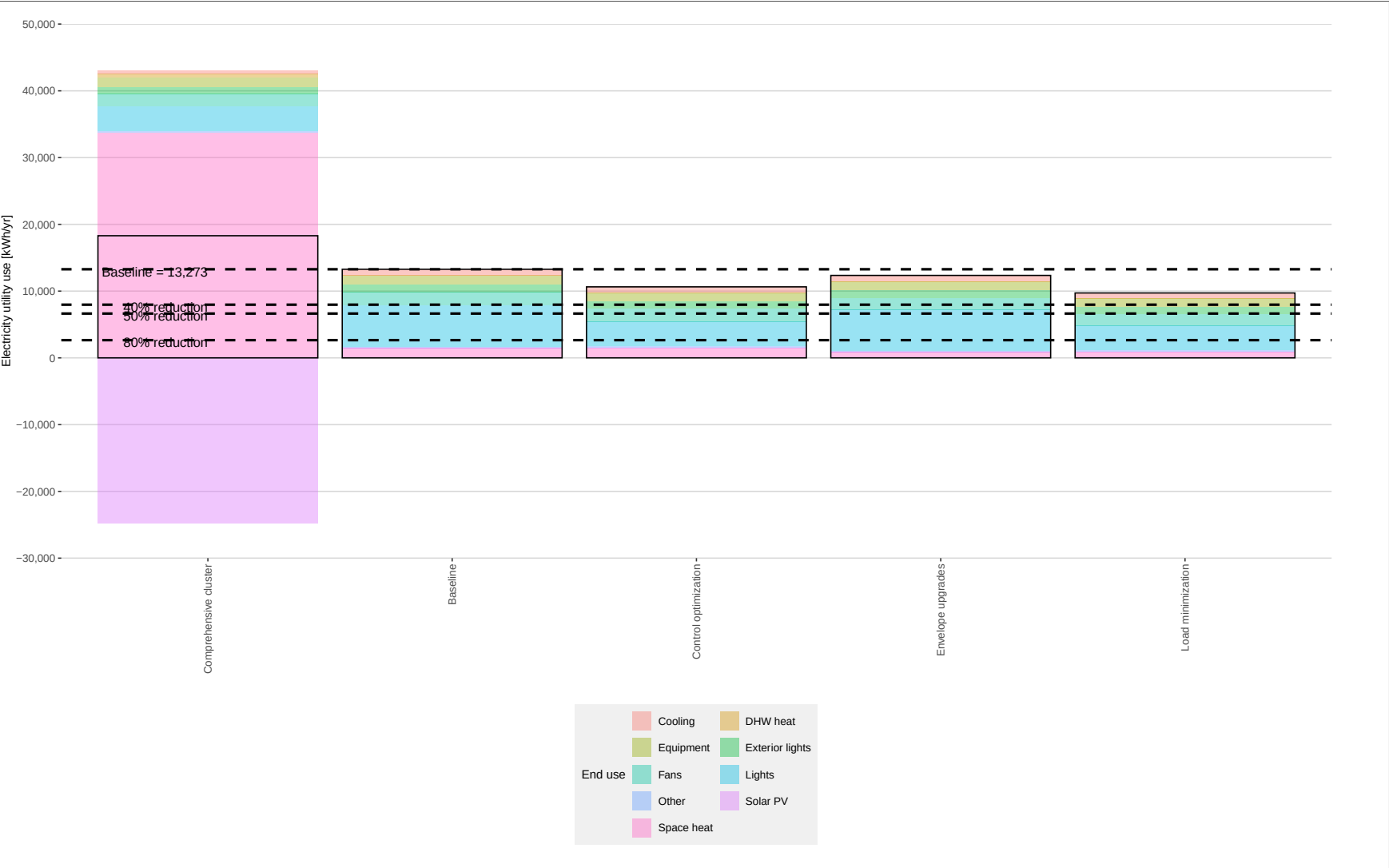


Figure 102: Electricity utility use expected yearly for each scenario by end use

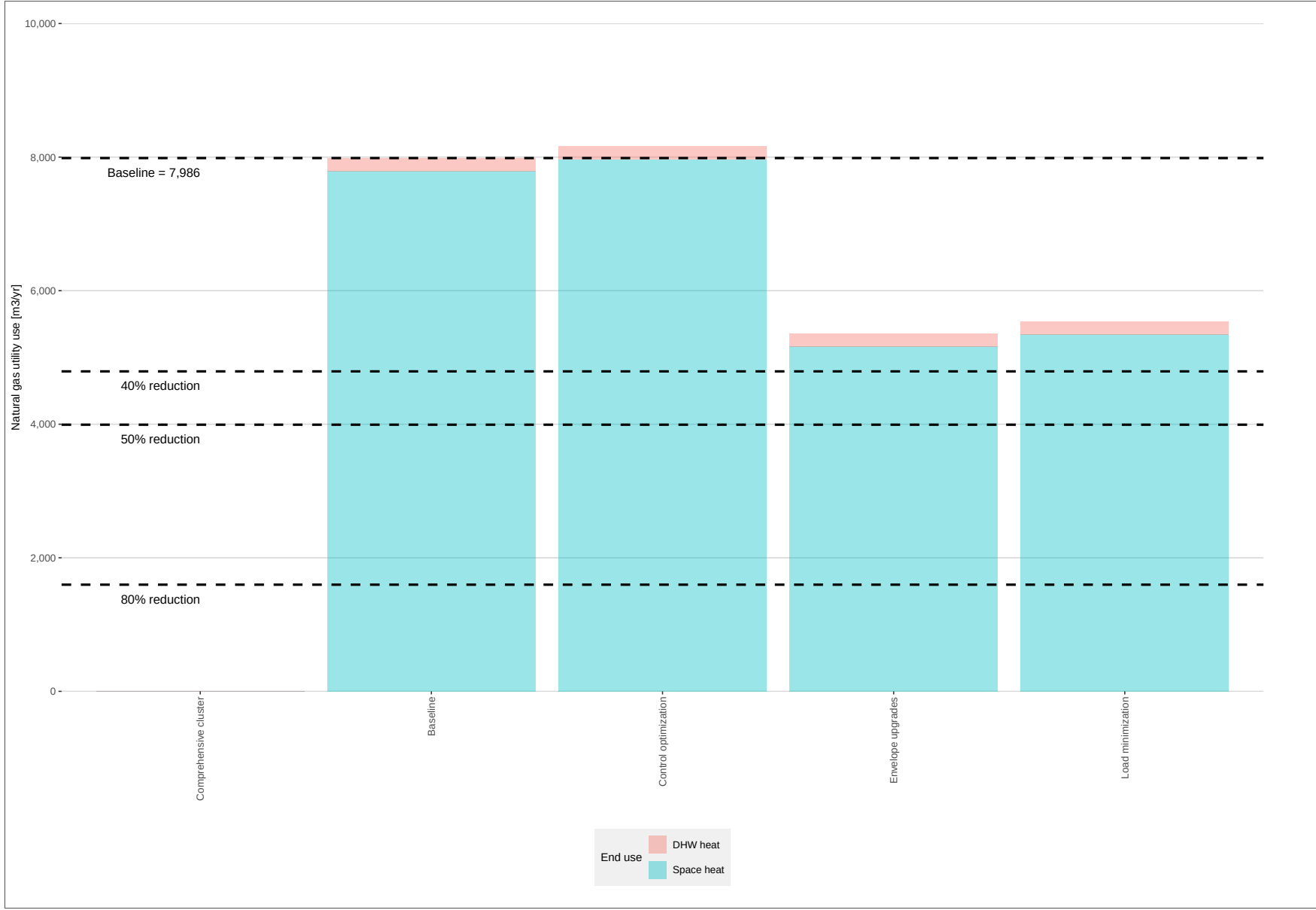


Figure 103: Natural gas utility use expected yearly for each scenario by end use

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.

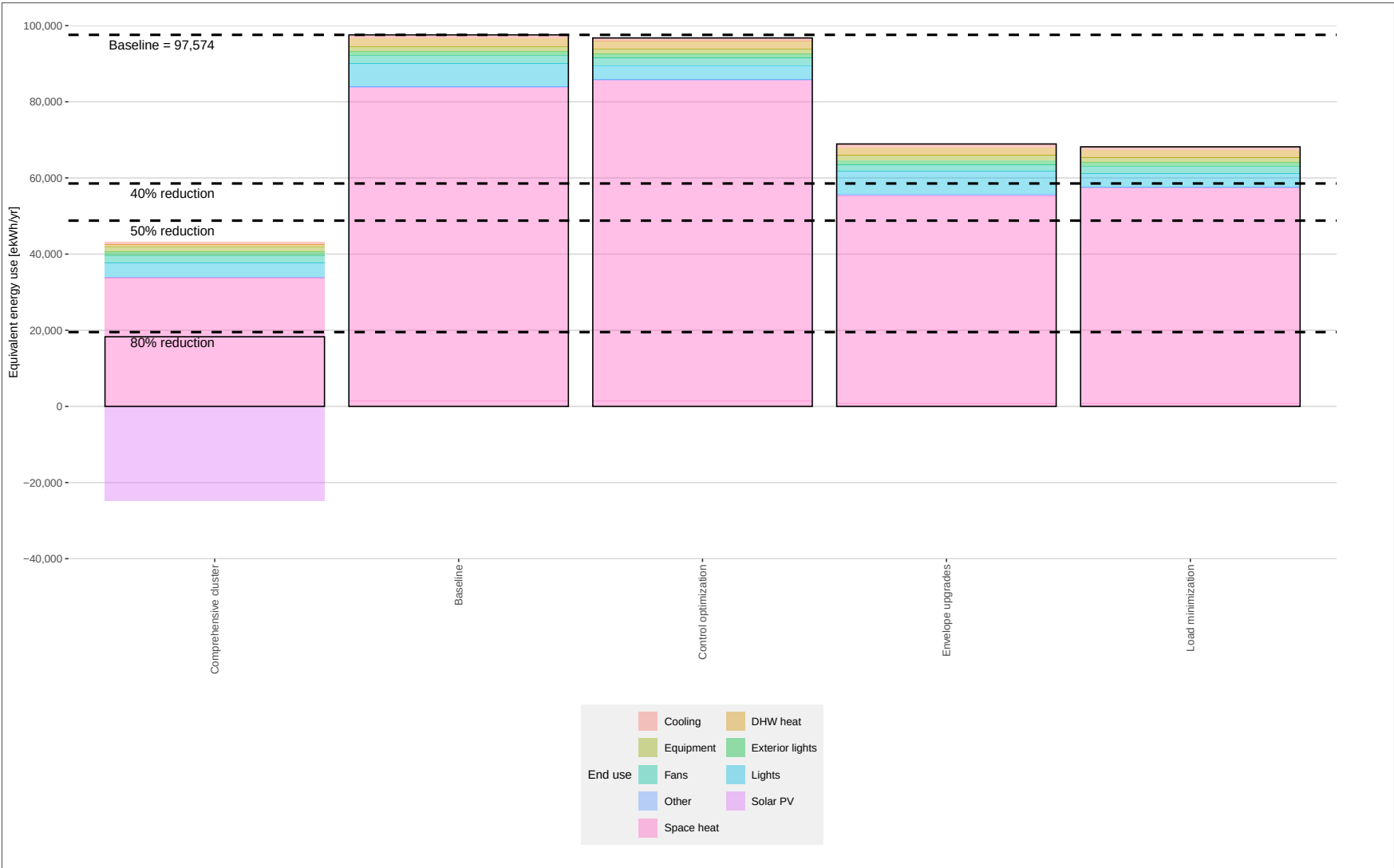


Figure 104: Equivalent energy use expected yearly for each scenario by end use



Figure 105: GHG emissions expected yearly for each scenario by end use

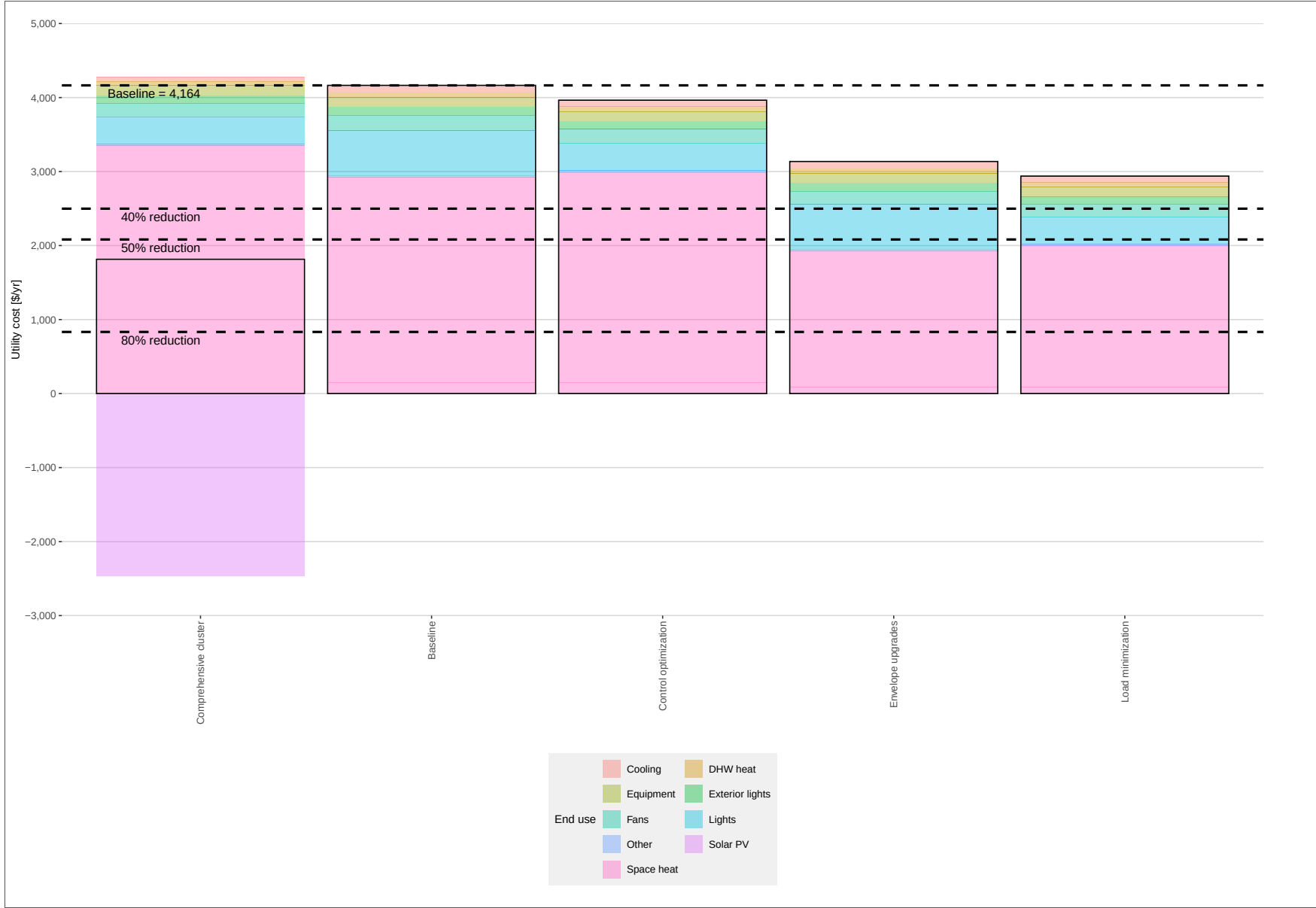


Figure 106: Utility costs expected yearly for each scenario by end use

Financial performance comparison

The following figures compare the financial performance between each scenario.

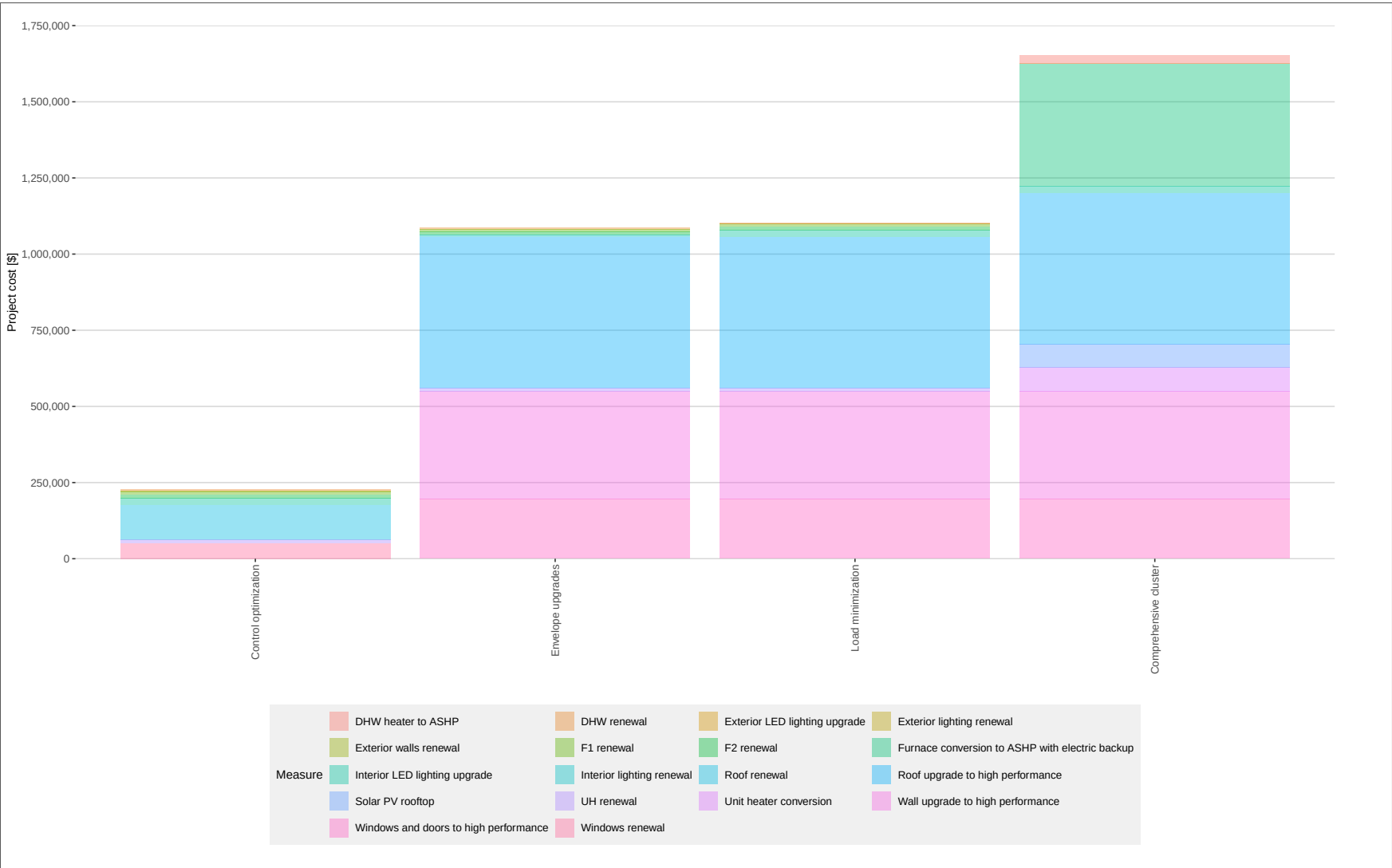


Figure 107: Project cost expected for each scenario by measure

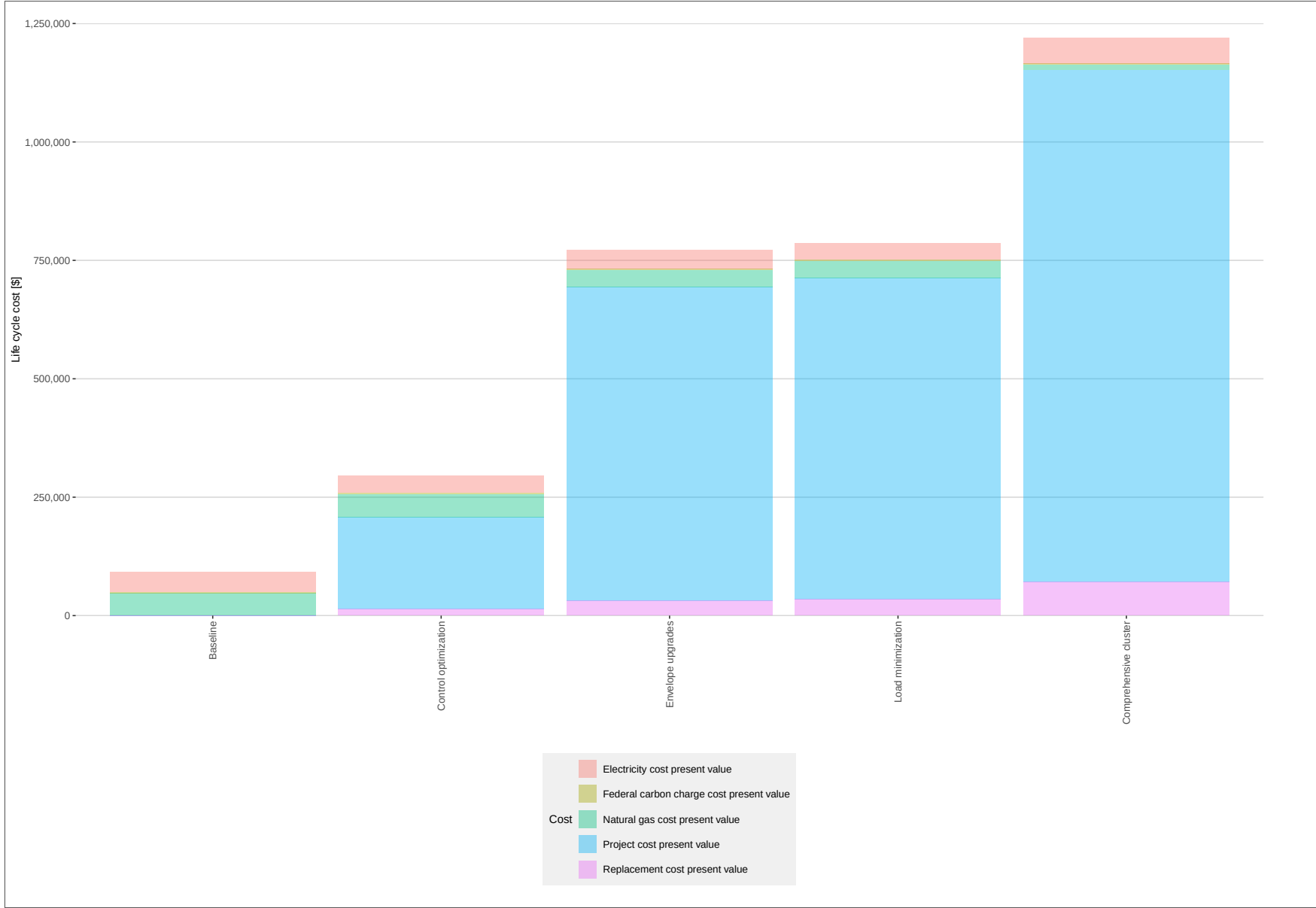


Figure 108: Life cycle cost expected for each scenario by cost item

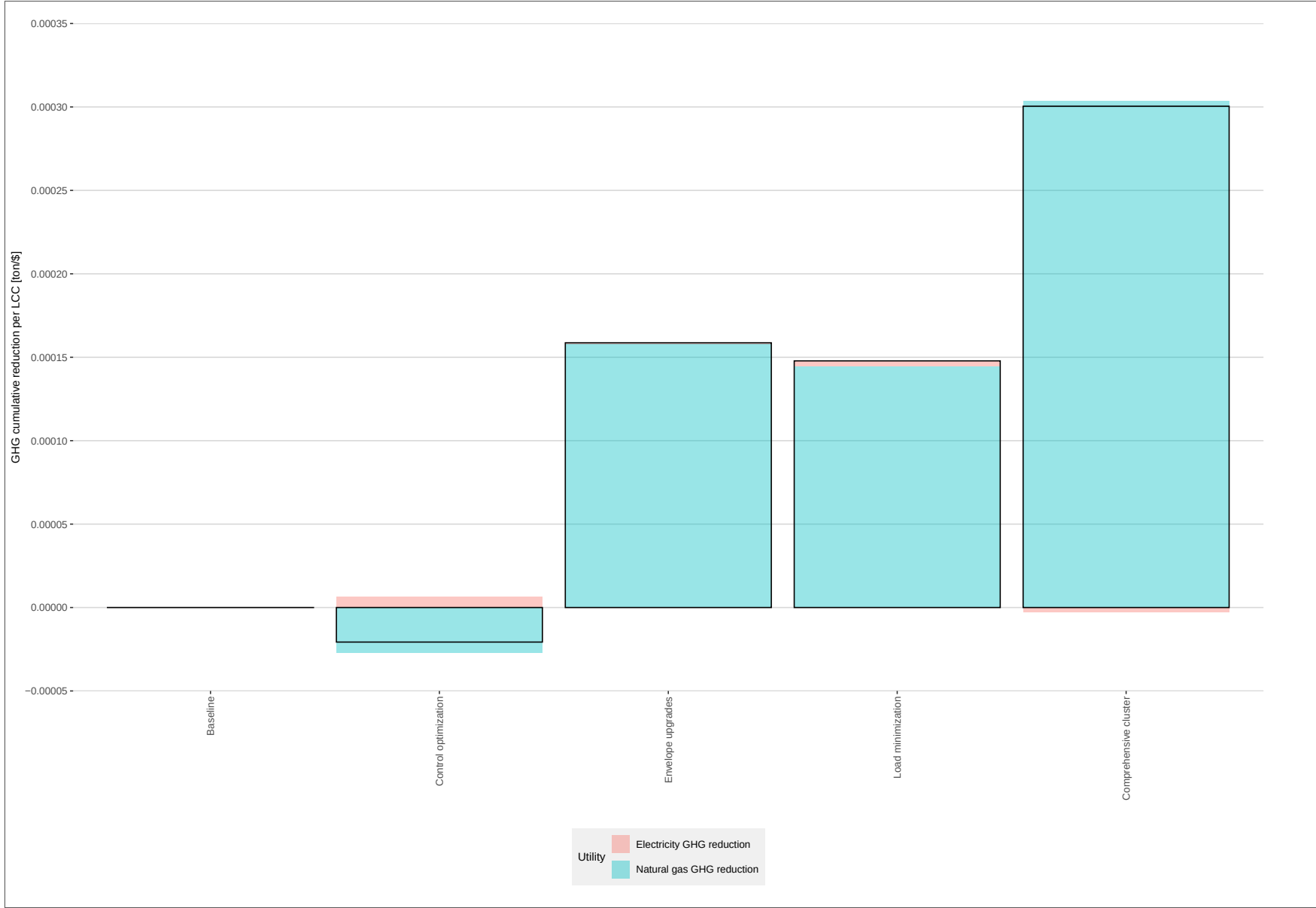


Figure 109: GHG cumulative reduction per life cycle cost (LCC) dollar expected for each scenario by utility

6.5 Plan scenario development

Plan scenario identification and objectives

The plan scenarios that were analyzed and their objectives are summarized in Table 48.

Table 48: 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 48. Results of the plan scenario composition are presented in Figure 110, 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 49 to 54.

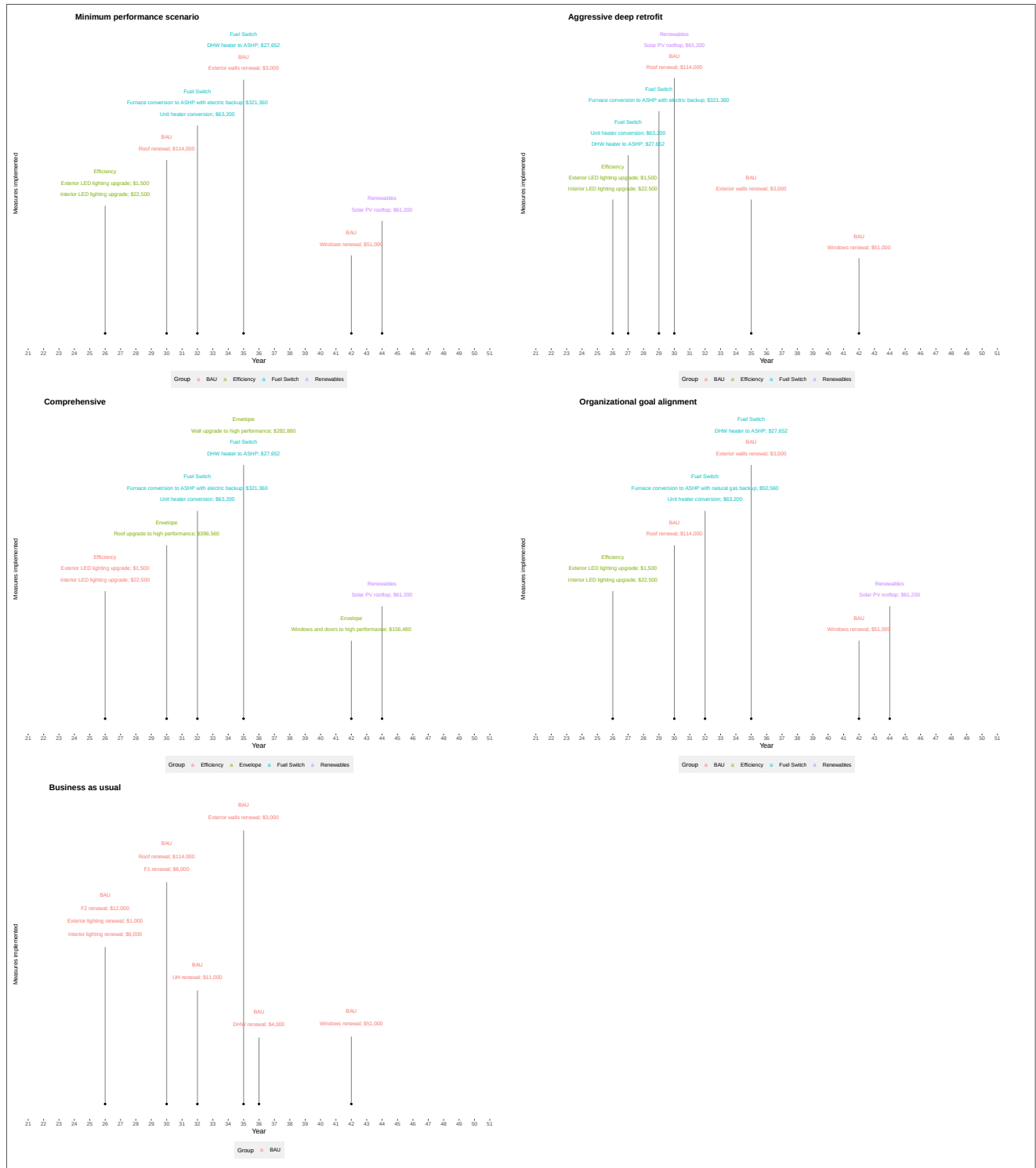


Figure 110: Plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

Table 49: Scenario composition summary

Measure	Minimum performance scenario	Aggressive deep retrofit	Comprehensive	Organizational goal alignment
Carbon offsets 20	✗	✗	✗	✗
DHW heater to ASHP	✓	✓	✓	✓
Exterior LED lighting upgrade	✓	✓	✓	✓
Furnace conversion to ASHP with electric backup	✓	✓	✓	✗
Furnace conversion to ASHP with natural gas backup	✗	✗	✗	✓
Interior LED lighting upgrade	✓	✓	✓	✓
Roof upgrade to high performance	✗	✗	✓	✗
Solar PV rooftop	✓	✓	✓	✓
Unit heater conversion	✓	✓	✓	✓
Wall upgrade to high performance	✗	✗	✓	✗
Windows and doors to high performance	✗	✗	✓	✗
DHW renewal	✗	✗	✗	✗
Exterior lighting renewal	✗	✗	✗	✗
Exterior walls renewal	✓	✓	✗	✓
F1 renewal	✗	✗	✗	✗
F2 renewal	✗	✗	✗	✗
Interior lighting renewal	✗	✗	✗	✗
Roof renewal	✓	✓	✗	✓
UH renewal	✗	✗	✗	✗
Windows renewal	✓	✓	✗	✓

Table 50: Minimum performance scenario measure implementation timeline

Measure	Year
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Roof renewal	2030
Furnace conversion to ASHP with electric backup	2032
Unit heater conversion	2032
DHW heater to ASHP	2035
Exterior walls renewal	2035
Windows renewal	2042
Solar PV rooftop	2044

Table 51: Aggressive deep retrofit measure implementation timeline

Measure	Year
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
DHW heater to ASHP	2027
Unit heater conversion	2027
Furnace conversion to ASHP with electric backup	2029
Roof renewal	2030
Solar PV rooftop	2030
Exterior walls renewal	2035
Windows renewal	2042

Table 52: Comprehensive measure implementation timeline

Measure	Year
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Roof upgrade to high performance	2030
Furnace conversion to ASHP with electric backup	2032
Unit heater conversion	2032
DHW heater to ASHP	2035
Wall upgrade to high performance	2035
Windows and doors to high performance	2042
Solar PV rooftop	2044

Table 53: Organizational goal alignment measure implementation timeline

Measure	Year
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Roof renewal	2030
Furnace conversion to ASHP with natural gas backup	2032
Unit heater conversion	2032
DHW heater to ASHP	2035
Exterior walls renewal	2035
Windows renewal	2042
Solar PV rooftop	2044

Table 54: Business as usual measure implementation timeline

Measure	Year
Exterior lighting renewal	2026
F2 renewal	2026
Interior lighting renewal	2026
F1 renewal	2030
Roof renewal	2030
UH renewal	2032
Exterior walls renewal	2035
DHW renewal	2036
Windows renewal	2042

6.6 Plan performance analysis

Figures 111 through 114 present the projected yearly electricity use, natural gas use, GHG emissions and life cycle costs associated with each plan scenario.

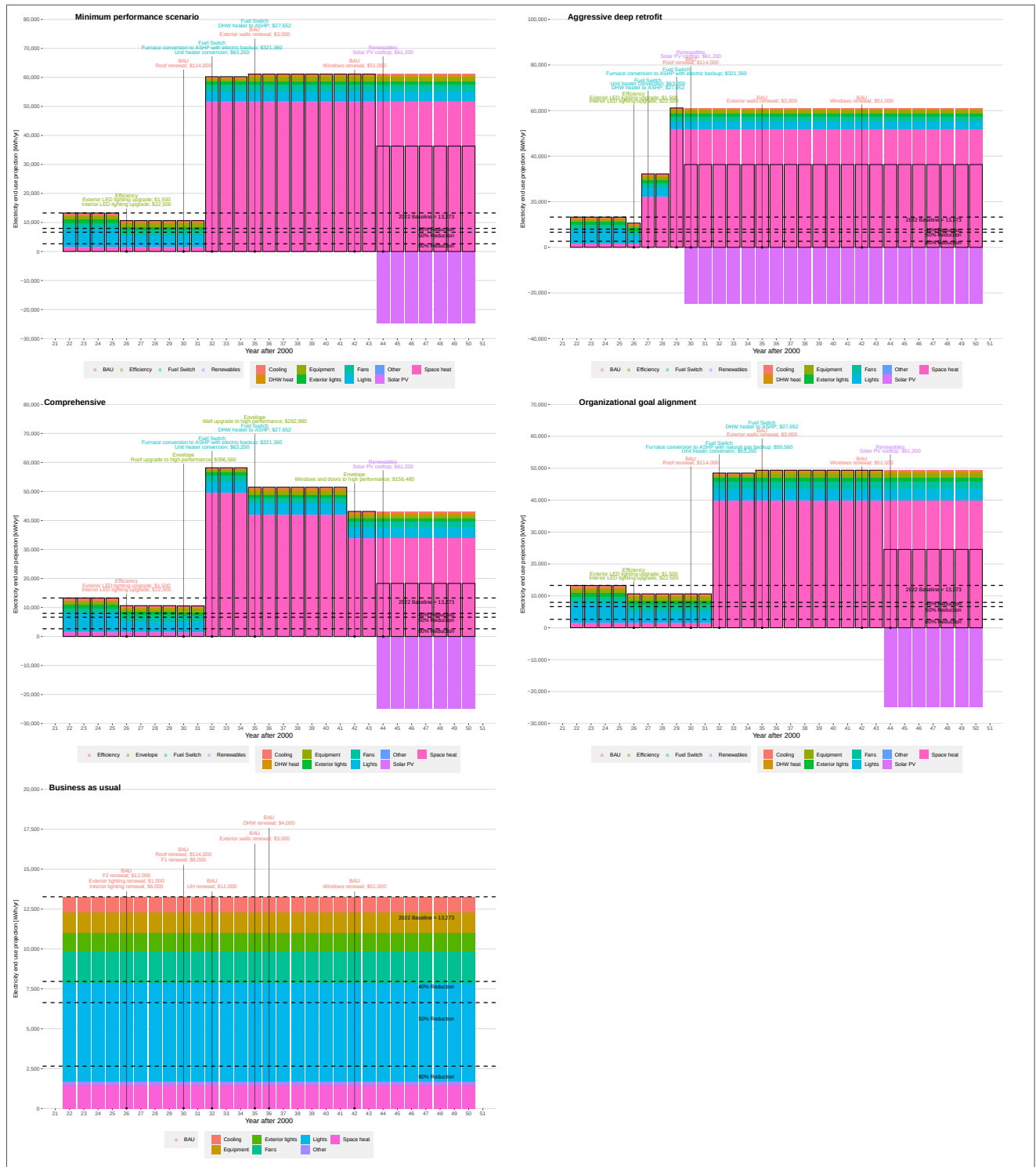


Figure 111: Electricity yearly utility use projection for each scenario



Figure 112: Natural gas yearly utility use projection for each scenario



Figure 113: GHG yearly emissions projection for each scenario



Figure 114: Life cycle yearly cost (after discounting to present value) projection for each scenario

6.7 Plan performance summary

Plan performance summary

Table 55 summarizes the performance of each plan scenario with respect to utility use, GHG emissions, utility cost, and financial metrics. The first half of Table 55 represents the estimated performance in the final year (2050) of the evaluation period. The second half of Table 55 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 55 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 114).

Table 55: 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]	36,325	36,325	18,294	24,563	13,273
	Electricity monthly peak (av)	[kW]	12.7	12.7	9.1	9.0	2.7
	Electricity yearly peak (max)	[kW]	25.9	25.9	19.6	15.0	4.5
	Natural gas use	[m3/yr]	0	0	0	1,389	7,986
GHG emissions final	Electricity GHGs	[tCO2e/yr]	0.35	0.35	0.17	0.23	0.13
	Natural gas GHGs	[tCO2e/yr]	0.0	0.0	0.0	2.7	15.4
	Carbon offsets GHGs	[tCO2e/yr]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e/yr]	0.3	0.3	0.2	2.9	15.6
Utility cost final	Electricity utility cost	[\$/yr]	8,856	8,856	4,460	5,988	3,236
	Natural gas utility cost	[\$/yr]	0	0	0	629	3,614
	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]	8,856	8,856	4,460	6,617	6,850
Utility use cumulative	Electricity use	[kWh]	1,102,227	952,159	865,692	878,747	384,906
	Natural gas use	[m3]	81,473	50,523	80,808	107,865	231,580
GHG emissions cumulative	Electricity GHGs	[tCO2e]	35.8	33.2	30.7	29.6	14.0
	Natural gas GHGs	[tCO2e]	157	98	156	208	447
	Carbon offsets GHGs	[tCO2e]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e]	193	131	187	238	462
Utility cost cumulative	Electricity utility cost	[\$]	215,823	182,849	165,057	169,963	72,102
	Natural gas utility cost	[\$]	23,226	13,874	23,021	33,280	80,530
	Carbon offsets utility cost	[\$]	0.00	0.00	0.00	0.00	0.00
	Federal carbon charge	[\$]	3,009	3,009	3,009	3,009	3,009
	Total utility cost	[\$]	242,058	199,732	191,088	206,252	155,641
Financial cumulative	Project cost	[\$]	922,800	855,700	1,974,082	533,970	246,756
	Replacement cost	[\$]	193,777	507,746	506,886	193,777	122,479
	Life cycle cost	[\$]	608,128	691,952	934,466	381,600	240,742

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 to heat pump would be required.

Aggressive deep retrofit

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

Organizational goal alignment

- To achieve the organizational goal alignment of 80% reduction in GHG emissions without carbon offsets, all measures must be implemented, with the exception of the envelope measures. Heating systems should be electrified, although natural gas can be used for backup heating.

Comprehensive

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

7 END