

PATHWAY TO DECARBONIZATION FEASIBILITY STUDY

CITY OF TEMISKAMING SHORES

BUILDING MAINTENANCE SHOP
500 Broadway Street, Haileybury, ON

WalterFedy Project No: 2023-0734-11

July 21, 2025



DISCLAIMER AND LIMITATION OF LIABILITY

This document was prepared by WalterFedy for the above stated client ("Client") for the specific purpose and use by the client, as described in the report and subsequent scope of work agreement. This report was completed based on the information that was available at the time of the report preparation and completion, and is subject to all limitations, assumptions and qualifications contained herein. Any events or circumstances that have occurred since the date on which the report was prepared, are the responsibility of the client, and WalterFedy accepts no responsibility to update the report to reflect these changes.

WalterFedy agrees that this report represents its professional judgement and any estimates or opinions regarding probable costs, schedules, or technical estimates provided represent the professional judgement in light of WalterFedy's experience as well as the information available at the time of report preparation. In addition, WalterFedy accepts no responsibilities for changes in market or economic conditions, price fluctuations for labour and material costs, and therefore makes no representations, guarantees or warranties for the estimates in this report. Persons relying on such estimates or opinions do so at their own risk.

Reported utility company incentive amounts are estimated based on information that was available at the time of report preparation. Actual incentive amounts are to be determined and provided by the utility company. The utility company must be contacted prior to beginning any work for which an incentive will be applied for.

This report may not be disclosed or referred to in any public document without the prior formal written consent of WalterFedy. Any use which a third party makes of the report is at the sole responsibility and risk of the third party.

WalterFedy agrees with the Client that it will provide under this Agreement the standards of care, skill and diligence normally provided in the performance of services in respect of work similar to that contemplated by this Agreement. WalterFedy at its own expense carries professional liability insurance to the extent that it deems prudent and WalterFedy's liability under this Agreement to the Client for any claim in contract or in tort related to the services provided under this Agreement howsoever arising shall be limited to the extent that such liability is covered by such professional liability insurance from time to time in effect including the deductible therein, and which is available to indemnify WalterFedy and in any event WalterFedy's liability under this Agreement shall be limited to loss or damage directly attributable to the negligent acts of WalterFedy, its officers, servants or agents, or its failure to provide the standards of care, skill and diligence aforesaid. In no event shall WalterFedy be liable for loss or damage caused by delays beyond WalterFedy's control, or for loss of earnings or for other consequential damage howsoever caused.

The errors and omissions policies are available for inspection by the Client at all times upon request. If the Client, because of its particular circumstances or otherwise, desires to obtain further insurance to protect it against any risk beyond the coverage provided by such policies, WalterFedy will co-operate with the Client to obtain such insurance at the Client's expense.

The Client, in consideration of the provision by WalterFedy of the services set forth in this Agreement, agrees to the limitations of the liability of WalterFedy aforesaid. The Client shall have no right of set-off against any billings of WalterFedy under this Agreement.

COPYRIGHT

© 2025, City of Temiskaming Shores. All Rights Reserved.

This project was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

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 Building Maintenance Shop, which is located at 500 Broadway Street in Haileybury, ON. Certain parts of this report are designed to be viewed in digital/PDF format. This approach will enable the reader to zoom in on images and navigate the document using the provided hyperlinks.

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

All of which is respectfully submitted,

WALTERFEDY



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

jmansfield@walterfedy.com
519 576 2150 x 336

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	9
2.4 Space use	10
2.5 Building Envelope	11
2.6 HVAC	13
2.7 Domestic hot water	15
2.8 Lighting	16
2.9 Process and plug loads	18
2.10 Water fixtures	20
2.11 Utility services	21
2.12 Onsite energy sources	22
2.13 Electrical infrastructure	23
3 UTILITY USE ANALYSIS	24
3.1 Utility analysis methodology	24
3.2 Utility analysis assumptions	26
3.3 Electricity metered utility use	27
3.4 Natural gas metered utility use	29
3.5 Utility use baseline	30
3.6 Benchmarking analysis	31
3.7 ENERGY STAR Portfolio Manager benchmarking analysis	33
3.8 Utility use analysis discussion	34
4 ENERGY MODEL DEVELOPMENT	35
4.1 Energy model development methodology	35
4.2 Hourly utility use profiles	36
4.3 Monthly utility use profiles	39
4.4 Calibration analysis	40
4.5 End use analysis	44
5 MEASURE ANALYSIS	45
5.1 Measure analysis methodology	45
5.2 Measure analysis assumptions	47
5.3 Measure identification	50
5.4 Carbon offsets 20	51
5.5 Implement a thermostat schedule for UH1	53
5.6 Install a mini split system in the lunchroom	55
5.7 Roof upgrade to high performance	57
5.8 Solar PV rooftop	59
5.9 Unit heaters conversion	62

5.10 Wall upgrade to high performance	64
5.11 Windows and doors to high performance	66
5.12 Measure risk analysis	68
5.13 Measure analysis summary	70
6 SCENARIO ANALYSIS	71
6.1 Cluster scenario analysis methodology	71
6.2 Cluster scenario objectives	71
6.3 Cluster scenario composition	72
6.4 Cluster scenario performance analysis	73
6.5 Plan scenario development	83
6.6 Plan performance analysis	87
6.7 Plan performance summary	91
6.8 Scenario analysis discussion	92
7 END	93

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 Building Maintenance Shop aerial view	8
4 Aluminum framed window	12
5 Doors to the cold storage area	12
6 Entry door	12
7 Gable end has exposed siding on the south elevation	12
8 Gap at the bottom of the overhead door on the north elevation	12
9 Metal siding on the interior layer	12
10 North elevation	12
11 Overhead door on the east elevation	12
12 Overhead door on the north elevation	12
13 Siding is in poor condition	12
14 Siding missing on the cold storage side	12
15 Underside of roof	12
16 Windows on the cold storage side	12
17 Windows on the south elevation appear original to the building	12
18 Wood siding	12
19 Ceiling fan control	14
20 Ceiling fan	14
21 EF1 control switch	14
22 EF1 exhaust	14
23 EF1	14
24 Electric baseboard in the washroom	14
25 Electric space heater in the clubhouse (ESH1)	14
26 UH1 thermostat	14
27 UH1	14
28 UH2 - mothballed	14
29 Unitary air conditioner with condenser faced out to shop area (AC1)	14
30 DHW1	15
31 Old light no longer used	17
32 Type A	17
33 Type AA	17

34	Type B	17
35	Type C	17
36	Type D	17
37	Type D1	17
38	Type E	17
39	Type F	17
40	Type G	17
41	Type H	17
42	Air compressor pressure gauge	18
43	Air compressor	18
44	Door opener for the south overhead door	18
45	Drill press	18
46	Exterior receptacle	18
47	Fuel station control panel	18
48	Fuelling station	18
49	Microwave and radio	18
50	Mitre saw	18
51	Pancake compressor	19
52	Printer in the clubhouse	19
53	Table saw	19
54	Former sink retrofitted with a garden hose	20
55	Handwashing faucets in the washroom	20
56	Sink in the clubhouse	20
57	Toilet	20
58	Electricity meter	21
59	Natural gas meter	21
60	Natural gas piping that is going to UH1	21
61	60A disconnect for Panel LR	23
62	Compressor disconnect	23
63	Fuel pump and washroom heater disconnects	23
64	Hot water tank disconnect	23
65	Main disconnect	23
66	Panel A	23
67	Panel C	23
68	Panel LR	23
69	Hourly electricity use	27
70	Hourly electricity use hairball plot	27
71	Monthly electricity use	28
72	Monthly natural gas use	29
73	Electricity use intensity benchmarking analysis comparison	31
74	Natural gas use intensity benchmarking analysis comparison	31
75	Total energy use intensity benchmarking analysis comparison	32
76	GHG emissions intensity benchmarking analysis comparison	32
77	Energy Star energy performance scorecard.	33
78	Hourly electricity utility use by end use (made by calibrated energy model)	37
79	Hourly natural gas utility use by end use (made by calibrated energy model)	38
80	Monthly utility use profiles for each modelled utility	39
81	Electricity calibration analysis (metered vs modelled utility use)	40
82	Natural gas calibration analysis (metered vs modelled utility use)	41
83	Electricity end use breakdown (calculated by calibrated energy model)	44
84	Natural gas end use breakdown (calculated by calibrated energy model)	44
85	Utility cumulative use sensitivity analysis	68
86	GHG cumulative emissions and life cycle cost sensitivity analysis	69
87	Scenario composition	72

88	Electricity utility use expected yearly for each scenario by end use	75
89	Natural gas utility use expected yearly for each scenario by end use	76
90	Equivalent energy use expected yearly for each scenario by end use	77
91	GHG emissions expected yearly for each scenario by end use	78
92	Utility costs expected yearly for each scenario by end use	79
93	Project cost expected for each scenario by measure	80
94	Life cycle cost expected for each scenario by cost item	81
95	GHG cumulative reduction per life cycle cost (LCC) dollar expected for each scenario by utility . . .	82
96	Plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario	84
97	Electricity yearly utility use projection for each scenario	87
98	Natural gas yearly utility use projection for each scenario	88
99	GHG yearly emissions projection for each scenario	89
100	Life cycle yearly cost (after discounting to present value) projection for each scenario	90

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	10
6	Building envelope summary	11
7	Air distribution systems summary	13
8	Heating systems summary	13
9	Cooling systems summary	13
10	Lighting systems summary	16
11	Water fixture summary	20
12	Baseline performance data source for each utility	24
13	GHG emissions factor assumptions	26
14	Utility cost rate assumptions for the baseline year (2022)	26
15	Baseline utility use performance	30
16	Utility and end use summary and definitions	35
17	Statistical calibration analysis summary	42
18	Utility cost rate future assumptions	47
19	Financial incentive assumptions	48
20	Life cycle cost analysis assumptions	48
21	Risk parameter and case definitions	48
22	Measure identification and triaging summary	50
23	Carbon offsets 20 analysis results summary	52
24	Project cost estimate (Implement a thermostat schedule for UH1)	53
25	Implement a thermostat schedule for UH1 analysis results summary	54
26	Project cost estimate (Install a mini split system in the lunchroom)	56
27	Install a mini split system in the lunchroom analysis results summary	56
28	Project cost estimate (Roof upgrade to high performance)	57
29	Roof upgrade to high performance analysis results summary	58
30	Project cost estimate (Solar PV rooftop)	60
31	Solar PV rooftop analysis results summary	61
32	Project cost estimate (Unit heaters conversion)	63
33	Unit heaters conversion analysis results summary	63
34	Project cost estimate (Wall upgrade to high performance)	65
35	Wall upgrade to high performance analysis results summary	65
36	Project cost estimate (Windows and doors to high performance)	67

37	Windows and doors to high performance analysis results summary	67
38	Measure analysis summary	70
39	Scenario objectives	71
40	Cluster composition	73
41	Scenario analysis summary	74
42	Plan scenario identification and objectives	83
43	Scenario composition summary	85
44	Minimum performance scenario measure implementation timeline	85
45	Aggressive deep retrofit measure implementation timeline	85
46	Comprehensive measure implementation timeline	85
47	Organizational goal alignment measure implementation timeline	86
48	Business as usual measure implementation timeline	86
49	Plan performance summary	91

EXECUTIVE SUMMARY

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

1. **Facility description.** The existing conditions of the facility were reviewed through available documentation and a site survey completed on 2024-04-17 to gain an understanding of the facility and its operations. A facility description, summarizing findings, is provided in Section 2.
2. **Utility use baseline.** Metered utility data provided by the City of Temiskaming Shores was reviewed to understand historical utility use trends, and to establish the utility use baseline for the Building Maintenance Shop. 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 Building Maintenance Shop 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.

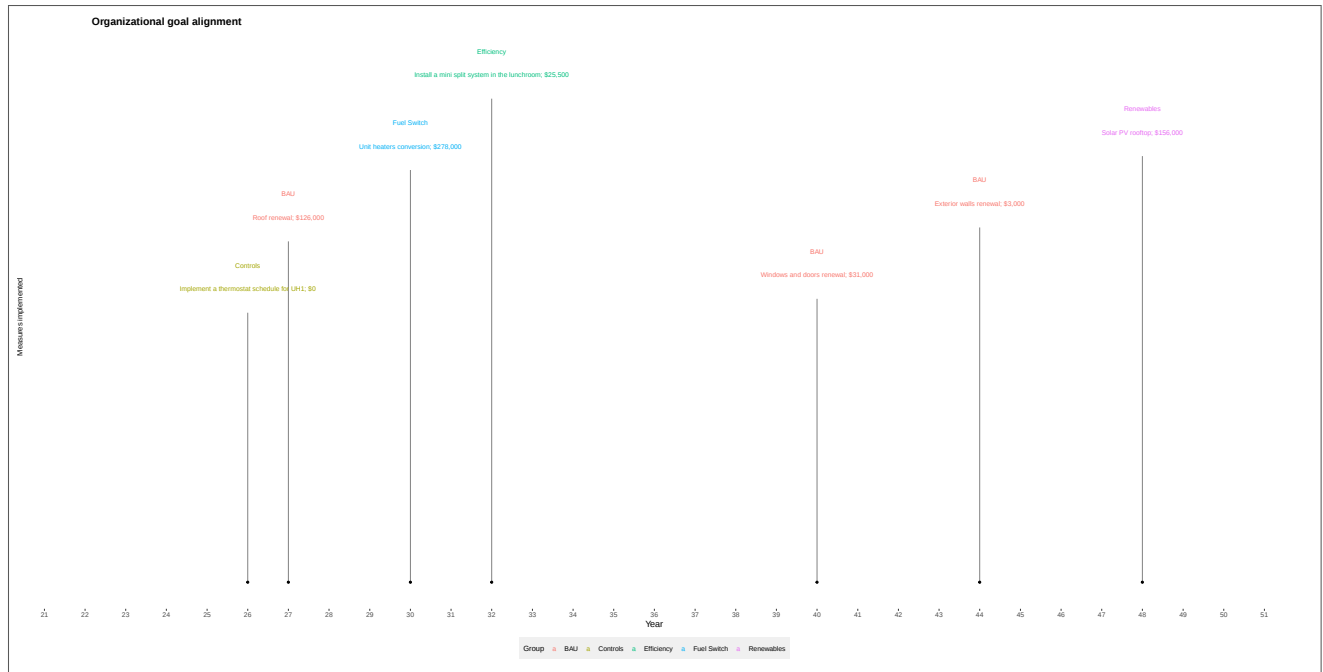


Figure 1: Recommended plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

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

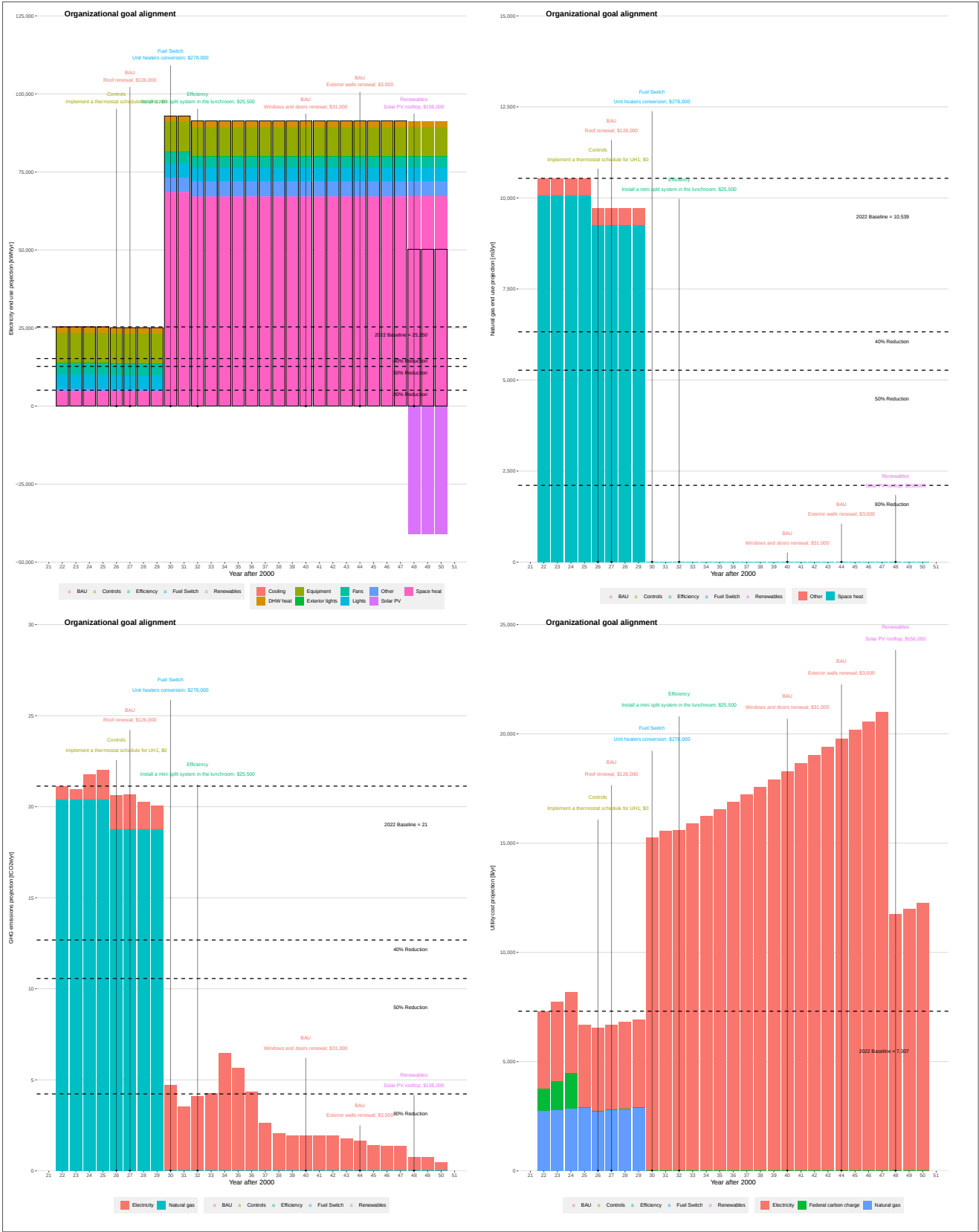


Figure 2: Recommended scenario performance

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]	50,219	50,219	23,301	50,219	25,350
	Electricity monthly peak (av)	[kW]	20.0	20.0	14.3	20.0	6.5
	Electricity yearly peak (max)	[kW]	37.4	37.4	26.8	37.4	7.3
	Natural gas use	[m3/yr]	0	0	0	0	10,539
GHG emissions final	Electricity GHGs	[tCO2e/yr]	0.48	0.48	0.22	0.48	0.24
	Natural gas GHGs	[tCO2e/yr]	0.0	0.0	0.0	0.0	20.4
	Carbon offsets GHGs	[tCO2e/yr]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e/yr]	0.5	0.5	0.2	0.5	20.6
Utility cost final	Electricity utility cost	[\$/yr]	12,243	12,243	5,681	12,243	6,180
	Natural gas utility cost	[\$/yr]	0	0	0	0	4,770
	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]	12,243	12,243	5,681	12,243	10,950
Utility use cumulative	Electricity use	[kWh]	1,999,930	1,455,155	1,628,645	1,999,930	735,164
	Natural gas use	[m3]	81,009	51,869	81,009	81,009	305,628
GHG emissions cumulative	Electricity GHGs	[tCO2e]	66.2	54.6	58.4	66.2	26.8
	Natural gas GHGs	[tCO2e]	157	100	157	157	591
	Carbon offsets GHGs	[tCO2e]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e]	223	155	215	223	617
Utility cost cumulative	Electricity utility cost	[\$]	387,800	274,114	308,121	387,800	137,714
	Natural gas utility cost	[\$]	22,558	14,027	22,558	22,558	106,280
	Carbon offsets utility cost	[\$]	0.00	0.00	0.00	0.00	0.00
	Federal carbon charge	[\$]	3,971	3,971	3,971	3,971	3,971
	Total utility cost	[\$]	414,329	292,112	334,650	414,329	247,965
Financial cumulative	Project cost	[\$]	897,638	780,548	1,970,378	897,638	186,556
	Replacement cost	[\$]	375,291	358,542	277,895	375,291	97,397
	Life cycle cost	[\$]	673,710	756,979	633,842	673,710	284,476

1 INTRODUCTION

1.1 Overview

WalterFedy was engaged by the City of Temiskaming Shores to complete a Pathway to Decarbonization Feasibility Study for the Building Maintenance Shop. 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 Building Maintenance Shop 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 Building Maintenance Shop represented 22 tCO₂e in 2019, or 1.1% 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 Building Maintenance Shop.

Table 2: Asset management summary for this facility

Group	Metric	Unit	Value
Financial	Content Value Estimated	[\$]	59,102
	Building Land Tank	[\$]	644,859
	Replacement Cost	[\$]	703,961
Information	Install Date	[yr]	1969
	Age	[yrs]	56
Condition Rating	Structure Condition Score	[-]	3.9
	Final Condition Score	[-]	3.9
Risk	Probability of Failure	[-]	2
	Consequence of Failure	[-]	4
	Risk Score	[-]	2.4

1.3 Contact information

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

Table 3: Contact information

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

2 FACILITY DESCRIPTION

2.1 Facility description methodology

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

1. **Facility document review.** Facility documents from the following list were reviewed, if available. Further information on available documentation are available in Section 2.3.
 - Building drawings.
 - Building automation system graphics and points lists.
 - Previously completed Engineering studies, including Energy Audits, Feasibility Studies, and Building Condition Assessments.
 - Historical utility use data.
 - Other documentation made available by the City of Temiskaming Shores.
2. **Site survey.** A site survey was completed on 2024-04-17 to review the energy systems applicable to the desired retrofit scenario.

2.2 Facility overview

An overview of the Building Maintenance Shop is provided in Table 4.

Table 4: Facility overview

Description	Unit	Value
Name	[-]	Building Maintenance Shop
Address	[-]	500 Broadway Street
Location	[-]	Haileybury, ON
Type	[-]	Public works
Construction year	[-]	1969
Gross floor area	[m2]	530
Gross floor area	[ft2]	5,710

An aerial view of the Building Maintenance Shop is provided in Figure 3.



Figure 3: Building Maintenance Shop aerial view

2.3 Building information

Renovations

There are no known renovations to this building.

Additions

It is assumed that 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
- Fuel pumps

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

Only document was available, which is a CAD drawing showing the floor plans of the facility.

2.4 Space use

Type summary

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

- Workshop
- Cold storage (west elevation)
- Electrical area
- Office/lunch room
- Washroom
- Storage

It appears that spaces are being used as intended.

Occupancy scheduling

The facility operation hours is assumed as follows:

- 07:00-15:30 Monday to Friday

There are typically only two staff members in this building. However, their time spent in this space is intermittent based on work order assignment.

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]	-	-
Shop space	305	UH1	Drawings.
Clubhouse	8	ESH1	Drawings.
Washroom	4	Baseboards	Drawings.
Storage and mezzanine	144	Unconditioned	Drawings.

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]
483	491	450	1.8	39.1

Overview

No architectural drawings were available, and therefore no detailed information on building assemblies. All overall R-Values are based on the requirements listed in the Model National Energy Code of Canada for Buildings, 1997.

Roof

- The roof exterior layer appears to be metal. There appears to be minimal insulation.
- The overall R-Value is assumed to be R11.
- The roof condition could not be assessed.

Opaque Walls (above ground)

- The exterior walls had an outer layer of wood siding.
- The overall R-Value is assumed to be R11.
- The wall condition was poor. Siding is becoming unfastened in some areas with other areas missing siding altogether.

Fenestration

Windows

- The facility has aluminum-framed, double-pane slider windows and single-pane windows at the south elevation.
- The original windows are in poor condition, and the double pane sliders appear to be in fair condition.
- The overall R-Value is assumed to be 0.625 Btu/hr.ft².F for the window system with a solar heat gain coefficient of 0.35.

Doors

- The facility has hollow metal and overhead doors.
- The overall fenestration-to-wall ratio is estimated to be 8%, as elevation drawings were not made available.

Overall Enclosure Tightness

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

Building Envelope documentation

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



Figure 4: Aluminum framed window



Figure 5: Doors to the cold storage area



Figure 6: Entry door



Figure 7: Gable end has exposed siding on the south elevation



Figure 8: Gap at the bottom of the overhead door on the north elevation



Figure 9: Metal siding on the interior layer



Figure 10: North elevation



Figure 11: Overhead door on the east elevation



Figure 12: Overhead door on the north elevation



Figure 13: Siding is in poor condition



Figure 14: Siding missing on the cold storage side



Figure 15: Underside of roof



Figure 16: Windows on the cold storage side



Figure 17: Windows on the south elevation appear original to the building



Figure 18: Wood siding

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]	-
EF1	-	-	Shop space	200	0.10	Assumption.

Table 8: Heating systems summary

Tag	Serves	Utility	Efficiency	Output	Data source
-	-	-	[decimal]	[btuh]	-
ESH1	Clubhouse	Electricity	1.00	5,118	Nameplate.
UH1	Shop space	Natural gas	0.82	147,600	Nameplate.
Baseboard	Washroom	Electricity	1.00	3,595	Assumption.
DHW1	Domestic hot water heater	Electricity	1.00	15,355	Assumption.

Table 9: Cooling systems summary

Tag	Serves	Efficiency	Output	Data source
-	-	[decimal]	[ton]	-
AC1	Clubhouse	3	0.50	Assumption.

System type

The facility utilizes the following equipment:

- One natural gas-fired unit heater (UH1) serves the shop space. This unit is controlled by a programmable thermostat. However, it is set to hold at 71F.
- There is an old natural gas fired unit heater (UH2), no longer working, that is still present at the site.
- An electric portable space heater is used in the clubhouse. This unit is manually controlled.
- An electric baseboard heater is used in the washroom, which has a built-in thermostat.
- There is an exhaust fan (EF1) which is manually controlled via a switch.
- The clubhouse has one unitary air conditioner and the condenser side is inside the building, interfacing with the shop area.

Central Plant

There is no central plant at this facility.

Distribution system

There are no pumps or ductwork present at this site.

Controls

- No BAS is present at this site.

HVAC system documentation

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



Figure 19: Ceiling fan control



Figure 20: Ceiling fan



Figure 21: EF1 control switch



Figure 22: EF1 exhaust

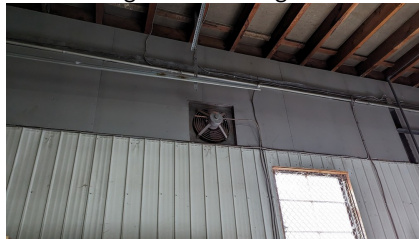


Figure 23: EF1



Figure 24: Electric baseboard in the washroom



Figure 25: Electric space heater in the clubhouse (ESH1)

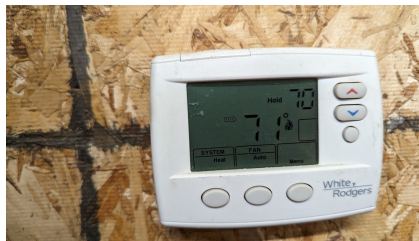


Figure 26: UH1 thermostat



Figure 27: UH1



Figure 28: UH2 - mothballed



Figure 29: Unitary air conditioner with condenser faced out to shop area (AC1)

2.7 Domestic hot water

Overview

One electric DHW heater serves the washroom and clubhouse with a tank capacity of 74 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 30: DHW1

2.8 Lighting

Lighting system summary

Lighting systems are summarized in Table 10.

Table 10: Lighting systems summary

Space name	Floor area of space	Light power density	Light power input	Data source
-	[m2]	[W/m2]	[W]	-
Shop space	305	3.2	976	Assumed based on ASHRAE 2004 standard for storage garages.
Clubhouse	8	3.2	26	Assumed based on ASHRAE 2004 standard for storage garages.
Washroom	4	3.2	13	Assumed based on ASHRAE 2004 standard for storage garages.
Storage and mezzanine	144	3.2	461	Assumed based on ASHRAE 2004 standard for storage garages.

Interior lighting

Fixtures

The following interior light fixtures were observed during the site survey. Types have been assigned for referencing purposes.

- Type A: 1'x4', surface mounted, 2 lamps, LED, 24 W
- Type B: 1'x4', wall surface mounted, 2 lamps, T8, 56 W
- Type C: strip light, surface mounted, LED, 48 W (assumed)
- Type D: 1'x4', surface mounted, 2 lamps, LED, 24 W
- Type D1: 1'x4', suspended, 2 lamps, LED, 24 W
- Type D: 1'x4', surface mounted, 2 lamps, LED, 24 W (assumed)
- Type F: Strip, surface mounted, 1 lamp, LED, 12 W
- Type G: 1 lamp, 9 W (assumed)
- Type H: 1'x4', surface mounted, 2 lamps, LED, 24 W

Controls

Interior lighting control is done through manual switches.

Exterior lighting

Fixtures

The following exterior light fixture was observed during the site survey:

- Type AA: Wall pack, LED, 30 W (assumed)

Controls

It's assumed that the exterior lights are controlled by a photocell.

Lighting system documentation

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



Figure 31: Old light no longer used

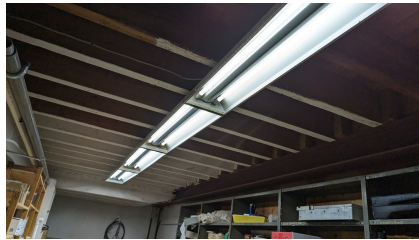


Figure 32: Type A



Figure 33: Type AA

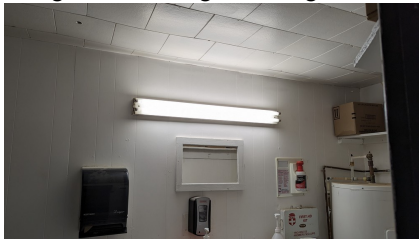


Figure 34: Type B

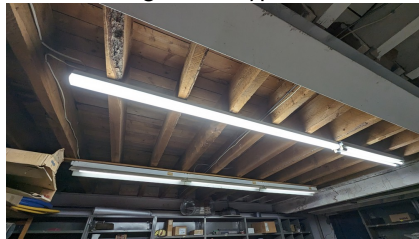


Figure 35: Type C

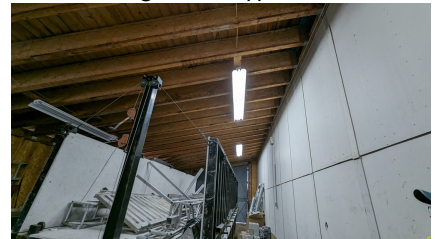


Figure 36: Type D

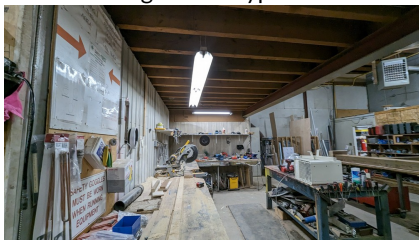


Figure 37: Type D1



Figure 38: Type E

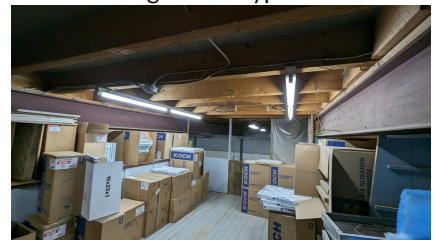


Figure 39: Type F



Figure 40: Type G



Figure 41: Type H

2.9 Process and plug loads

Process

Various process loads are present at the facility, including:

- Air compressor (15 hp). There were no signs of leaks. The compressor also did not fire during our site visit.
- Overhead door openers
- Shop equipment (e.g., drill press, mitre saw, table saw, etc.)
- Fuel pumps

Plug loads

Various plug loads are present at the facility, including:

- Personal computers
- Appliances (e.g., microwave)

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.

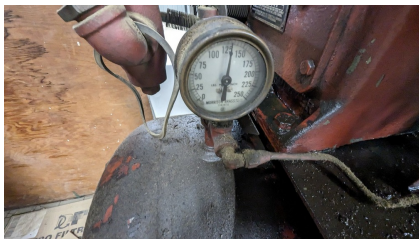


Figure 42: Air compressor pressure gauge



Figure 43: Air compressor



Figure 44: Door opener for the south overhead door

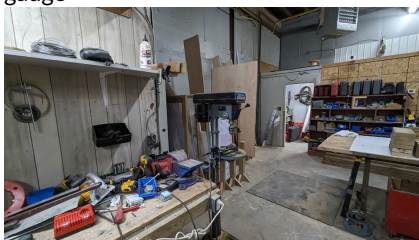


Figure 45: Drill press

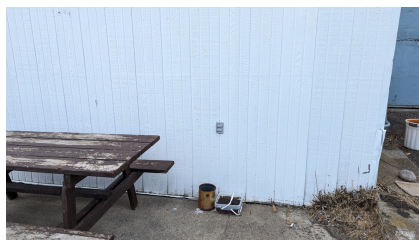


Figure 46: Exterior receptacle



Figure 47: Fuel station control panel



Figure 48: Fuelling station



Figure 49: Microwave and radio

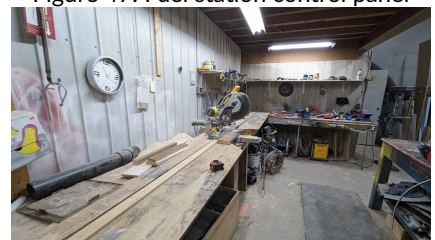


Figure 50: Mitre saw



Figure 51: Pancake compressor



Figure 52: Printer in the clubhouse



Figure 53: Table saw

2.10 Water fixtures

Water fixture summary

Water fixtures at Building Maintenance Shop are summarized in Table 11.

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

Overview

A summary of water fixtures is as follows:

- Two handwashing faucets.
- One kitchen sink.
- One toilet.

Water fixture documentation

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



Figure 54: Former sink retrofitted with a garden hose



Figure 55: Handwashing faucets in the washroom

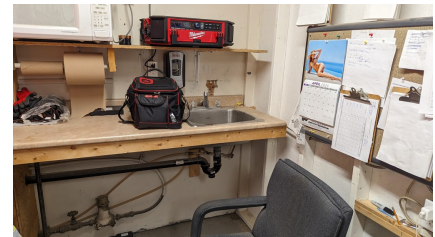


Figure 56: Sink in the clubhouse



Figure 57: Toilet

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 58: Electricity meter



Figure 59: Natural gas meter



Figure 60: Natural gas piping that is going to UH1

2.12 Onsite energy sources

Overview

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

2.13 Electrical infrastructure

Overview

The existing systems is 200A at 208V-3P running at a maximum load of 10.64 kW, which is approximately 20% of the full load of 57.6 kW of the building. The existing system consists of a main disconnect to the main splitter, which has three panels powered from it. Panel A and Panel C are at physical breaker capacity, where as Panel LR has a lot of available space.

Based on interval data, the peak hourly electrical load of the building since 2020 is 10.64 kW. Based on this information and the size of the main disconnect (200A), there is approximately 85% of load available.

Panel summary

The three panels at this site are summarized below:

- Panel A, 100A
- Panel LR, 70A
- Panel C, 100A

Electrical infrastructure documentation

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



Figure 61: 60A disconnect for Panel LR



Figure 62: Compressor disconnect



Figure 63: Fuel pump and washroom heater disconnects



Figure 64: Hot water tank disconnect



Figure 65: Main disconnect

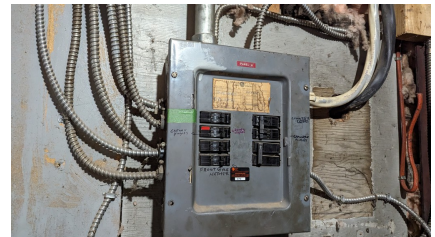


Figure 66: Panel A



Figure 67: Panel C



Figure 68: Panel LR

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 Building Maintenance Shop.
 - 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 Building Maintenance Shop 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 Building Maintenance Shop.
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 69.

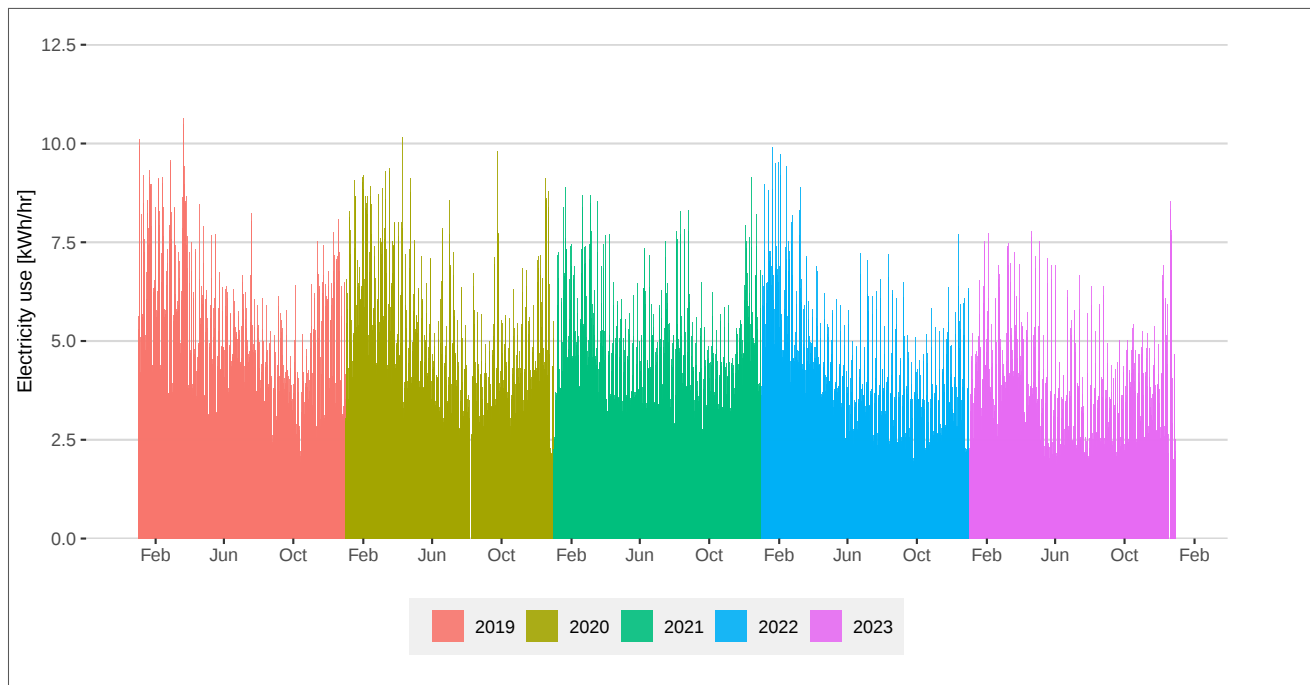


Figure 69: Hourly electricity use

The same hourly electricity use data is plotted in Figure 70, which highlights how electricity use is influenced by year, season, day of week and hour of day. The vertical axis on Figure 70 may be rescaled relative to in Figure 69 for greater resolution.

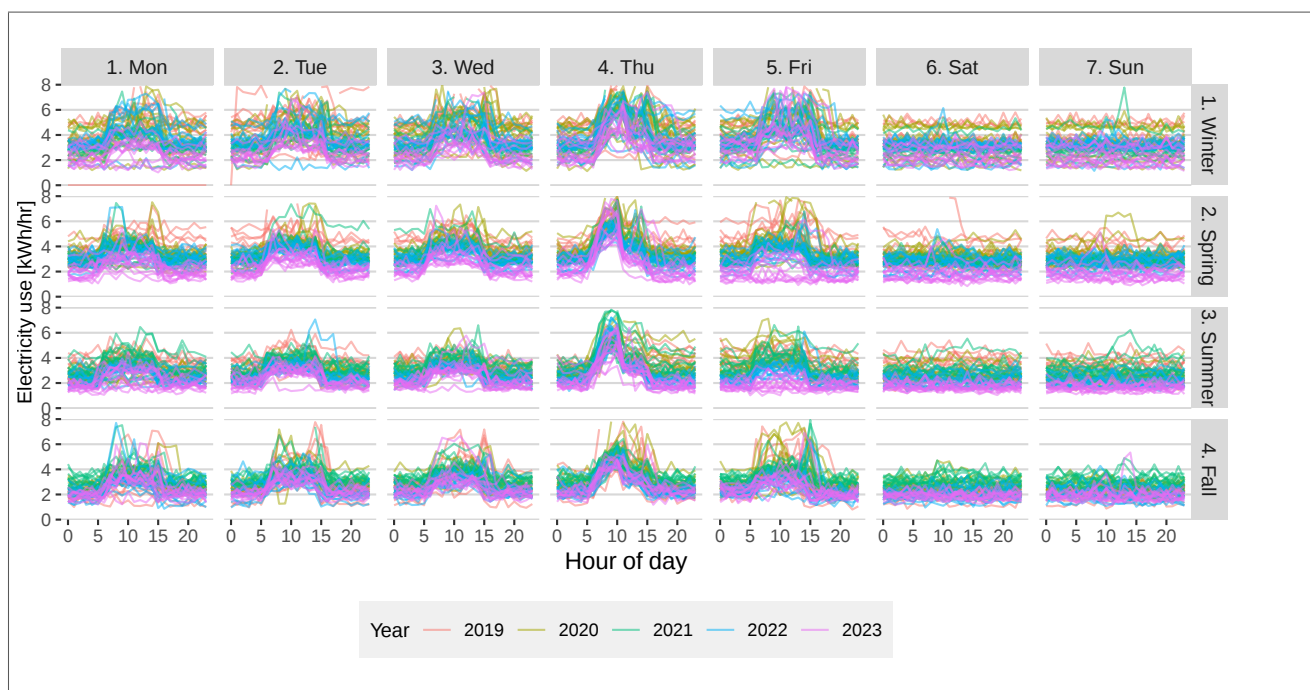


Figure 70: Hourly electricity use hairball plot

Monthly electricity use is plotted in Figure 71.

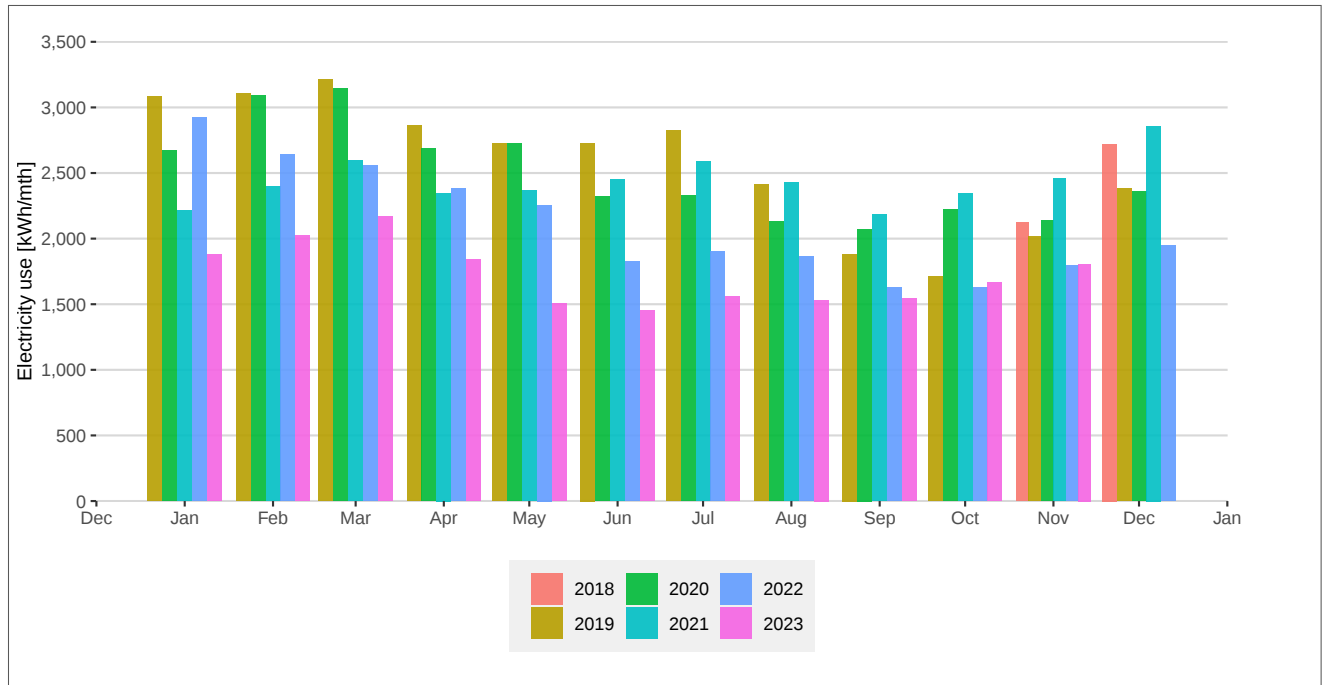


Figure 71: Monthly electricity use

3.4 Natural gas metered utility use

Monthly natural gas use is plotted in Figure 72.

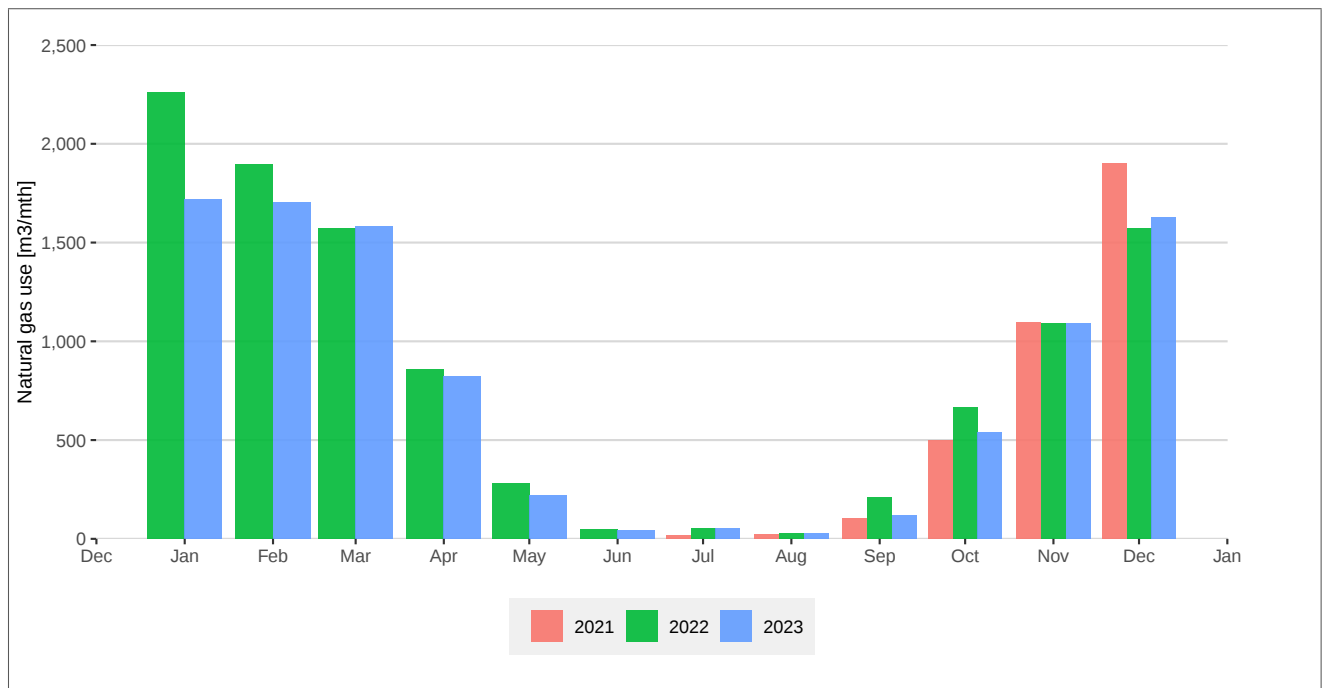


Figure 72: Monthly natural gas use

3.5 Utility use baseline

Baseline year

The baseline year for Building Maintenance Shop, 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]	25,350
	Natural gas use	[m3/yr]	10,539
	Carbon offset use	[tCO2e/yr]	0
Equivalent energy use	Electricity energy	[kWh/yr]	25,350
	Natural gas energy	[kWh/yr]	111,256
	Total energy	[kWh/yr]	136,607
GHG emissions	Electricity GHGs	[tCO2e/yr]	1
	Natural gas GHGs	[tCO2e/yr]	20
	Carbon offsets GHGs	[tCO2e/yr]	0
	Total GHGs	[tCO2e/yr]	21
Utility cost	Electricity utility cost	[\$/yr]	2,515
	Natural gas utility cost	[\$/yr]	2,740
	Carbon offsets utility cost	[\$/yr]	0
	Federal carbon charge	[\$/yr]	1,018
	Total utility cost	[\$/yr]	6,273

3.6 Benchmarking analysis

Benchmarking analysis results are presented in the following figures.

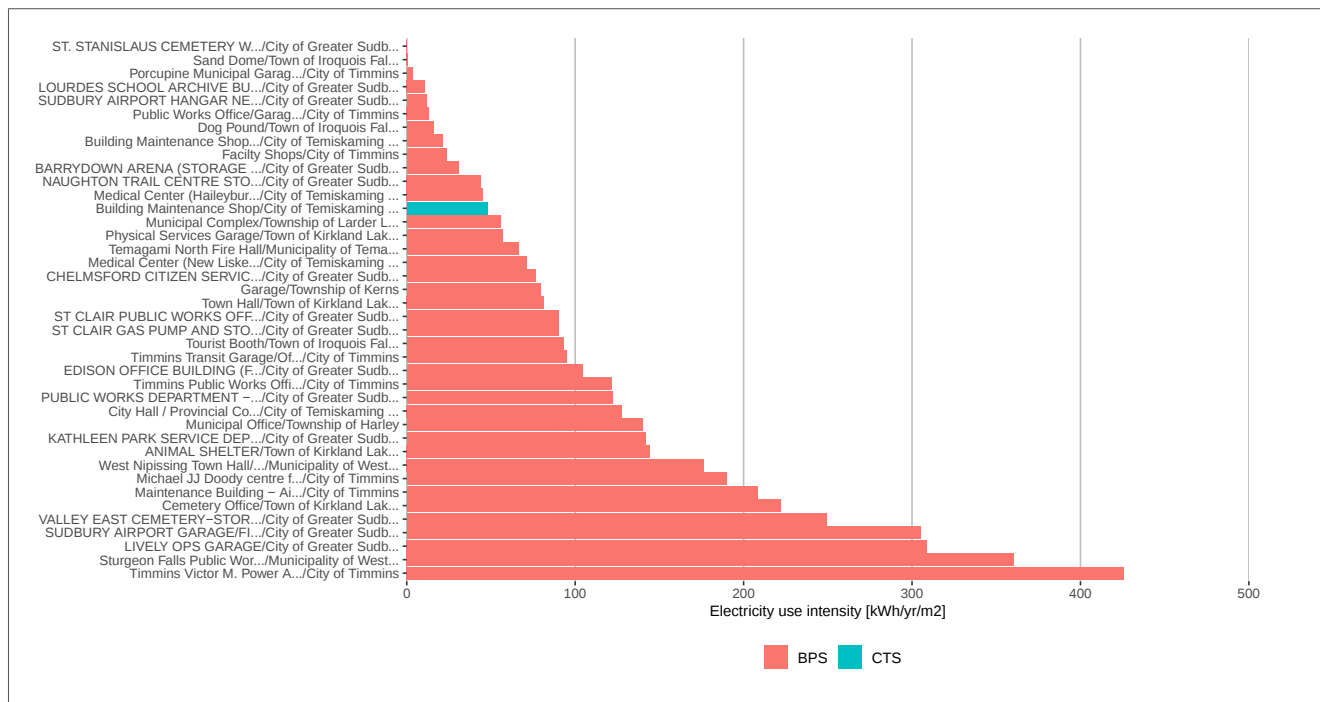


Figure 73: Electricity use intensity benchmarking analysis comparison

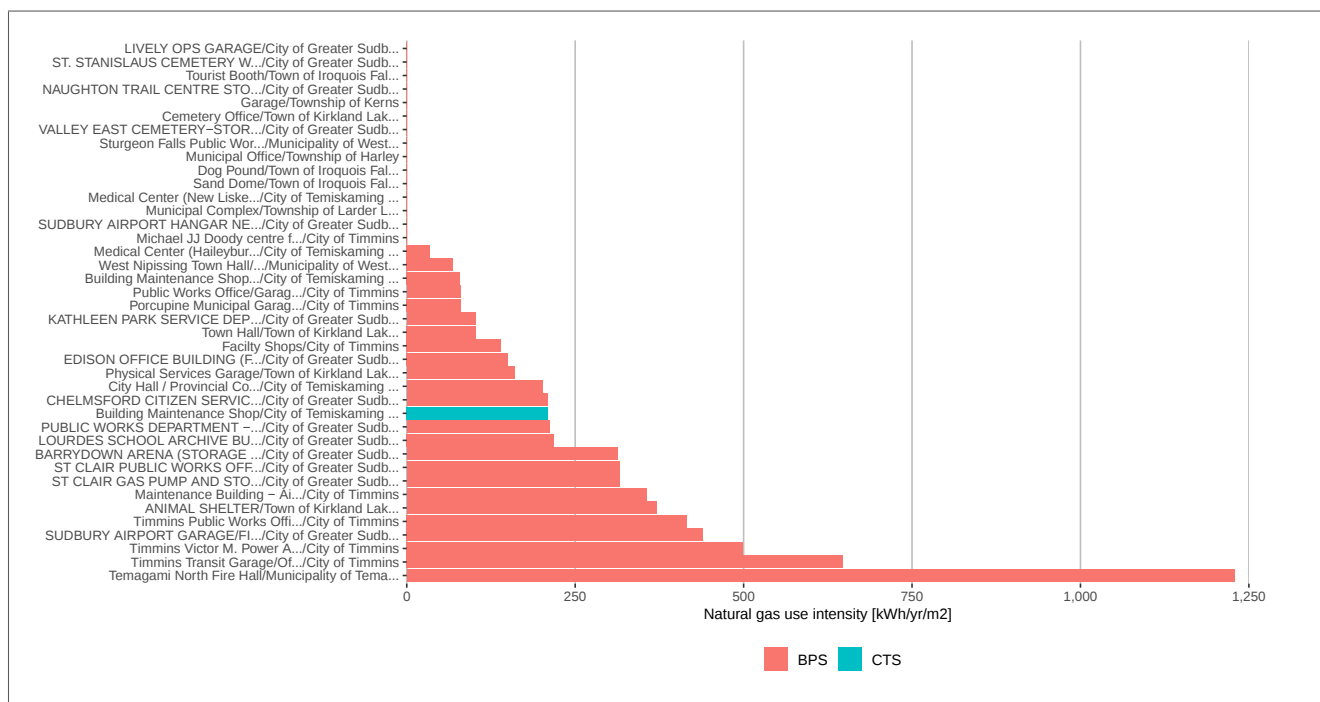


Figure 74: Natural gas use intensity benchmarking analysis comparison

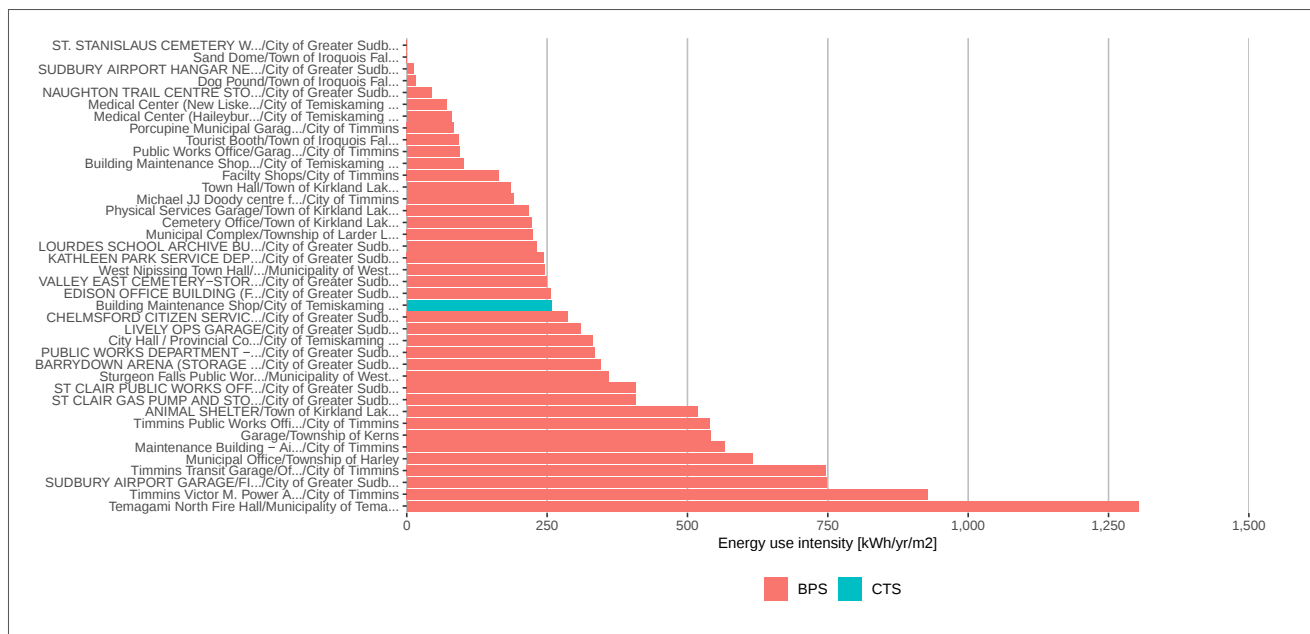


Figure 75: Total energy use intensity benchmarking analysis comparison

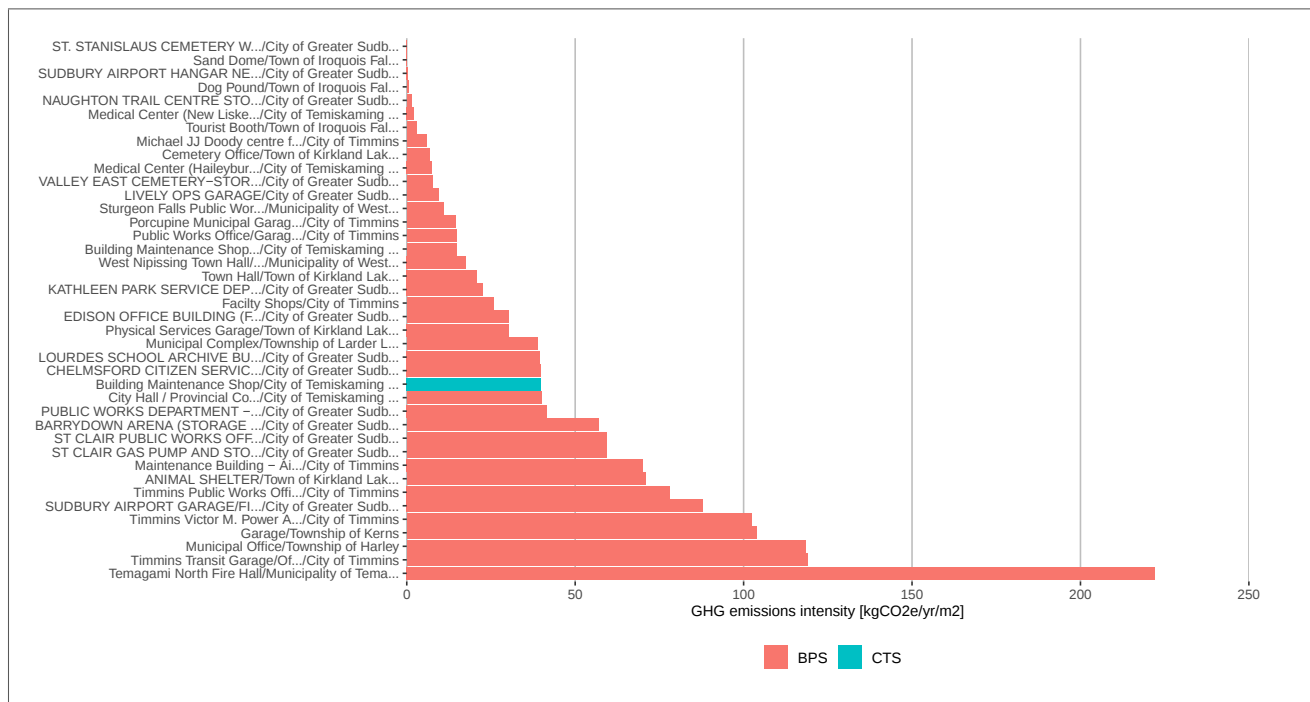


Figure 76: GHG emissions intensity benchmarking analysis comparison

3.7 ENERGY STAR Portfolio Manager benchmarking analysis

The scorecard is shown in Figure 77.

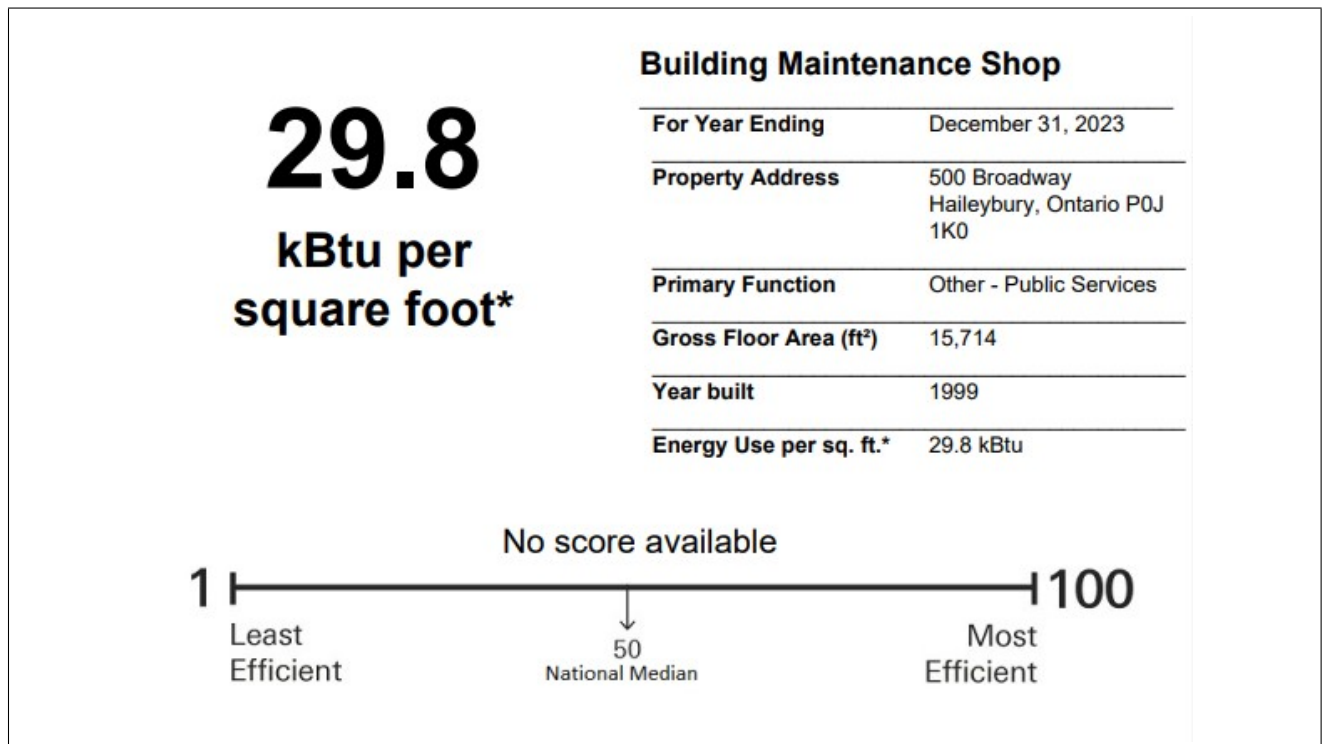


Figure 77: Energy Star energy performance scorecard.

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 and in the winter, most likely due to cooling and space heating.
- Hourly consumption is typically under 7.5 kWh and above 2 kWh.
- Higher consumption in the winter and summer suggests electric heating in the winter and cooling in the summer.

Electricity - Monthly

- **2019:** Peak consumption from January to March.
- **2020:** Similar consumption to 2020.
- **2021:** Minimal change in monthly consumption throughout the year.
- **2022:** Starting in June, 2022 has reduced consumption compared to other years.
- **2023:** Consumption year-round is lower than the average monthly consumption from other years, and similar to electricity use from June to December 2022.

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.
- Natural gas use for the Building Maintenance Shop is used for space heating.
- Of the thirty data points available for monthly natural gas consumption, only 13 were actual readings, not estimates. This observation can lead to calibration issues, as the model may not pass ASHRAE Guideline 14.

4 ENERGY MODEL DEVELOPMENT

4.1 Energy model development methodology

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

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

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

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

- (a) *Utilities and end uses.* Hourly utility use profiles developed through this analysis were assigned to both utilities and end uses. The utilities and end uses that were modelled are summarized in Table 16.

Table 16: Utility and end use summary and definitions

Utility	End use	Definition of end use
Electricity	Cooling	Cooling energy use.
	DHW heat	Domestic hot water heating energy use.
	Equipment	Equipment energy use.
	Exterior lights	Exterior lighting energy use.
	Fans	Fan motor energy use.
	Lights	Lighting energy use.
	Other	Metered use less modelled use.
	Space heat	Space heating energy use.
Natural gas	Other	Metered use less modelled use.
	Space heat	Space heating energy use.

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

- (f) *Generators*. The utility use and generation of on-site systems that generate energy or utilities was modelled based on the assumed capacities and operations of those systems according to findings documented in Section 2; examples include solar PV, CHP, etc. Utilities generated on site were treated as negative utility consumption relative to utilities consumed on site so that the consumption, generation and the aggregate use of utilities could be tracked accordingly.
 - (g) *Other*. For each utility having valid metered utility use data available for the baseline year, the Other end use was modelled from the top down to reconcile results of the above utility-consuming systems that were modelled from the bottom up with metered utility use data for the baseline year. This end use was called Other.
2. **Monthly utility use profiles**. A monthly utility use profile for each utility was developed by grouping and summing up the hourly utility use profiles by end use and by month. Results were presented in Section 4.3.
 3. **Calibration analysis**. After explicitly modeling the above systems, the model was calibrated for each of the following utilities (utilities for which valid metered data for the baseline year was available) through the Other end use, which was calculated as the difference of metered and modeled utility use. The above modeling steps were iterated as required to achieve reasonable calibration.
 - Electricity
 - Natural gas
 4. **End use analysis**. An end use analysis of each utility was completed. Since the hourly utility use profiles already track the hourly utility use by each end use, the end use analysis involved summarizing data from the hourly utility use profiles to obtain yearly utility use by each end use. Results were presented in Section 4.5.

4.2 Hourly utility use profiles

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

Electricity

The hourly electricity utility use profile by end use made by the energy model is plotted in Figure 78. See Table 16 for end use definitions.

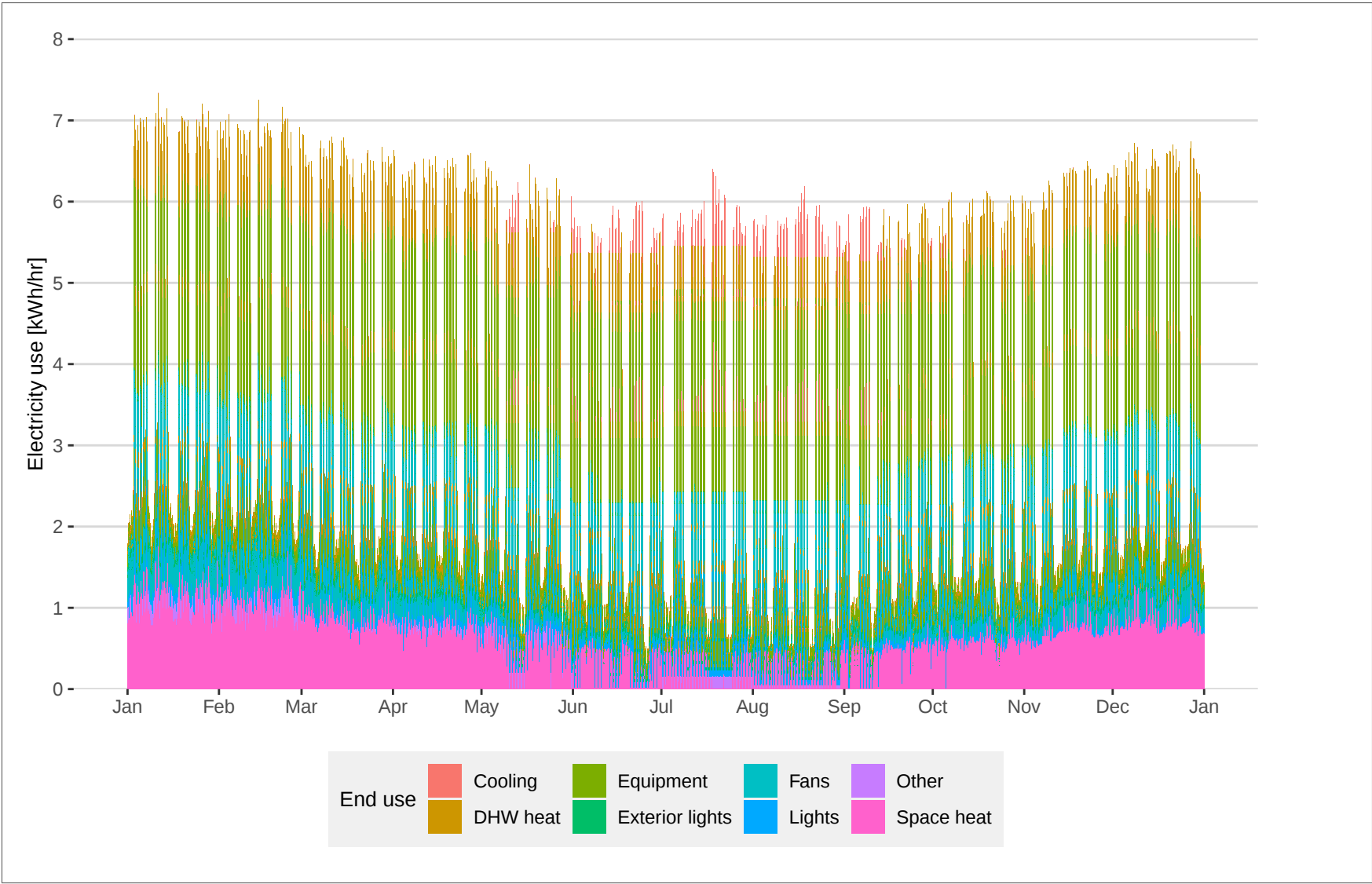


Figure 78: Hourly electricity utility use by end use (made by calibrated energy model)

Natural gas

The hourly natural gas utility use profile by end use made by the energy model is plotted in Figure 79. See Table 16 for end use definitions.

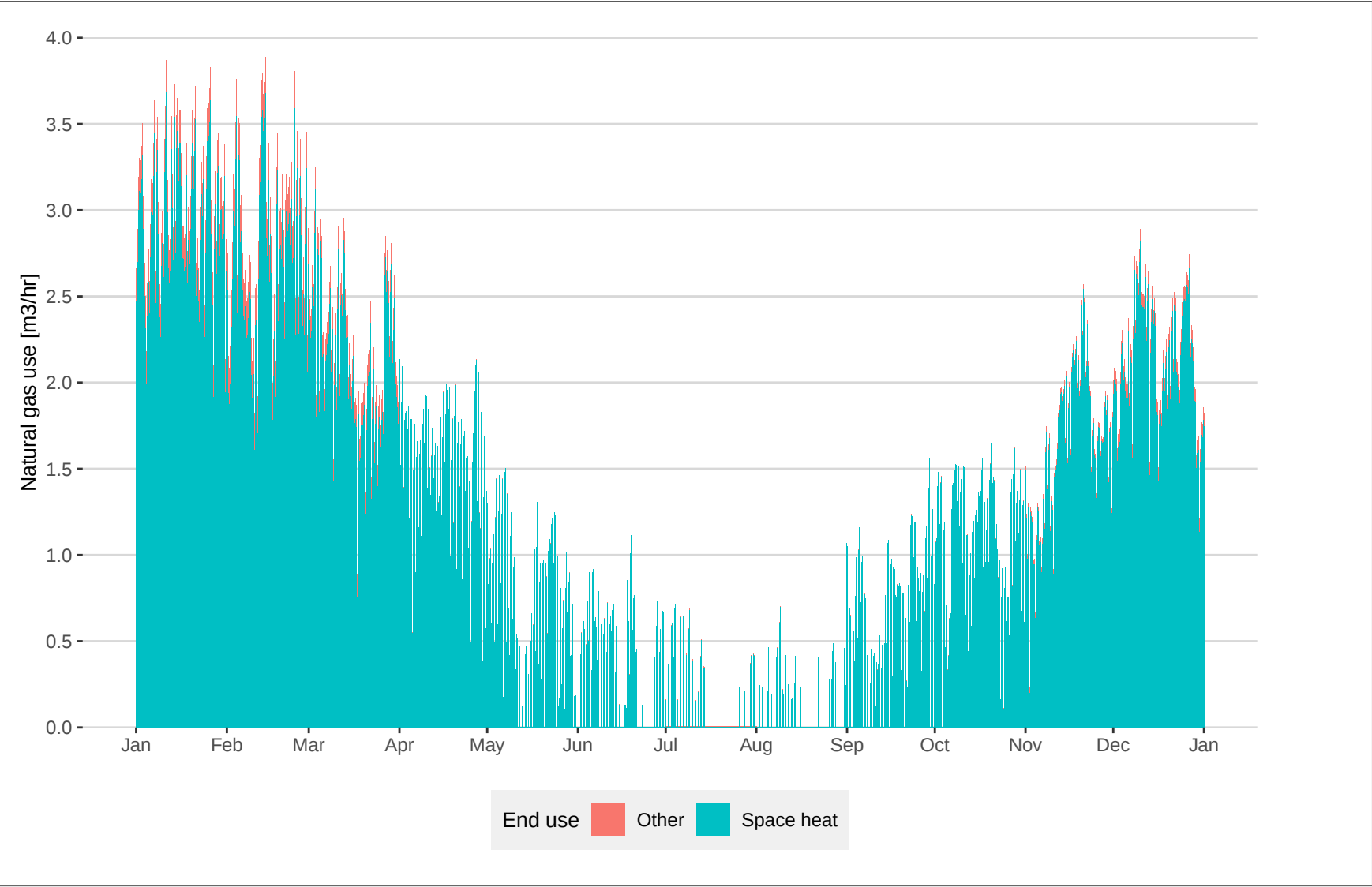


Figure 79: Hourly natural gas utility use by end use (made by calibrated energy model)

4.3 Monthly utility use profiles

Monthly utility use profiles for each modelled utility are presented in Figure 80.

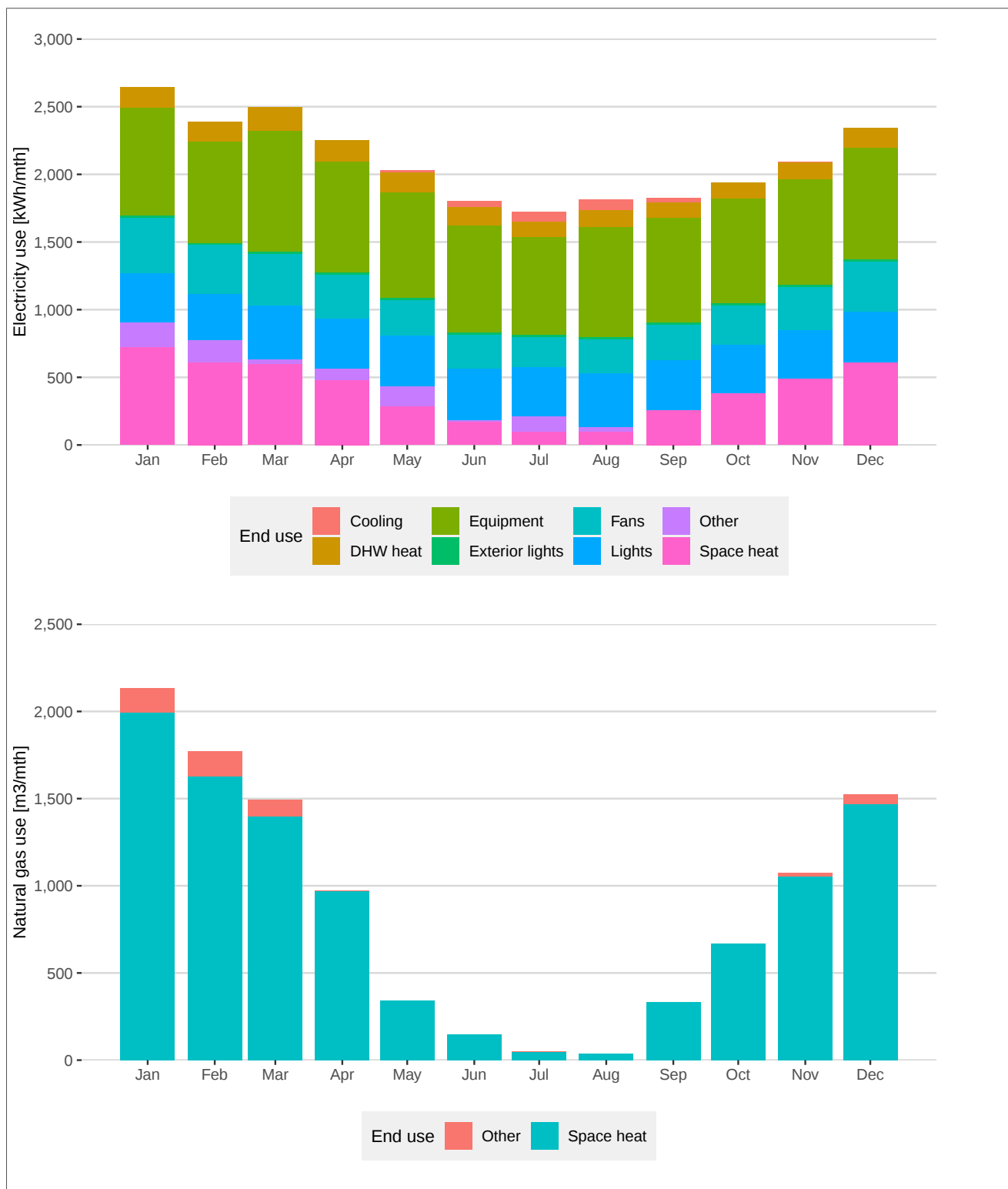


Figure 80: Monthly utility use profiles for each modelled utility

4.4 Calibration analysis

Electricity

Figure 81 compares the metered utility use with the modelled use to check how well the model is calibrated.

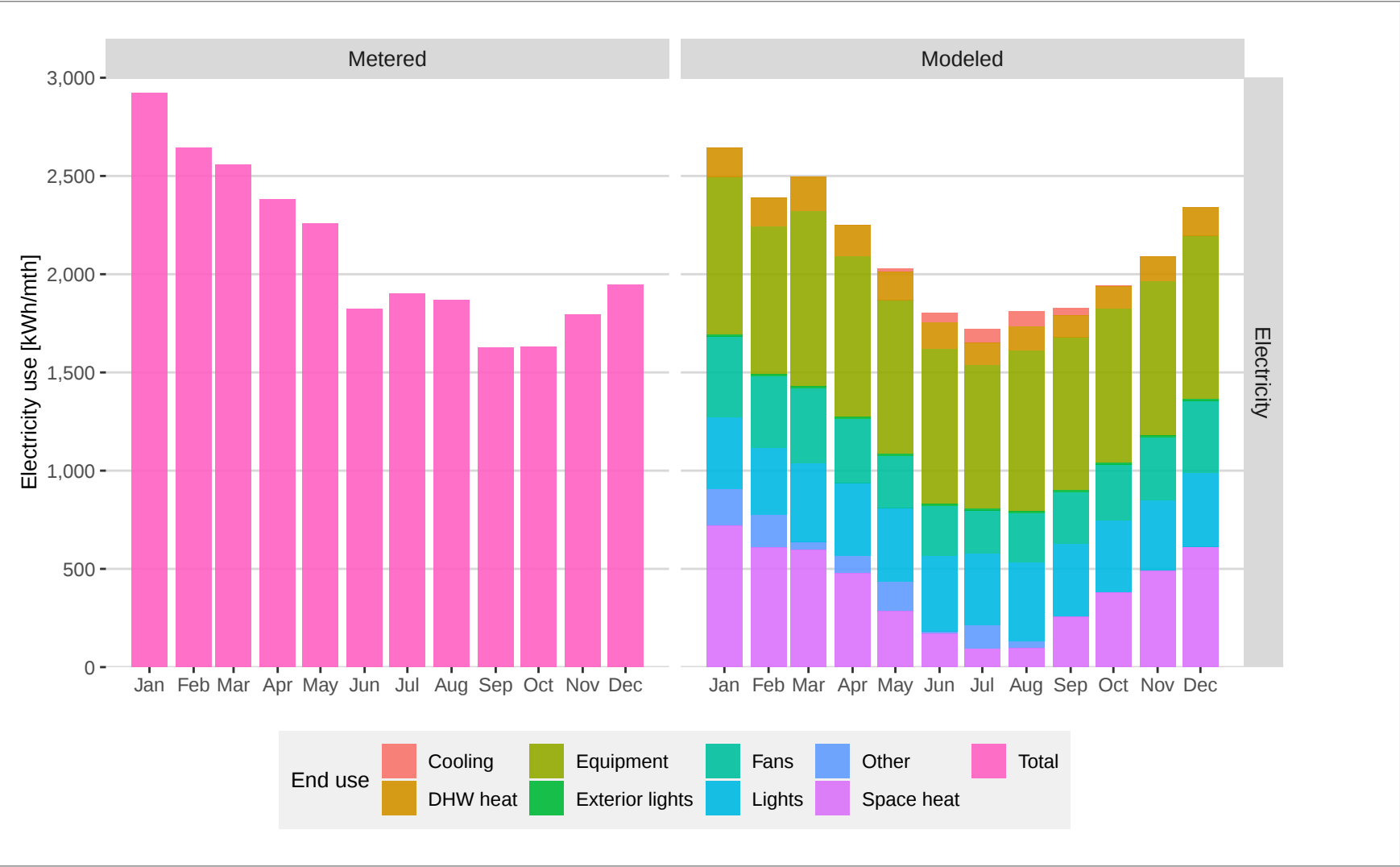


Figure 81: Electricity calibration analysis (metered vs modelled utility use)

Natural gas

Figure 82 compares the metered utility use with the modelled use to check how well the model is calibrated.

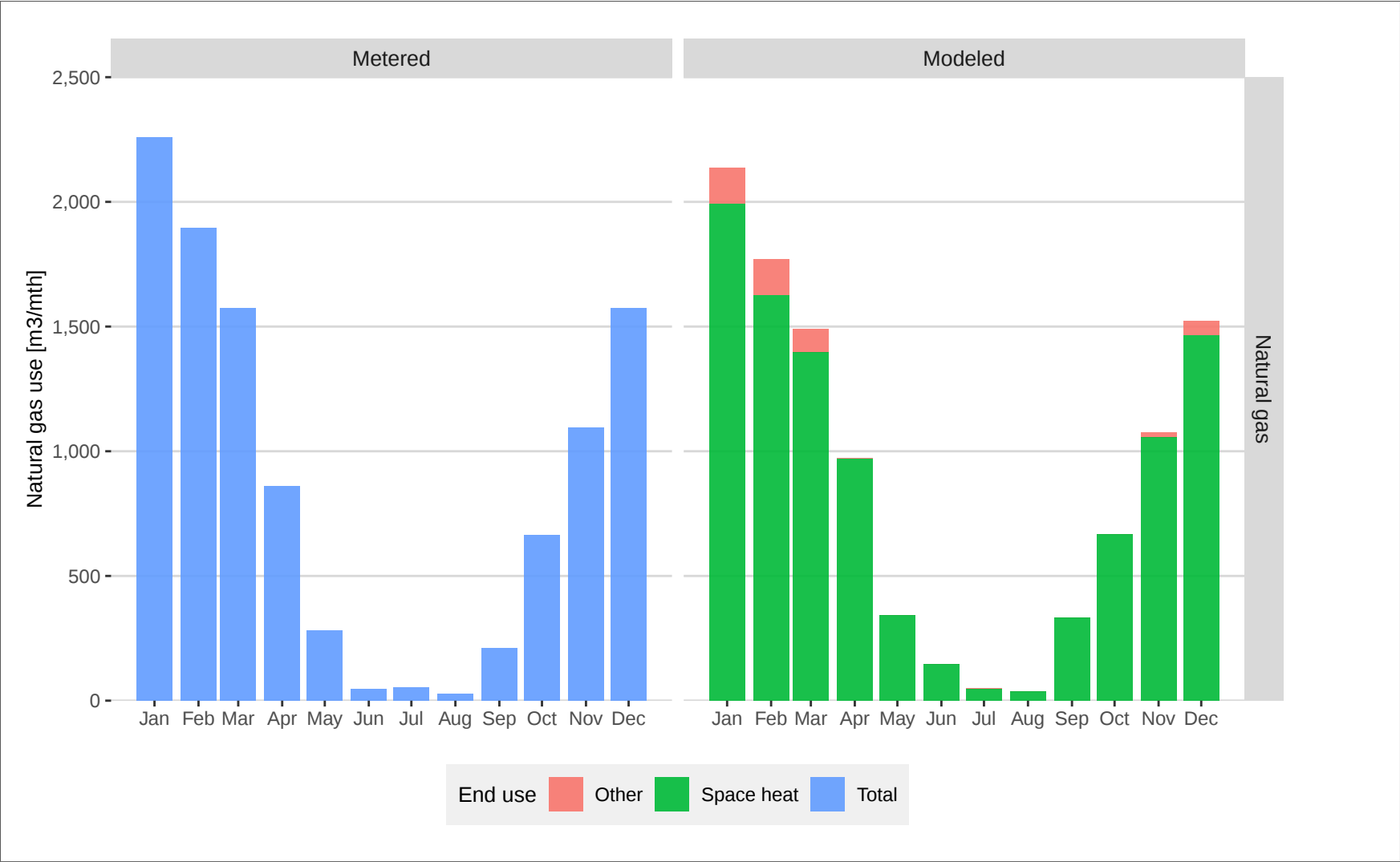


Figure 82: Natural gas calibration analysis (metered vs modelled utility use)

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	11.3	Pass
Natural gas	Mean bias error	[%]	< +/- 5	-0.0	Pass
	Root mean square error	[%]	< 15	9.8	Pass

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

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

- Figures 81 and 82 both demonstrate a strong agreement between monthly trends observed in the metered utility use data and the monthly utility use predicted by the calibrated energy model.
- Electricity and natural gas use were successfully calibrated according to the standards of ASHRAE Guideline 14. Note that 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.
- 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 as observed during the site survey, so that these systems could be explicitly modelled one-to-one, precisely reflecting the unique operations associated with each system. 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 81 indicates strong agreement between modelled and metered data.
- The peak and trough hourly consumption align with the metered interval data.
- Note that the "Other" end use is highest from January to May, suggesting that the energy model underestimates the electricity use during those months. As observed in the utility use discussion, in 2022, the electricity use dropped below the seasonal average starting in June, and stayed at the new level throughout 2023. As such, although the modeled data is lower than the baseline year of 2022 from those months, the model is believed to be more representative of the facility's current state.

Natural gas

- Figure 82 indicates good agreement between modelled and metered data.
- The annual amount of natural gas consumption in the model is very close to the annual amount of the metered data.

4.5 End use analysis

Electricity

The yearly electricity end use breakdown calculated by the energy model is plotted in Figure 83. See Table 16 for end use definitions.

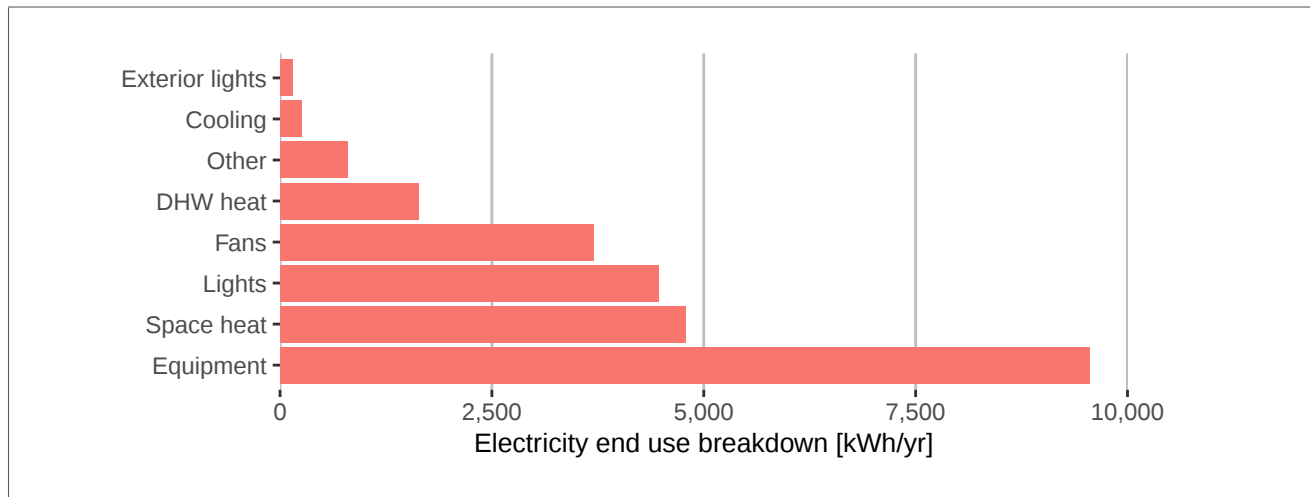


Figure 83: Electricity end use breakdown (calculated by calibrated energy model)

Natural gas

The yearly natural gas end use breakdown calculated by the energy model is plotted in Figure 84. See Table 16 for end use definitions.

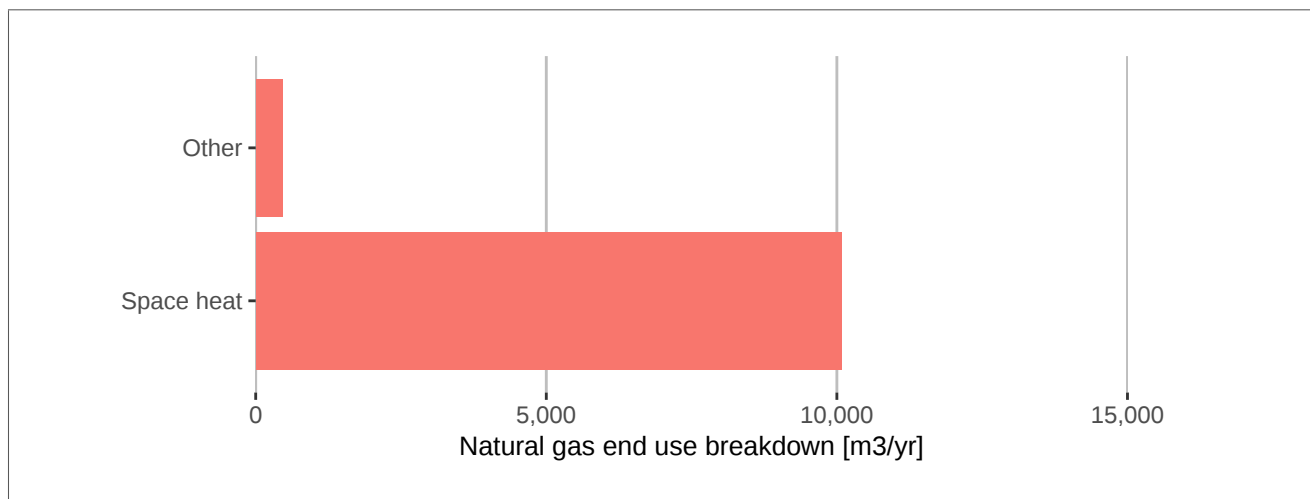


Figure 84: Natural gas end use breakdown (calculated by calibrated energy model)

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 5.11). In each sub-section, the following was documented.
 - *Measure description.* The relevant existing condition was summarized, an opportunity for improving the stated existing condition was described, and the intended utility-savings mechanism associated with the opportunity was described.
 - *Design description.* A conceptual design description was provided, including a written description of the proposed design concept and the associated project cost estimate.
 - *Utility analysis.* A utility analysis was completed using the energy model introduced in Section 4. Measure-specific assumptions applied in calculating the impacts on utility use were provided for each measure. For each measure, the expected GHG emissions, utility costs and financial incentives associated with implementing the measure were calculated based on utility use, using the assumptions outlined in Section 5.2. A life cycle cost analysis was completed, applying the assumptions summarized in Tables 14 and 20 according to the following methodology.
 - (a) The life cycle cost for each measure was calculated based on the assumed implementation year of 2026 for each measure. The life cycle cost for each measure was calculated as the sum of the following future financial cost expenditures, discounted back to present value using the discount rate from Table 20, over the evaluation period of present to 2050.
 - (b) Project costs: The future value of project costs was calculated based on the project cost estimate of each measure, inflated to future value associated with the assumed implementation year using the general inflation rate from Table 20. In the life cycle cost calculation, the project cost was amortized over the expected life of the measure such that the yearly present value is constant over every year of the expected life of the measure. This results in the net present value of the project cost being equal to what it would be if the owner was to pay for it via lump sum in the implementation year for that measure.
 - (c) Replacement costs: The future value of replacement costs was calculated assuming that a financial cost was incurred to replace equipment associated with each measure at the end of the expected life of that measure equal to 50% of the initial project cost, inflated to future value associated with the estimated time of replacement using the general inflation rate from Table 20. The same amortization approach as for project costs was used.
 - (d) Utility costs: The future value of yearly utility costs of the entire facility was accounted for in the life cycle cost calculation for each measure. The future value of yearly utility costs was calculated by applying the future utility cost rates from Table 18 to the utility use of the entire facility for that year as predicted by the calibrated energy model for each measure and scenario.
3. **Measure risk analysis.** A risk analysis of each individual measure was completed to test how the performance of that measure might be affected by changes to certain risk parameters. In this risk analysis, each of the risk parameters defined in Table 21 was tested under each risk case also defined in Table 21 for that risk parameter. For each risk case of each risk parameter, the expected performance of each measure was quantified, and the results were summarized using box and whisker plots indicating the range over

which performance might be expected to vary. Findings from the risk analysis were summarized in Section 5.12.

4. **Measure analysis summary.** Measure analysis results for all measures were summarized in table format in Section 5.13.

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.
Implement a thermostat schedule for UH1	Analyzed.
Install a mini split system in the lunchroom	Analyzed.
Roof upgrade to high performance	Analyzed.
Solar PV rooftop	Analyzed.
Unit heaters conversion	Analyzed.
Wall upgrade to high performance	Analyzed.
Windows and doors to high performance	Analyzed.
Exterior walls renewal	Business as usual.
Roof renewal	Business as usual.
Unit heater renewal	Business as usual.
Windows and doors renewal	Business as usual.
Exterior LED lighting upgrade	Not analyzed: already LED.
Interior LED lighting upgrade	Not analyzed: already retrofitted to LED. It should be noted that the washroom still has T8 fluorescent lighting. They should be replaced when possible.
Reduce DHW tank size	Not analyzed: difficult to quantify energy savings.

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

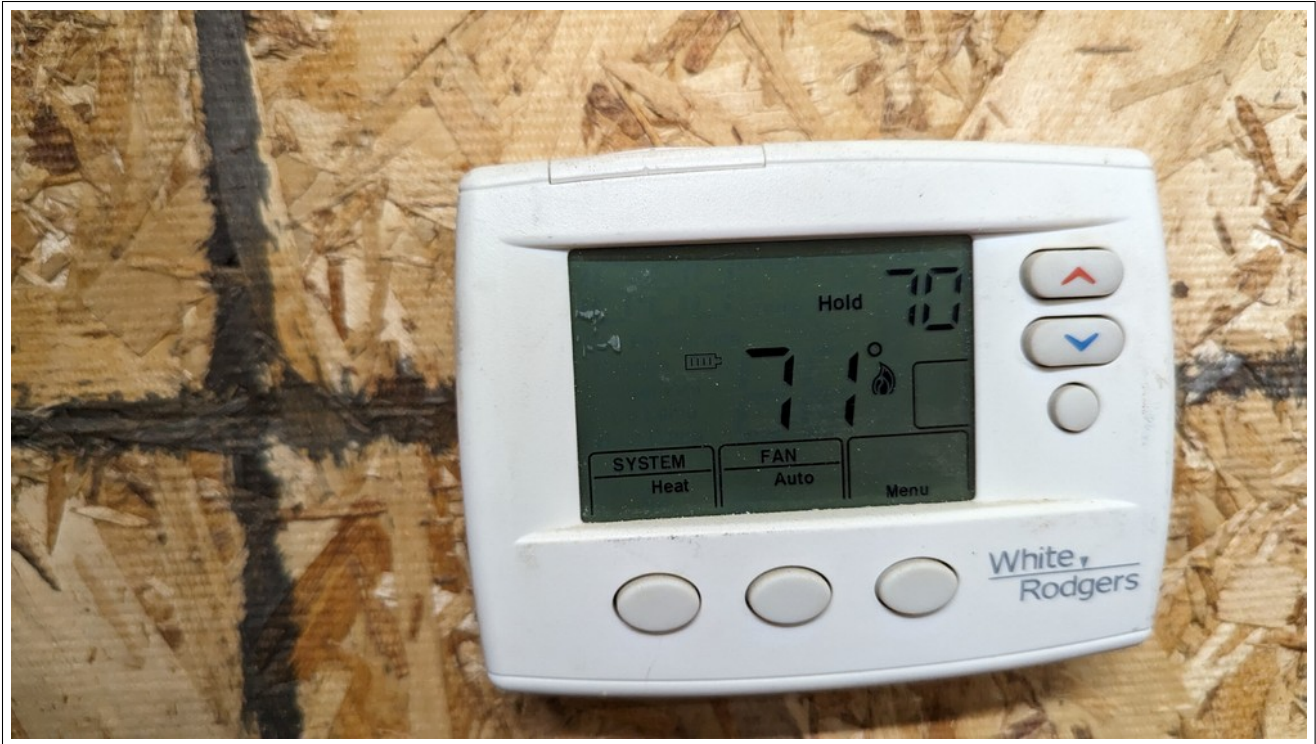
Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	25,350	25,350	0	0
	Natural gas use	[m3/yr]	10,539	10,539	0	0
	Carbon offset use	[tCO ₂ e/yr]	0	4.2	-4.2	—
Equivalent energy use	Electricity energy	[kWh/yr]	25,350	25,350	0	0
	Natural gas energy	[kWh/yr]	111,256	111,256	0	0
	Total energy	[kWh/yr]	136,607	136,607	0	0
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	0.77	0.77	0	0
	Natural gas GHGs	[tCO ₂ e/yr]	20.4	20.4	0	0
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	-4.2	4.2	—
	Total GHGs	[tCO ₂ e/yr]	21.1	16.9	4.2	20.0
Utility cost	Electricity utility cost	[\$/yr]	2,515	2,515	0	0
	Natural gas utility cost	[\$/yr]	2,740	2,740	0	0
	Carbon offsets utility cost	[\$/yr]	0	127	-127	—
	Federal carbon charge	[\$/yr]	1,018	1,018	0	0
	Total utility cost	[\$/yr]	6,273	6,400	-127	-2.0
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	—	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	—	—	—
	Life cycle cost	[\$]	146,890	149,202	—	—
	Net present value	[\$]	0	-2,312	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	—	—	—
	Simple payback period	[yr]	—	—	—	—

5.5 Implement a thermostat schedule for UH1

Measure description

Existing condition

UH1 is controlled by a programmable thermostat; however, it is set to hold at 71F.



Opportunity

Program the existing thermostat to introduce a temperature setback during unoccupied hours. Set the unit to turn off during unoccupied hours and cycle on only to maintain setback temperature.

Utility-savings mechanism

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

Design description

Project cost estimate

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

Table 24: Project cost estimate (Implement a thermostat schedule for UH1)

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

Utility analysis

Utility analysis methodology

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

- **Baseline.** The thermostat for UH1 is assumed to be kept at 71 F 24/7.
- **Proposed.** The thermostat for UH1 is set to 66 F from 6pm to 7am on weekdays, and over weekends.

Utility analysis results

Table 25: Implement a thermostat schedule for UH1 analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	25,350	25,101	249	0.98
	Natural gas use	[m3/yr]	10,539	9,713	826	7.8
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	25,350	25,101	249	0.98
	Natural gas energy	[kWh/yr]	111,256	102,540	8,716	7.8
	Total energy	[kWh/yr]	136,607	127,641	8,966	6.6
GHG emissions	Electricity GHGs	[tCO2e/yr]	0.77	0.76	0.01	0.98
	Natural gas GHGs	[tCO2e/yr]	20.4	18.8	1.6	7.8
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	21.1	19.5	1.6	7.6
Utility cost	Electricity utility cost	[\$/yr]	2,515	2,490	24.7	0.98
	Natural gas utility cost	[\$/yr]	2,740	2,525	215	7.8
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,018	938	79.8	7.8
	Total utility cost	[\$/yr]	6,273	5,954	319	5.1
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	0	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	0	—	—
	Life cycle cost	[\$]	146,890	142,248	—	—
	Net present value	[\$]	0	4,642	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	0	—	—
	Simple payback period	[yr]	—	0.0	—	—

5.6 Install a mini split system in the lunchroom

Measure description

Existing condition

The clubhouse has one unitary air conditioner and the condenser side is inside the building, interfacing with the shop area.



Opportunity

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

Utility-savings mechanism

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

Design description

Overview

Replace the window AC unit and electric resistance heating elements with a ductless mini-split. The unit shall be similar to a Moovair 1T unit.

Electrical

The ASHP will add approximately 1.5 kW of power to the existing system, however there will be a reduction in energy with the removal of the electric heater. The peak load will be less than the current measured peak load. The mini split can be powered from panel LR.

Project cost estimate

Table 26: Project cost estimate (Install a mini split system in the lunchroom)

Category	Line item	Unit	Value
Construction	Supply	[\$]	4,000
	Installation	[\$]	4,000
	Electrical	[\$]	5,000
	General requirements (25%)	[\$]	3,200
Contingency	Subtotal after Construction	[\$]	16,200
	Design Contingency (25%)	[\$]	4,000
	Construction Contingency (10%)	[\$]	1,600
Design, Contractors, PM	Subtotal after Contingency	[\$]	21,800
	Engineering Design and Field Review (10%)	[\$]	2,200
	Contractor Fee (7%)	[\$]	1,500
Total	Total	[\$]	25,500

Utility analysis

Utility analysis methodology

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

- **Baseline.** The clubhouse is heated by an electric space heater, with an efficiency of 100%. The clubhouse is cooled by a unitary air conditioner with a COP of 3.
- **Proposed.** Primary heating and cooling is provided from a mini-split with heating and cooling COPs of 2.8 and 4.1 (14 EER), respectively. Backup heating is provided by electric resistance, with an efficiency of 100%.

Utility analysis results

Table 27: Install a mini split system in the lunchroom analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	25,350	23,757	1,593	6.3
	Natural gas use	[m3/yr]	10,539	10,531	7.9	0.07
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	25,350	23,757	1,593	6.3
	Natural gas energy	[kWh/yr]	111,256	111,173	83.1	0.07
	Total energy	[kWh/yr]	136,607	134,930	1,676	1.2
GHG emissions	Electricity GHGs	[tCO2e/yr]	0.77	0.72	0.05	6.3
	Natural gas GHGs	[tCO2e/yr]	20.4	20.3	0.02	0.07
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	21.1	21.1	0.06	0.30
Utility cost	Electricity utility cost	[\$/yr]	2,515	2,357	158	6.3
	Natural gas utility cost	[\$/yr]	2,740	2,738	2.0	0.07
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,018	1,017	0.76	0.07
	Total utility cost	[\$/yr]	6,273	6,112	161	2.6
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	25,500	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	25,500	—	—
	Life cycle cost	[\$]	146,890	172,818	—	—
	Net present value	[\$]	0	-25,928	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	402,718	—	—
	Simple payback period	[yr]	—	>20	—	—

5.7 Roof upgrade to high performance

Measure description

Existing condition

The roofs appear to be corrugated metal on sheathing and wood strapping on a wood deck, supported by the wood stud walls, probably with little or no insulation.

Opportunity

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

Utility-savings mechanism

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

Design description

Overview

The roofs appear to be made of corrugated metal on sheathing and wood strapping on a wooden deck, supported by the wood stud walls, likely with little to no insulation.

We recommend removing the metal roofing, providing new sheathing and an air barrier which is tied to the air barrier on the wall, with 10-12 inches of rigid insulation on top of the air barrier and a PVC or TPO membrane on that, for a thermal performance of at least R40 which is the current code minimum.

Project cost estimate

Table 28: Project cost estimate (Roof upgrade to high performance)

Category	Line item	Unit	Value
Construction	Roof replacement	[\$]	168,000
	General requirements (25%)	[\$]	42,000
Contingency	Subtotal after Construction	[\$]	210,000
	Design Contingency (25%)	[\$]	52,500
	Construction Contingency (10%)	[\$]	21,000
Design, Contractors, PM	Subtotal after Contingency	[\$]	283,500
	Engineering Design and Field Review (10%)	[\$]	28,400
	Contractor Fee (7%)	[\$]	19,800
Total	Total	[\$]	331,700

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 0.0909 BTU/hr.ft².F (R11) was assumed.
- **Proposed.** An average roof U-value of 0.025 BTU/hr.ft².F (R40) was assumed.

Utility analysis results

Table 29: Roof upgrade to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	25,350	25,341	9.9	0.04
	Natural gas use	[m3/yr]	10,539	10,530	9.1	0.09
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	25,350	25,341	9.9	0.04
	Natural gas energy	[kWh/yr]	111,256	111,160	96.3	0.09
	Total energy	[kWh/yr]	136,607	136,501	106	0.08
GHG emissions	Electricity GHGs	[tCO2e/yr]	0.77	0.77	0.00	0.04
	Natural gas GHGs	[tCO2e/yr]	20.4	20.3	0.02	0.09
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	21.1	21.1	0.02	0.08
Utility cost	Electricity utility cost	[\$/yr]	2,515	2,514	0.98	0.04
	Natural gas utility cost	[\$/yr]	2,740	2,738	2.4	0.09
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,018	1,017	0.88	0.09
	Total utility cost	[\$/yr]	6,273	6,269	4.2	0.07
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	331,700	—	—
	Incentive amount	[\$]	0	66,340	—	—
	Incremental project cost	[\$]	0	265,360	—	—
	Life cycle cost	[\$]	146,890	427,156	—	—
	Net present value	[\$]	0	-280,266	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	14,802,501	—	—
	Simple payback period	[yr]	—	>20	—	—

5.8 Solar PV rooftop

Measure description

Existing condition

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

Opportunity

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

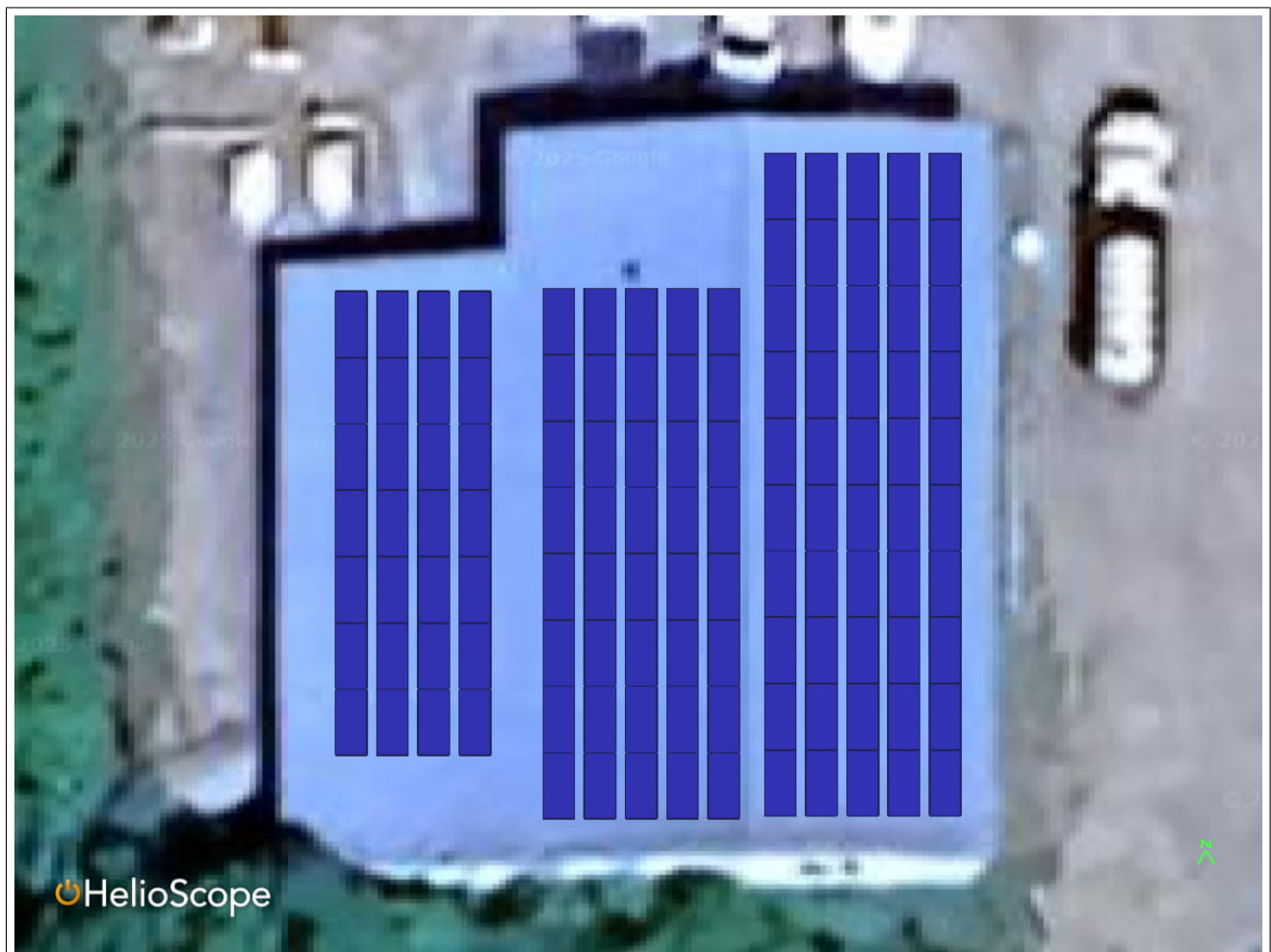
Utility-savings mechanism

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

Design description

Helioscope overview

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



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

- Total system output capacity (DC) = 50 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 splitter is not rated high enough to accommodate the additional incoming 50 kW load of the solar. A minimum panel of 400A at 208V - 3P outside of the solar equipment would be required.

Project cost estimate

Table 30: Project cost estimate (Solar PV rooftop)

Category	Line item	Unit	Value
Materials and labour	Solar PV electricity system installed (assuming 50 kW at 2000 \$/kW)	[\$]	100,000
	Electrical upgrades	[\$]	50,000
Contingency	Subtotal after Materials and labour	[\$]	150,000
	General Contingency (20%)	[\$]	30,000
	Design Contingency (10%)	[\$]	15,000
Total	Total	[\$]	195,000

Utility analysis

Utility analysis methodology

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

- **Baseline.** There is no solar PV present at this site.
- **Proposed.** The proposed solar PV electricity generation system described above was assumed to be implemented. Helioscope was used to model the hourly electricity output from the solar PV system. All electricity generated by the system was assumed to be used on-site, directly reducing grid electricity consumption, GHG emissions and utility costs. 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 31: Solar PV rooftop analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	25,350	-15,784	41,134	162
	Natural gas use	[m3/yr]	10,539	10,539	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	25,350	-15,784	41,134	162
	Natural gas energy	[kWh/yr]	111,256	111,256	0	0
	Total energy	[kWh/yr]	136,607	95,473	41,134	30.1
GHG emissions	Electricity GHGs	[tCO2e/yr]	0.77	-0.48	1.2	162
	Natural gas GHGs	[tCO2e/yr]	20.4	20.4	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	21.1	19.9	1.2	5.9
Utility cost	Electricity utility cost	[\$/yr]	2,515	0	2,515	100
	Natural gas utility cost	[\$/yr]	2,740	2,740	0	0
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,018	1,018	0	0
	Total utility cost	[\$/yr]	6,273	3,758	2,515	40.1
Financial	Assumed life	[yrs]	15	30	—	—
	Project cost	[\$]	0	195,000	—	—
	Incentive amount	[\$]	0	39,000	—	—
	Incremental project cost	[\$]	0	156,000	—	—
	Life cycle cost	[\$]	146,890	166,025	—	—
	Net present value	[\$]	0	-19,135	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	125,579	—	—
	Simple payback period	[yr]	—	>20	—	—

5.9 Unit heaters conversion

Measure description

Existing condition

One natural gas-fired unit heater (UH1) serves the shop space.



Opportunity

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

Utility-savings mechanism

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

Design description

Overview

Replace the natural gas unit heater with an electric resistance unit heater.

The UH shall be similar to a Modine model PTE400 and sized to match the existing unit - 30kW.

Electrical

The UH will add approximately 30 kW of power to the existing system, which will put the system at 40.64 kW, which exceeds the electrical capacity of the building. A system upgrade would be required to a minimum of 75kW transformer, or a 400A 208V-3PH service. The existing 200A splitter can be powered from the new 400A panel.

Project cost estimate

Table 32: Project cost estimate (Unit heaters conversion)

Category	Line item	Unit	Value
Construction	Unit heater supply	[\$]	4,000
	Installation of unit heater	[\$]	2,000
	Electrical	[\$]	170,000
	General requirements (25%)	[\$]	44,000
Contingency	Subtotal after Construction	[\$]	220,000
	Design Contingency (25%)	[\$]	55,000
	Construction Contingency (10%)	[\$]	22,000
Design, Contractors, PM	Subtotal after Contingency	[\$]	297,000
	Engineering Design and Field Review (10%)	[\$]	29,700
	Contractor Fee (7%)	[\$]	20,800
Total	Total	[\$]	347,500

Utility analysis

Utility analysis methodology

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

- **Baseline.** The shop space is heated by UH1, a gas-fired unit heater with an average burner thermal efficiency of 82%.
- **Proposed.** Heating for the shop space is provided by an electric unit heater, with an efficiency of 100%.

Utility analysis results

Table 33: Unit heaters conversion analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	25,350	99,748	-74,398	-293
	Natural gas use	[m3/yr]	10,539	0	10,539	100
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	25,350	99,748	-74,398	-293
	Natural gas energy	[kWh/yr]	111,256	0	111,256	100
	Total energy	[kWh/yr]	136,607	99,748	36,858	27.0
GHG emissions	Electricity GHGs	[tCO2e/yr]	0.77	3.0	-2.2	-293
	Natural gas GHGs	[tCO2e/yr]	20.4	0	20.4	100
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	21.1	3.0	18.1	85.7
Utility cost	Electricity utility cost	[\$/yr]	2,515	9,895	-7,380	-293
	Natural gas utility cost	[\$/yr]	2,740	0	2,740	100
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,018	0	1,018	100
	Total utility cost	[\$/yr]	6,273	9,895	-3,622	-57.7
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	347,500	—	—
	Incentive amount	[\$]	0	69,500	—	—
	Incremental project cost	[\$]	0	278,000	—	—
	Life cycle cost	[\$]	146,890	632,633	—	—
	Net present value	[\$]	0	-485,743	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	15,344	—	—
	Simple payback period	[yr]	—	—	—	—

5.10 Wall upgrade to high performance

Measure description

Existing condition

The exterior walls are finished with either corrugated metal siding or composite wood siding. They are constructed using wood studs, which do not have insulation. On the interior, some sections have exposed wood studs, while others are finished with drywall or metal liner panels.



Opportunity

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

Utility-savings mechanism

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

Design description

Overview

Air leakage through gaps in the foundation, around doors and windows, and at the top of the wall where it connects to the roof framing significantly reduces the structure's thermal performance. This issue can be effectively addressed by installing new sheathing on the exterior of the studs, along with an air barrier beneath a layer of exterior insulation on the walls. This setup should also be linked to a new air barrier on the roof, accompanied by new insulation, to create a continuous enclosure that prevents air leakage and protects the structure from the effects of thermal bridging.

We recommend removing the existing metal siding, applying sheathing and an air barrier to the current studs, and then installing either thermally broken girts with semi-rigid batt insulation and new metal siding on the exterior, or using rigid insulation in an EIFS (Exterior Insulation and Finish System) with thermally broken z-girts. In either

case, the goal is to upgrade the wall's thermal performance to at least R30, as R25 is the minimum required by code. Working from the exterior also allows all interior services and accessories to remain in place.

Project cost estimate

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

Category	Line item	Unit	Value
Construction	Add EIFS system to existing exterior wall	[\$]	265,000
	General requirements (25%)	[\$]	66,200
Contingency	Subtotal after Construction	[\$]	331,200
	Design Contingency (25%)	[\$]	82,800
	Construction Contingency (10%)	[\$]	33,100
Design, Contractors, PM	Subtotal after Contingency	[\$]	447,100
	Engineering Design and Field Review (10%)	[\$]	44,700
	Contractor Fee (7%)	[\$]	31,300
Total	Total	[\$]	523,100

Utility analysis

Utility analysis methodology

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

- **Baseline.** An average wall U-value of 0.125 BTU/hr.ft².F (R8) was assumed.
- **Proposed.** An average wall U-value of 0.0333 BTU/hr.ft².F (R30) was assumed. Infiltration flow was assumed to be reduced by 10% in total relative to the Baseline for affected spaces.

Utility analysis results

Table 35: Wall upgrade to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	25,350	24,054	1,296	5.1
	Natural gas use	[m3/yr]	10,539	8,633	1,906	18.1
	Carbon offset use	[tCO ₂ e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	25,350	24,054	1,296	5.1
	Natural gas energy	[kWh/yr]	111,256	91,133	20,123	18.1
	Total energy	[kWh/yr]	136,607	115,188	21,419	15.7
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	0.77	0.73	0.04	5.1
	Natural gas GHGs	[tCO ₂ e/yr]	20.4	16.7	3.7	18.1
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	0	0	—
	Total GHGs	[tCO ₂ e/yr]	21.1	17.4	3.7	17.6
Utility cost	Electricity utility cost	[\$/yr]	2,515	2,386	129	5.1
	Natural gas utility cost	[\$/yr]	2,740	2,245	496	18.1
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,018	834	184	18.1
	Total utility cost	[\$/yr]	6,273	5,465	808	12.9
Financial	Assumed life	[yrs]	15	75	—	—
	Project cost	[\$]	0	523,100	—	—
	Incentive amount	[\$]	0	104,620	—	—
	Incremental project cost	[\$]	0	418,480	—	—
	Life cycle cost	[\$]	146,890	269,804	—	—
	Net present value	[\$]	0	-122,915	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	112,418	—	—
	Simple payback period	[yr]	—	>20	—	—

5.11 Windows and doors to high performance

Measure description

Existing condition

The facility has aluminum-framed, double-pane slider windows and single-pane windows at the south elevation. The facility has hollow metal and overhead doors.



Opportunity

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

Utility-savings mechanism

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

Design description

Windows

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

Doors

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

- **Hollow Metal Doors:** Replace existing hollow metal doors with insulated doors in thermally broken frames.
- **Glazed Entry Doors:** Should be triple-glazed and thermally broken as part of the curtain wall/window improvements.

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

Project cost estimate

Table 36: Project cost estimate (Windows and doors to high performance)

Category	Line item	Unit	Value
Construction	Window and door replacement	[\$]	45,000
	General requirements (25%)	[\$]	11,200
Contingency	Subtotal after Construction	[\$]	56,200
	Design Contingency (25%)	[\$]	14,000
	Construction Contingency (10%)	[\$]	5,600
Design, Contractors, PM	Subtotal after Contingency	[\$]	75,800
	Engineering Design and Field Review (10%)	[\$]	7,600
	Contractor Fee (7%)	[\$]	5,300
Total	Total	[\$]	88,700

Utility analysis

Utility analysis methodology

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

- **Baseline.** The average U-value of all windows and doors was assumed to be 0.625 BTU/hr.ft².F and 1.057 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 37: Windows and doors to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	25,350	24,795	555	2.2
	Natural gas use	[m3/yr]	10,539	8,864	1,675	15.9
	Carbon offset use	[tCO ₂ e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	25,350	24,795	555	2.2
	Natural gas energy	[kWh/yr]	111,256	93,572	17,684	15.9
	Total energy	[kWh/yr]	136,607	118,367	18,239	13.4
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	0.77	0.75	0.02	2.2
	Natural gas GHGs	[tCO ₂ e/yr]	20.4	17.1	3.2	15.9
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	0	0	—
	Total GHGs	[tCO ₂ e/yr]	21.1	17.9	3.3	15.4
Utility cost	Electricity utility cost	[\$/yr]	2,515	2,460	55.1	2.2
	Natural gas utility cost	[\$/yr]	2,740	2,305	436	15.9
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,018	856	162	15.9
	Total utility cost	[\$/yr]	6,273	5,621	652	10.4
Financial	Assumed life	[yrs]	15	40	—	—
	Project cost	[\$]	0	88,700	—	—
	Incentive amount	[\$]	0	17,740	—	—
	Incremental project cost	[\$]	0	70,960	—	—
	Life cycle cost	[\$]	146,890	180,427	—	—
	Net present value	[\$]	0	-33,537	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	21,808	—	—
	Simple payback period	[yr]	—	>20	—	—

5.12 Measure risk analysis

Utility use sensitivity

Figure 85 indicates how sensitive cumulative electricity and natural gas use are to variations in each risk parameter.

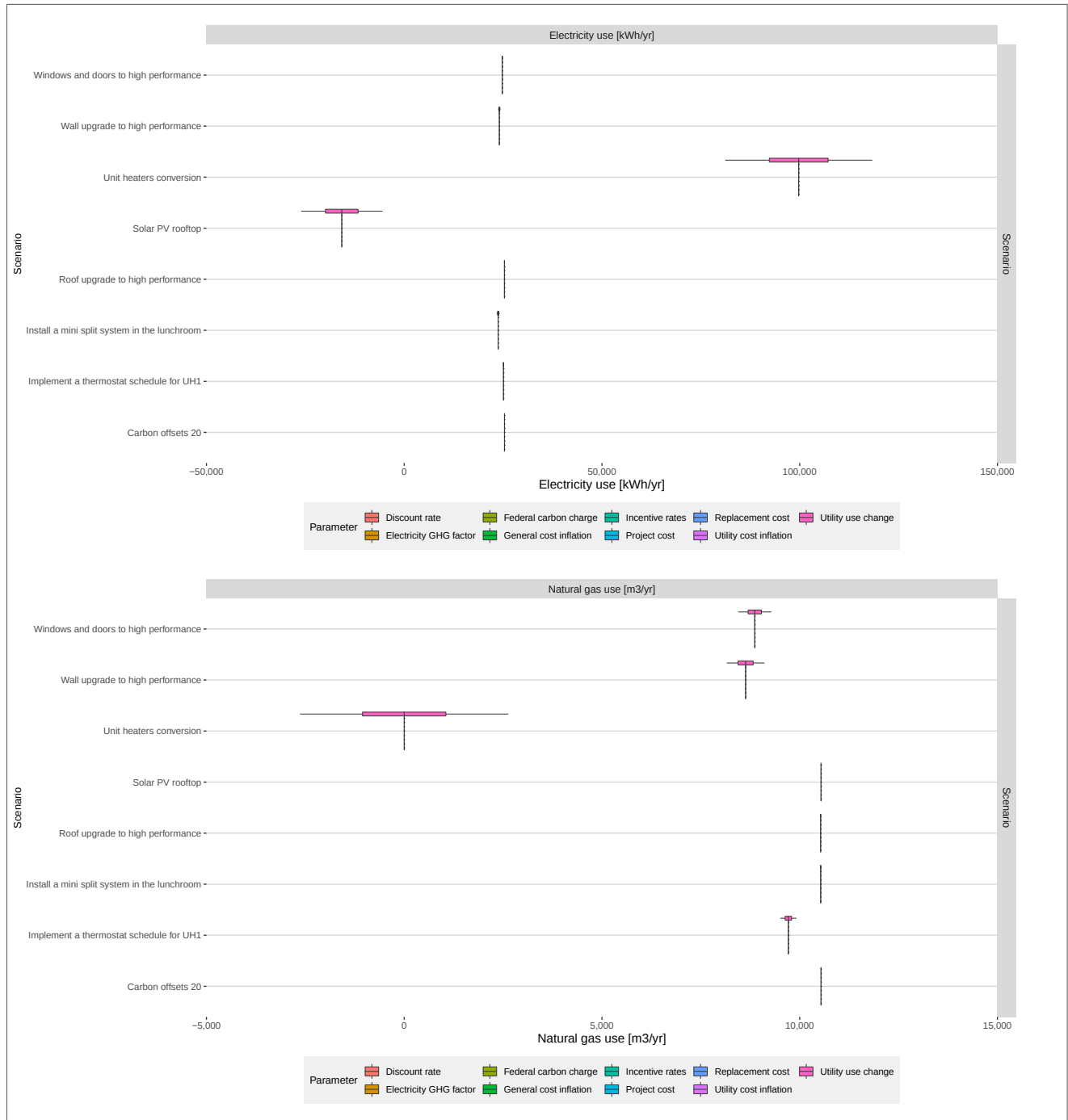


Figure 85: Utility cumulative use sensitivity analysis

GHG emissions and life cycle cost sensitivity

Figure 86 indicates how sensitive cumulative GHG emissions and life cycle costs are to variations in each risk parameter.

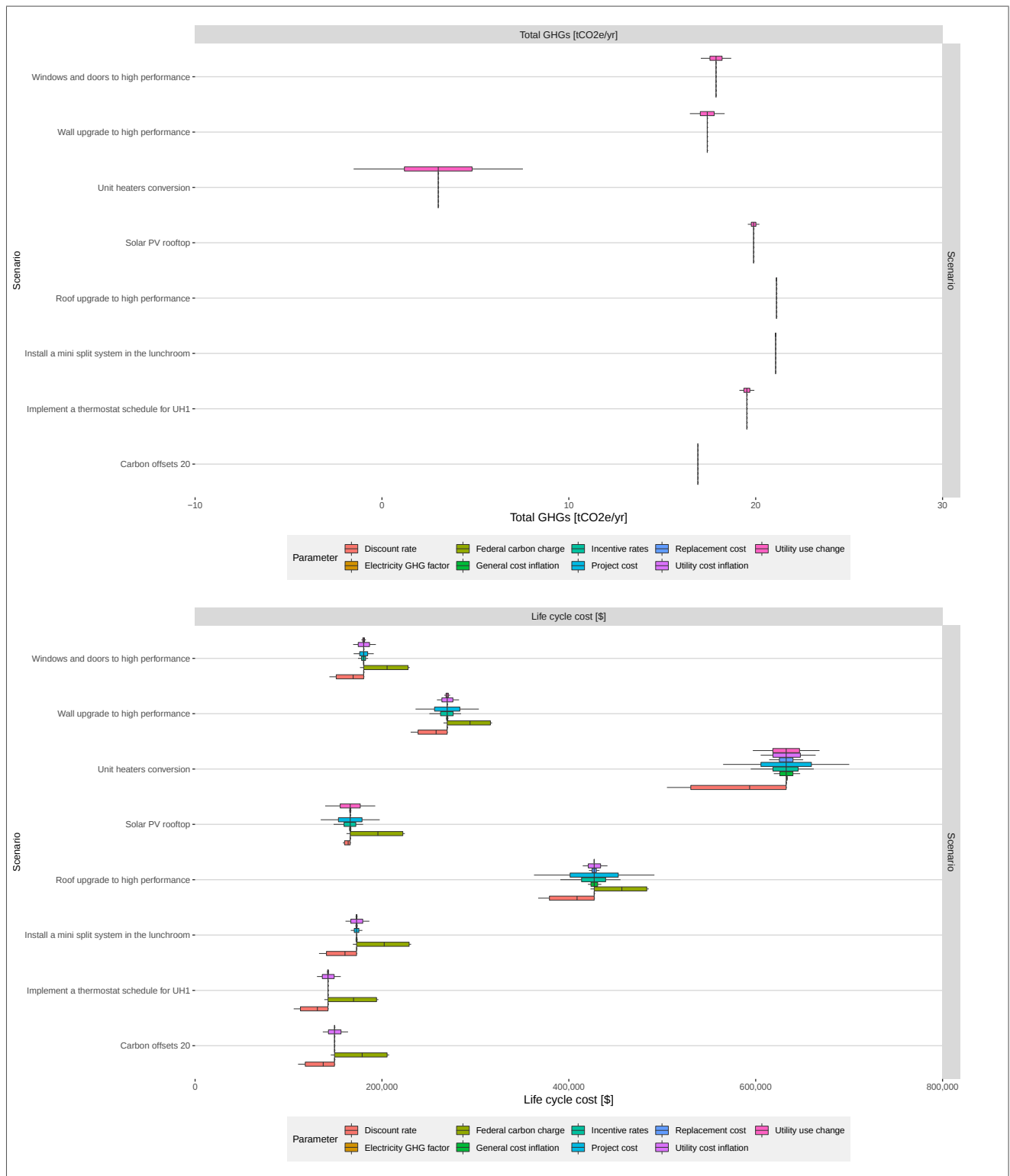


Figure 86: GHG cumulative emissions and life cycle cost sensitivity analysis

5.13 Measure analysis summary

For each analyzed measure, the analysis results are summarized in Table 38.

Table 38: 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	25,350	100.0	10,539	100.0	136,607	100.0	21	100.0	6,273	100.0	15	0	0	0	146,890	0	-	-
Carbon offsets 20	0	0.0	0	0.0	0	0.0	4	20.0	-127	-2.0	20	-	0	0	-	149,202	-2,312	-
Implement a thermostat schedule for UH1	249	1.0	826	7.8	8,966	6.6	2	7.6	319	5.1	15	25,500	0	0	25,500	172,818	-25,928	0
Install a mini split system in the lunchroom	1,593	6.3	8	0.1	1,676	1.2	0	0.3	161	2.6	15	25,500	0	0	25,500	172,818	-25,928	159
Roof upgrade to high performance	10	0.0	9	0.1	106	0.1	0	0.1	4	0.1	20	331,700	66,340	265,360	427,155	-280,266	14,802,501	62,674
Solar PV rooftop	41,134	162.3	0	0.0	41,134	30.1	1	5.9	2,515	40.1	30	195,000	39,000	156,000	166,025	-19,135	125,579	62
Unit heaters conversion	-74,398	-293.5	10,539	100.0	36,858	27.0	18	85.7	-3,622	-57.7	15	347,500	69,500	278,000	632,633	-485,743	15,344	-77
Wall upgrade to high performance	1,296	5.1	1,906	18.1	21,419	15.7	4	17.6	808	12.9	75	523,100	104,620	418,480	269,804	-122,914	112,418	518
Windows and doors to high performance	555	2.2	1,675	15.9	18,239	13.4	3	15.4	652	10.4	40	88,700	17,740	70,960	180,427	-33,537	21,808	109
Total project cost	-	-	-	-	-	-	-	-	-	-	-	1,511,500	-	-	-	-	-	-
Exterior walls renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	75	3,000	0	0	3,000	147,861	-971	-
Roof renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	126,000	0	0	126,000	277,859	-130,969	-
Unit heater renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	8,000	0	0	8,000	155,558	-8,668	-
Windows and doors renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	31,000	0	0	31,000	165,711	-18,821	-
BAU measure totals	-	-	-	-	-	-	-	-	-	-	-	168,000	-	-	-	-	-	-

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 39.
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 39.

Table 39: 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 87 and Table 40 present the results of this exercise, indicating which measures were assigned to which scenario.

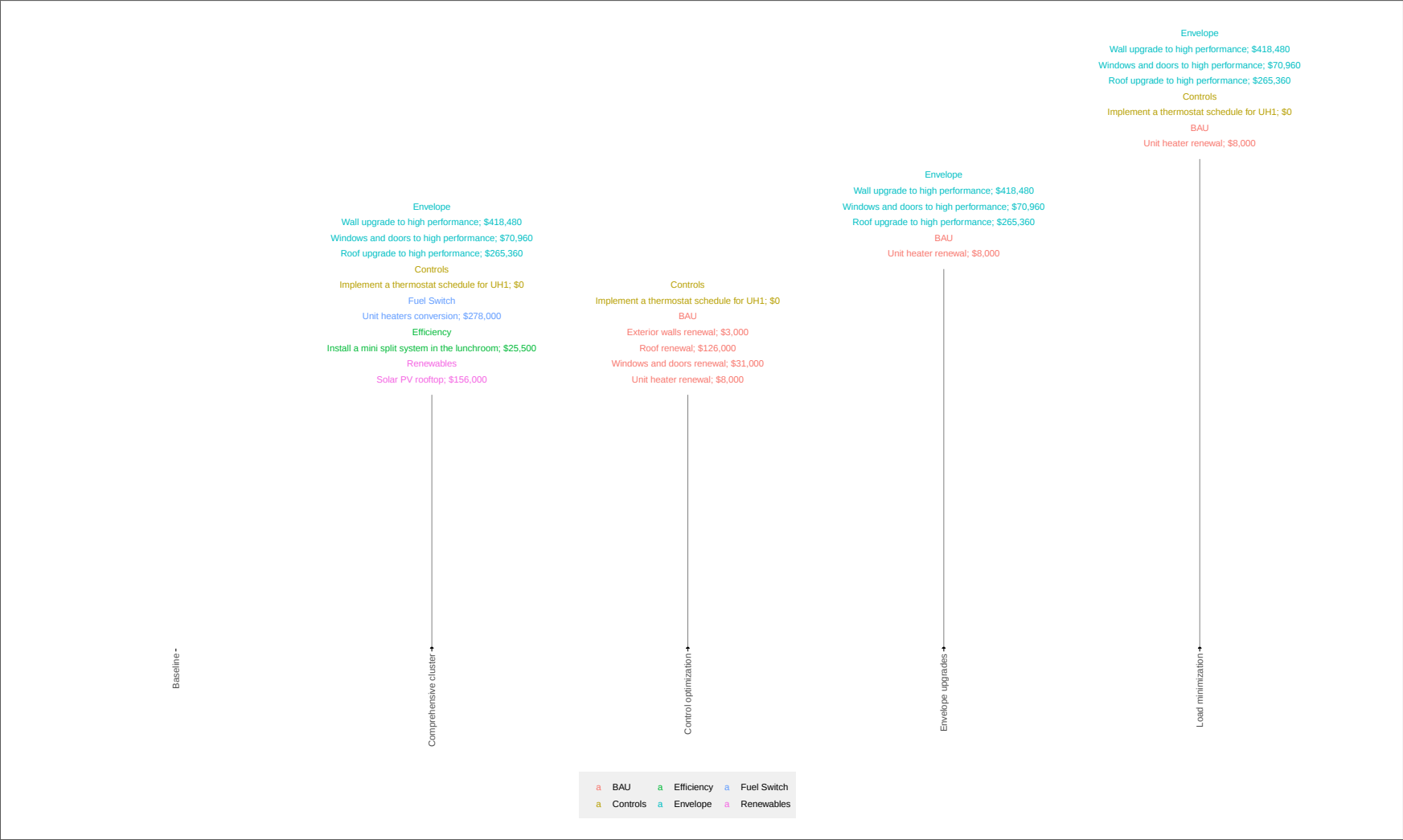


Figure 87: Scenario composition

Table 40: Cluster composition

Measure	Control optimization	Envelope upgrades	Load minimization	Comprehensive cluster
Carbon offsets 20	✗	✗	✗	✗
Implement a thermostat schedule for UH1	✓	✗	✓	✓
Install a mini split system in the lunchroom	✗	✗	✗	✓
Roof upgrade to high performance	✗	✓	✓	✓
Solar PV rooftop	✗	✗	✗	✓
Unit heaters conversion	✗	✗	✗	✓
Wall upgrade to high performance	✗	✓	✓	✓
Windows and doors to high performance	✗	✓	✓	✓
Exterior walls renewal	✓	✗	✗	✗
Roof renewal	✓	✗	✗	✗
Unit heater renewal	✓	✓	✓	✗
Windows and doors renewal	✓	✗	✗	✗

6.4 Cluster scenario performance analysis

The scenario performance analysis was completed by using the energy model (see Section 4) to determine the expected performance of implementing all measures in each scenario. Results are presented throughout Section 6.4.

Cluster scenario performance analysis summary

Results of the scenario analysis are summarized in Table 41, 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 41: Scenario analysis summary

Measure ID	Utility use					Equivalent energy use		GHG emissions		Utility cost		Financial							
Scenario	Measure name	Electricity use reduction	Electricity use reduction	Natural gas use reduction	Natural gas use reduction	Total energy reduction	Total energy reduction	Total GHG reduction	Total GHG reduction	Utility cost reduction	Utility cost reduction	Assumed life	Project cost	Incentive amount	Incremental project cost	Life cycle cost	Net present value	Project cost per GHG reduction	Simple payback period
-	-	[kWh/yr]	[%]	[m3/yr]	[%]	[kWh/yr]	[%]	[tCO2e/yr]	[%]	\$/yr]	\$/yr]	[yrs]	[\$]	[\$]	[\$]	[\$]	[\$]	[\$/tCO2e]	[yr]
Comprehensive cluster	Combined	2,050	8.1	10,539	100.0	113,306	82.9	20	96.7	3,962	63.2	-	1,511,500	297,200	1,214,300	1,000,740	-853,850	59,446	307
Comprehensive cluster	Wall upgrade to high performance	1,296	5.1	1,906	18.1	21,419	15.7	4	17.6	808	12.9	75	523,100	104,620	418,480	269,804	-122,914	112,418	518
Comprehensive cluster	Windows and doors to high performance	555	2.2	1,675	15.9	18,239	13.4	3	15.4	652	10.4	40	88,700	17,740	70,960	180,427	-33,537	21,808	109
Comprehensive cluster	Roof upgrade to high performance	10	0.0	9	0.1	106	0.1	0	0.1	4	0.1	20	331,700	66,340	265,360	427,155	-280,266	14,802,501	62,674
Comprehensive cluster	Implement a thermostat schedule for UH1	249	1.0	826	7.8	8,966	6.6	2	7.6	319	5.1	15	0	0	0	142,248	4,642	0	0
Comprehensive cluster	Unit heaters conversion	-74,398	-293.5	10,539	100.0	36,858	27.0	18	85.7	-3,622	-57.7	15	347,500	69,500	278,000	632,633	-485,743	15,344	-77
Comprehensive cluster	Install a mini split system in the lunchroom	1,593	6.3	8	0.1	1,676	1.2	0	0.3	161	2.6	15	25,500	0	25,500	172,818	-25,928	402,718	159
Comprehensive cluster	Solar PV rooftop	41,134	162.3	0	0.0	41,134	30.1	1	5.9	2,515	40.1	30	195,000	39,000	156,000	166,025	-19,135	125,579	62
Control optimization	Combined	249	1.0	826	7.8	8,966	6.6	2	7.6	319	5.1	-	168,000	0	168,000	294,822	-147,932	104,802	526
Control optimization	Implement a thermostat schedule for UH1	249	1.0	826	7.8	8,966	6.6	2	7.6	319	5.1	15	0	0	0	142,248	4,642	0	0
Control optimization	Exterior walls renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	75	3,000	0	3,000	147,861	-971	-	-
Control optimization	Roof renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	126,000	0	126,000	277,859	-130,969	-	-
Control optimization	Windows and doors renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	31,000	0	31,000	165,711	-18,821	-	-
Control optimization	Unit heater renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	8,000	0	8,000	155,558	-8,668	-	-
Envelope upgrades	Combined	1,593	6.3	3,447	32.7	37,983	27.8	7	31.8	1,387	22.1	-	951,500	188,700	762,800	570,013	-423,123	113,696	550
Envelope upgrades	Wall upgrade to high performance	1,296	5.1	1,906	18.1	21,419	15.7	4	17.6	808	12.9	75	523,100	104,620	418,480	269,804	-122,914	112,418	518
Envelope upgrades	Windows and doors to high performance	555	2.2	1,675	15.9	18,239	13.4	3	15.4	652	10.4	40	88,700	17,740	70,960	180,427	-33,537	21,808	109
Envelope upgrades	Roof upgrade to high performance	10	0.0	9	0.1	106	0.1	0	0.1	4	0.1	20	331,700	66,340	265,360	427,155	-280,266	14,802,501	62,674
Envelope upgrades	Unit heater renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	8,000	0	8,000	155,558	-8,668	-	-
Load minimization	Combined	1,819	7.2	4,006	38.0	44,109	32.3	8	36.9	1,609	25.6	-	951,500	188,700	762,800	566,906	-420,016	97,844	474
Load minimization	Wall upgrade to high performance	1,296	5.1	1,906	18.1	21,419	15.7	4	17.6	808	12.9	75	523,100	104,620	418,480	269,804	-122,914	112,418	518
Load minimization	Windows and doors to high performance	555	2.2	1,675	15.9	18,239	13.4	3	15.4	652	10.4	40	88,700	17,740	70,960	180,427	-33,537	21,808	109
Load minimization	Roof upgrade to high performance	10	0.0	9	0.1	106	0.1	0	0.1	4	0.1	20	331,700	66,340	265,360	427,155	-280,266	14,802,501	62,674
Load minimization	Implement a thermostat schedule for UH1	249	1.0	826	7.8	8,966	6.6	2	7.6	319	5.1	15	0	0	0	142,248	4,642	0	0
Load minimization	Unit heater renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	8,000	0	8,000	155,558	-8,668	-	-

Utility use comparison

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

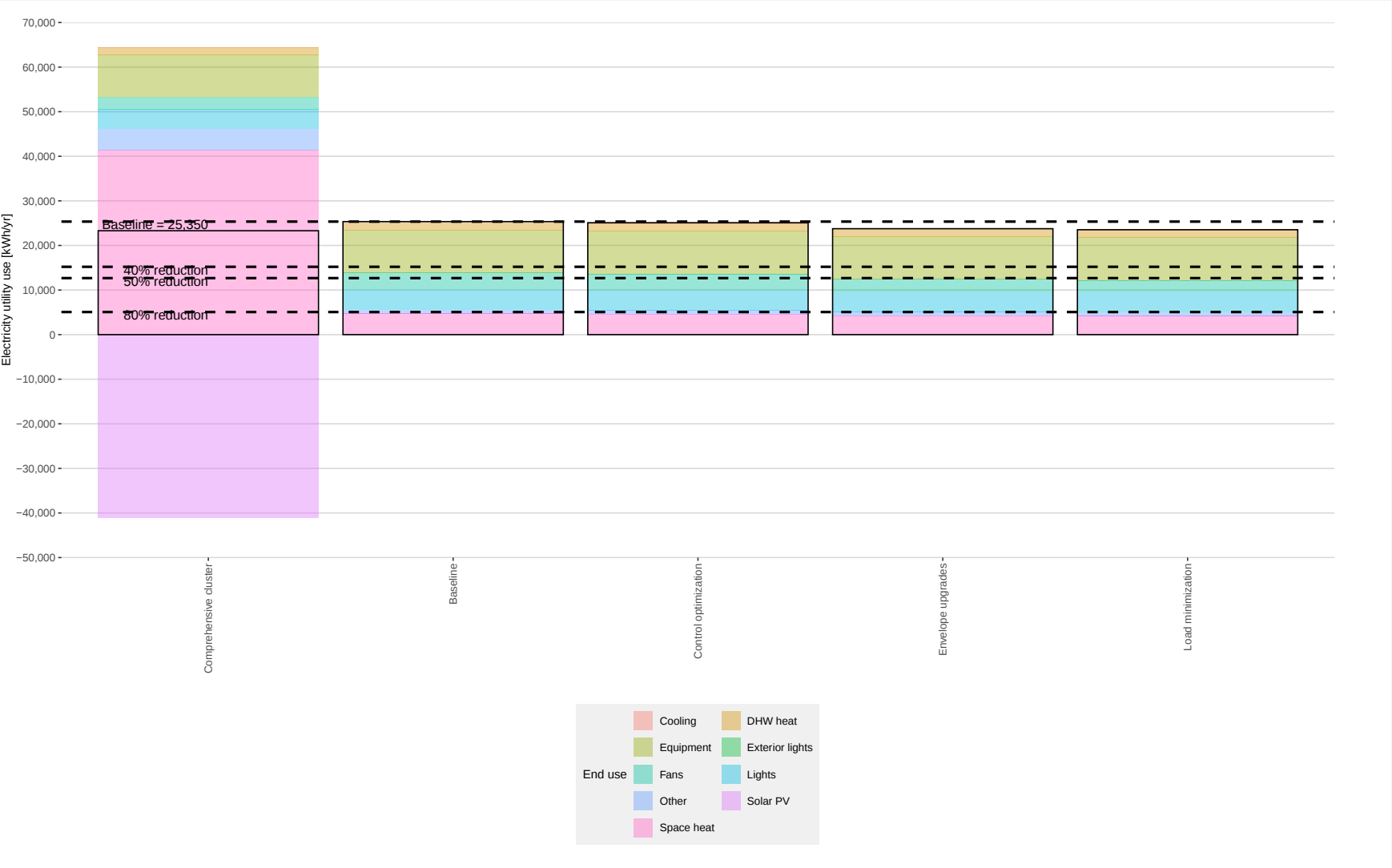


Figure 88: Electricity utility use expected yearly for each scenario by end use

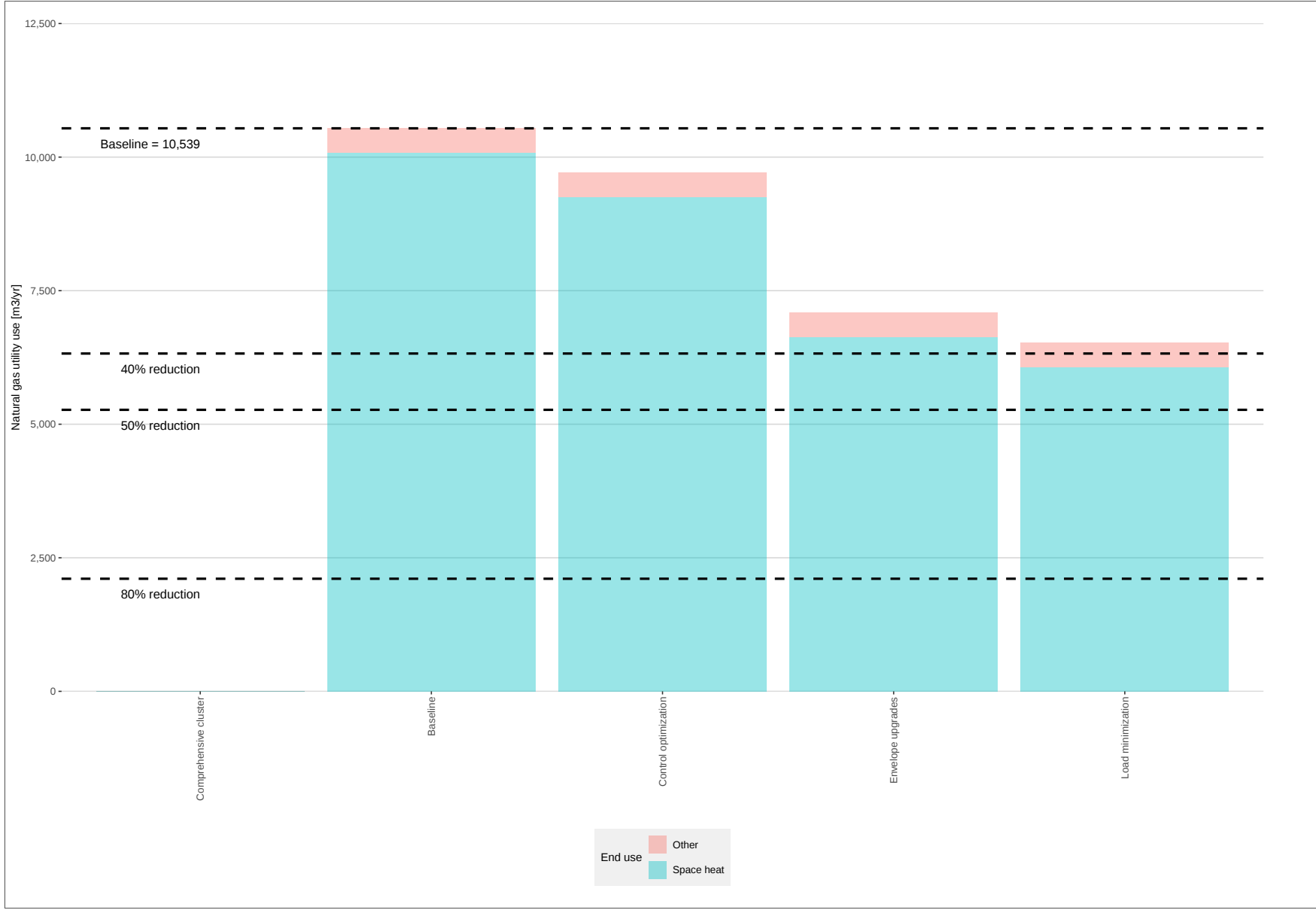


Figure 89: Natural gas utility use expected yearly for each scenario by end use

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.

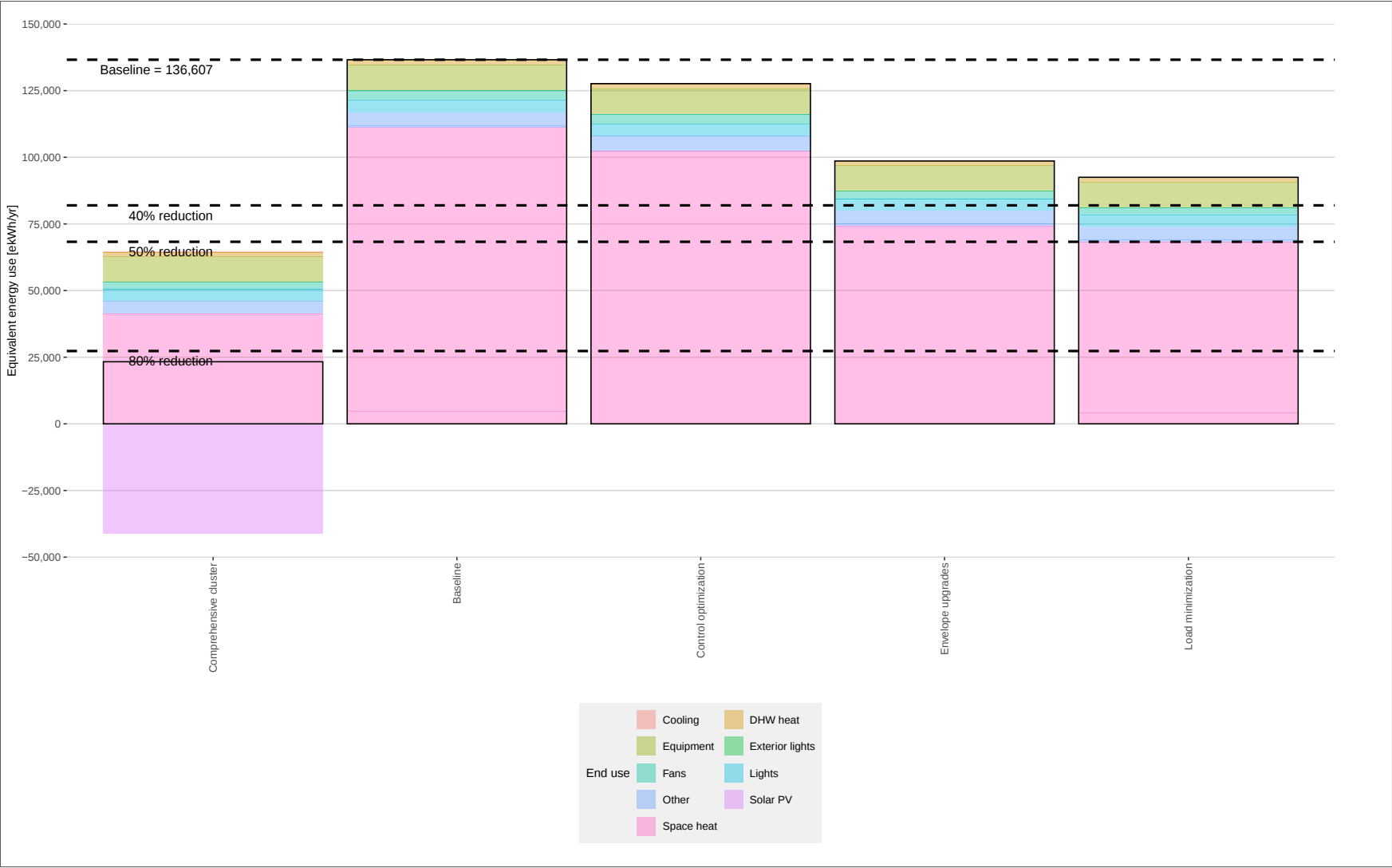


Figure 90: Equivalent energy use expected yearly for each scenario by end use

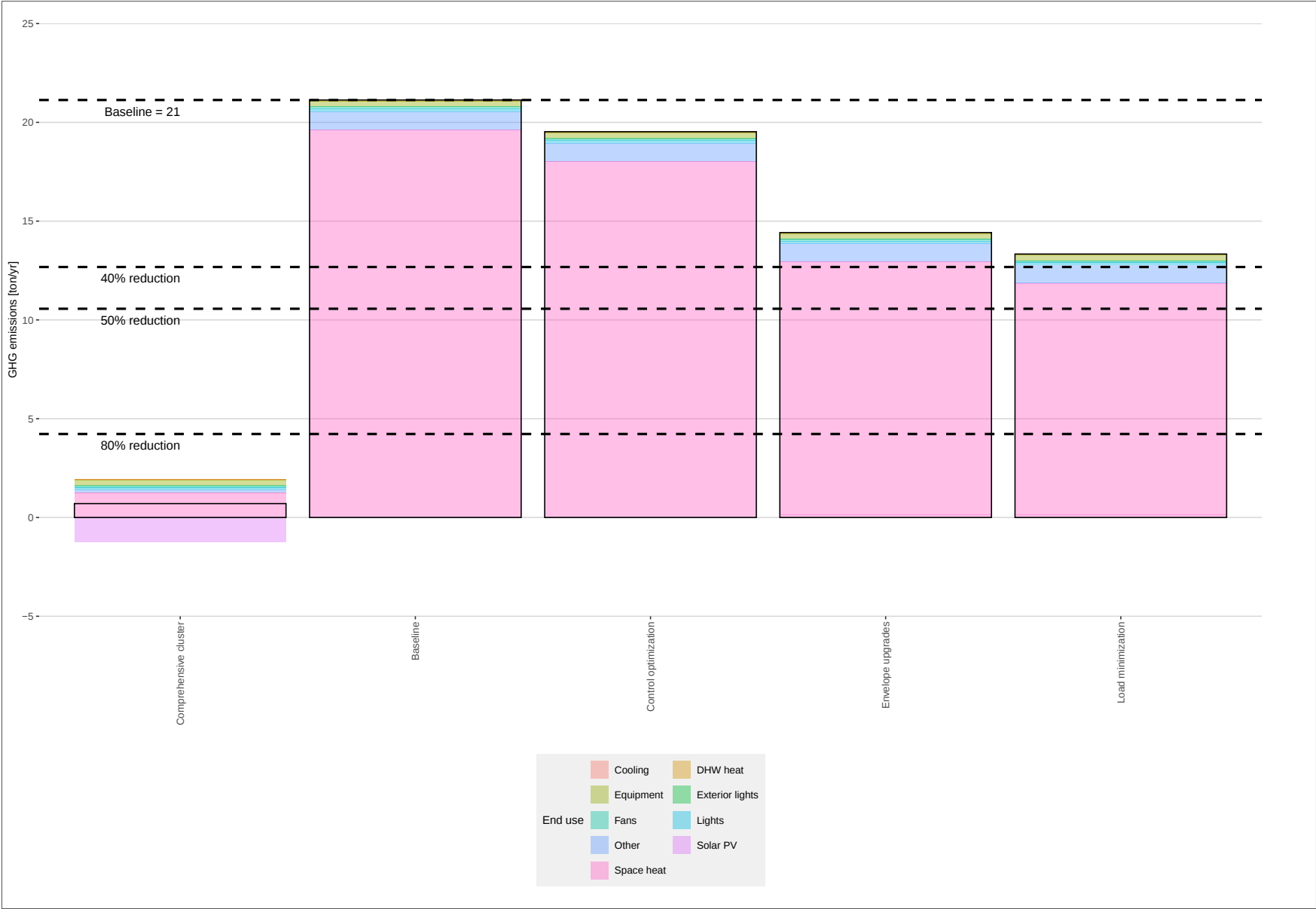


Figure 91: GHG emissions expected yearly for each scenario by end use

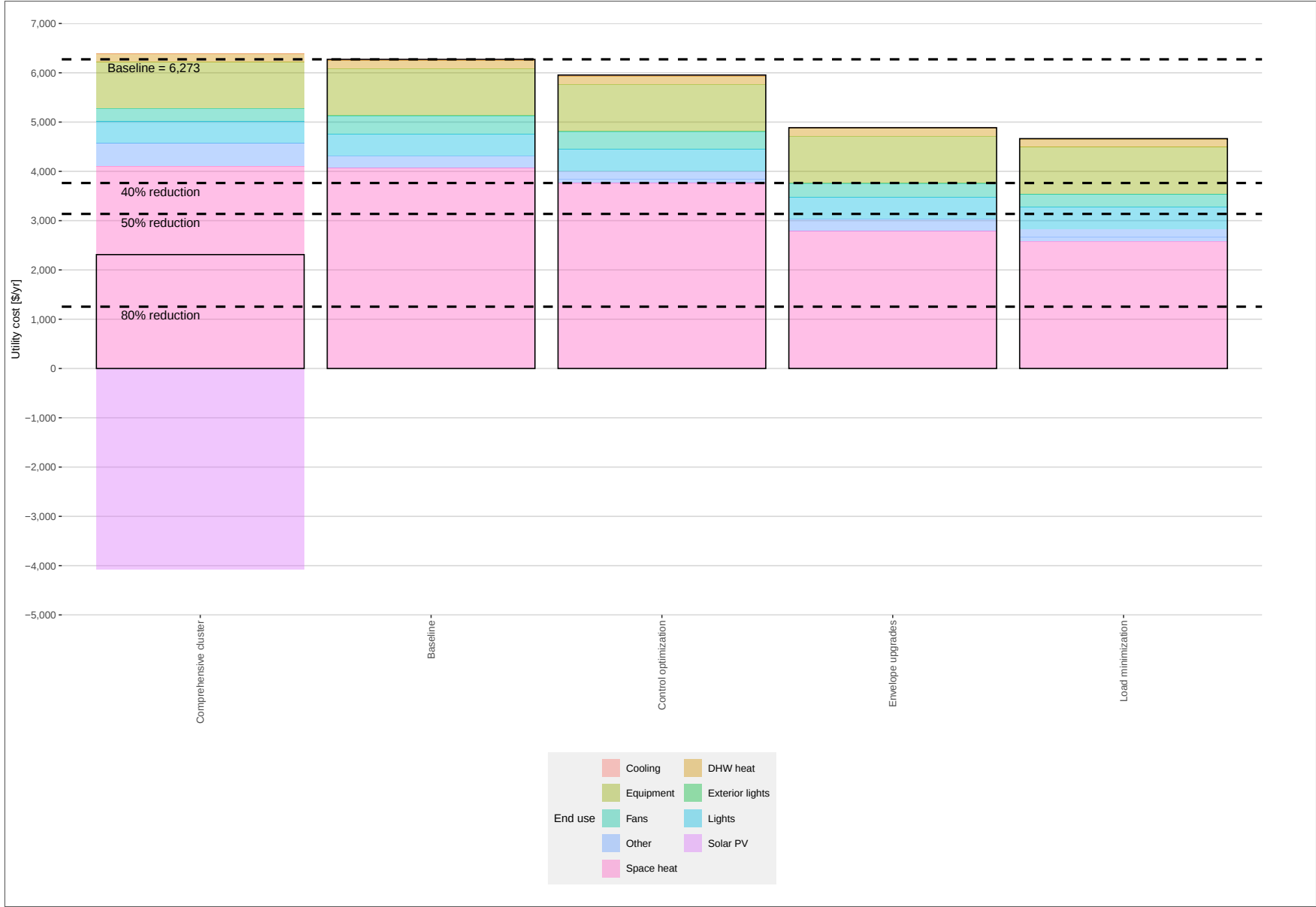


Figure 92: Utility costs expected yearly for each scenario by end use

Financial performance comparison

The following figures compare the financial performance between each scenario.

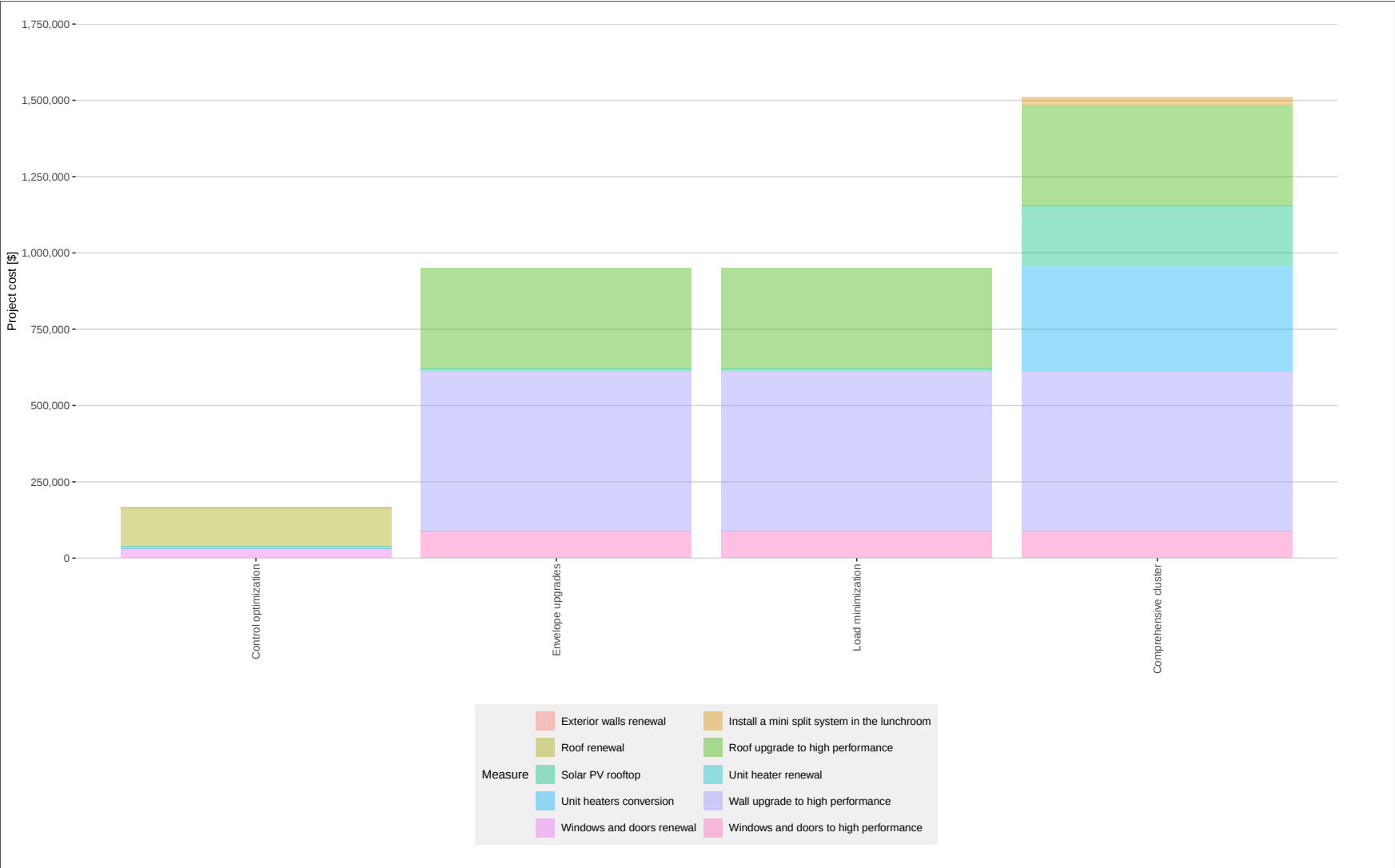


Figure 93: Project cost expected for each scenario by measure

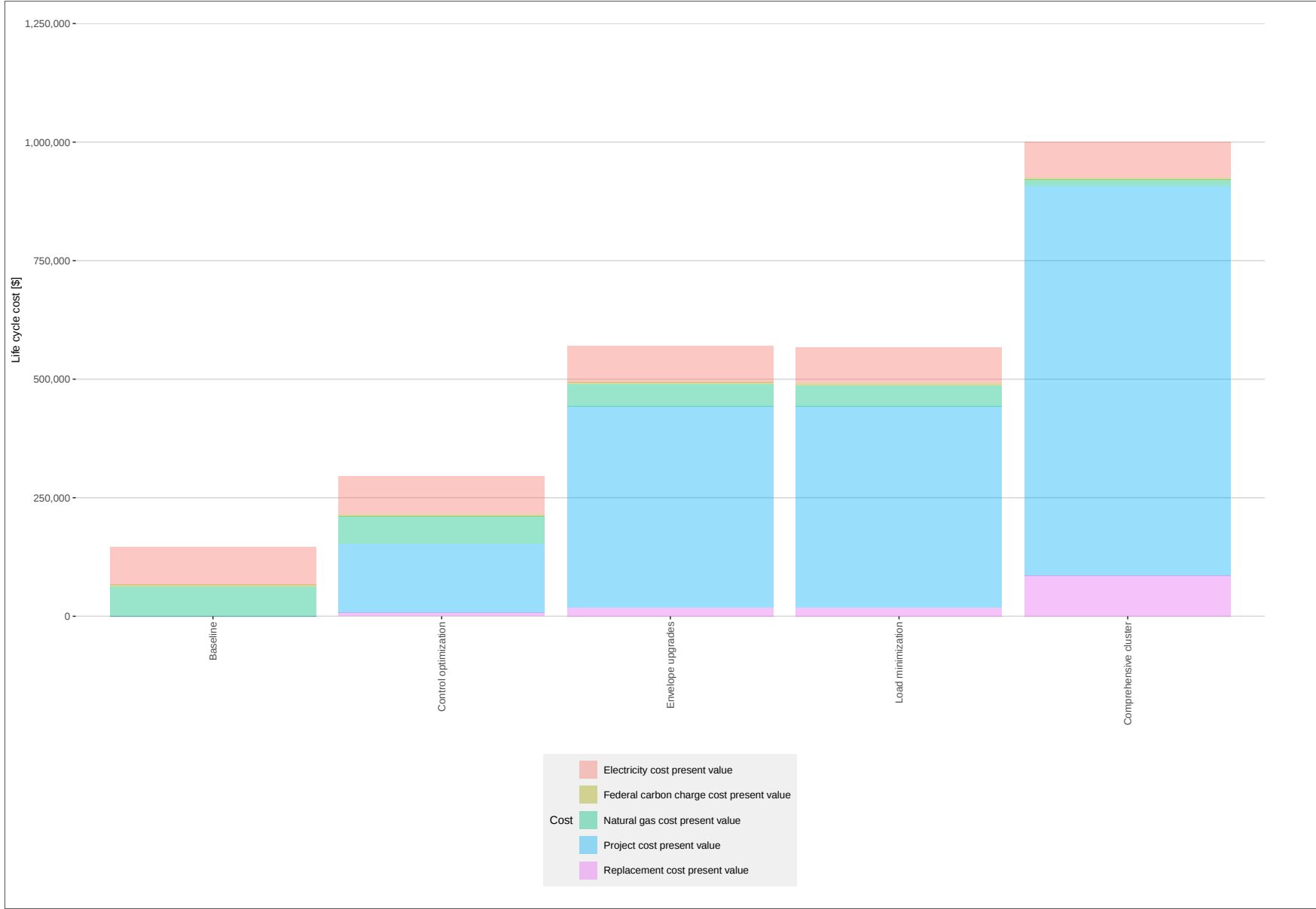


Figure 94: Life cycle cost expected for each scenario by cost item

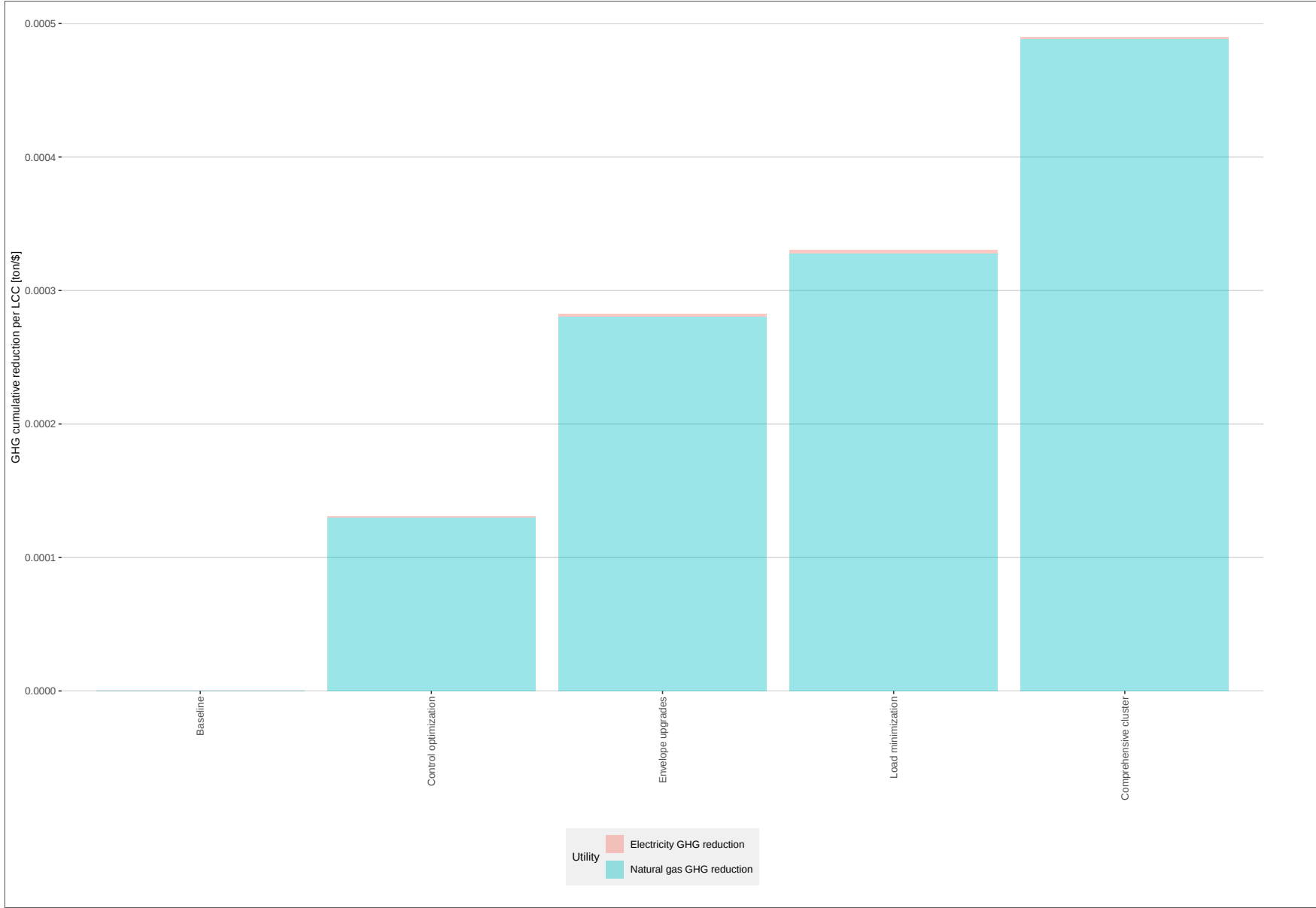


Figure 95: GHG cumulative reduction per life cycle cost (LCC) dollar expected for each scenario by utility

6.5 Plan scenario development

Plan scenario identification and objectives

The plan scenarios that were analyzed and their objectives are summarized in Table 42.

Table 42: 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 42. Results of the plan scenario composition are presented in Figure 96, 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 43 to 48.

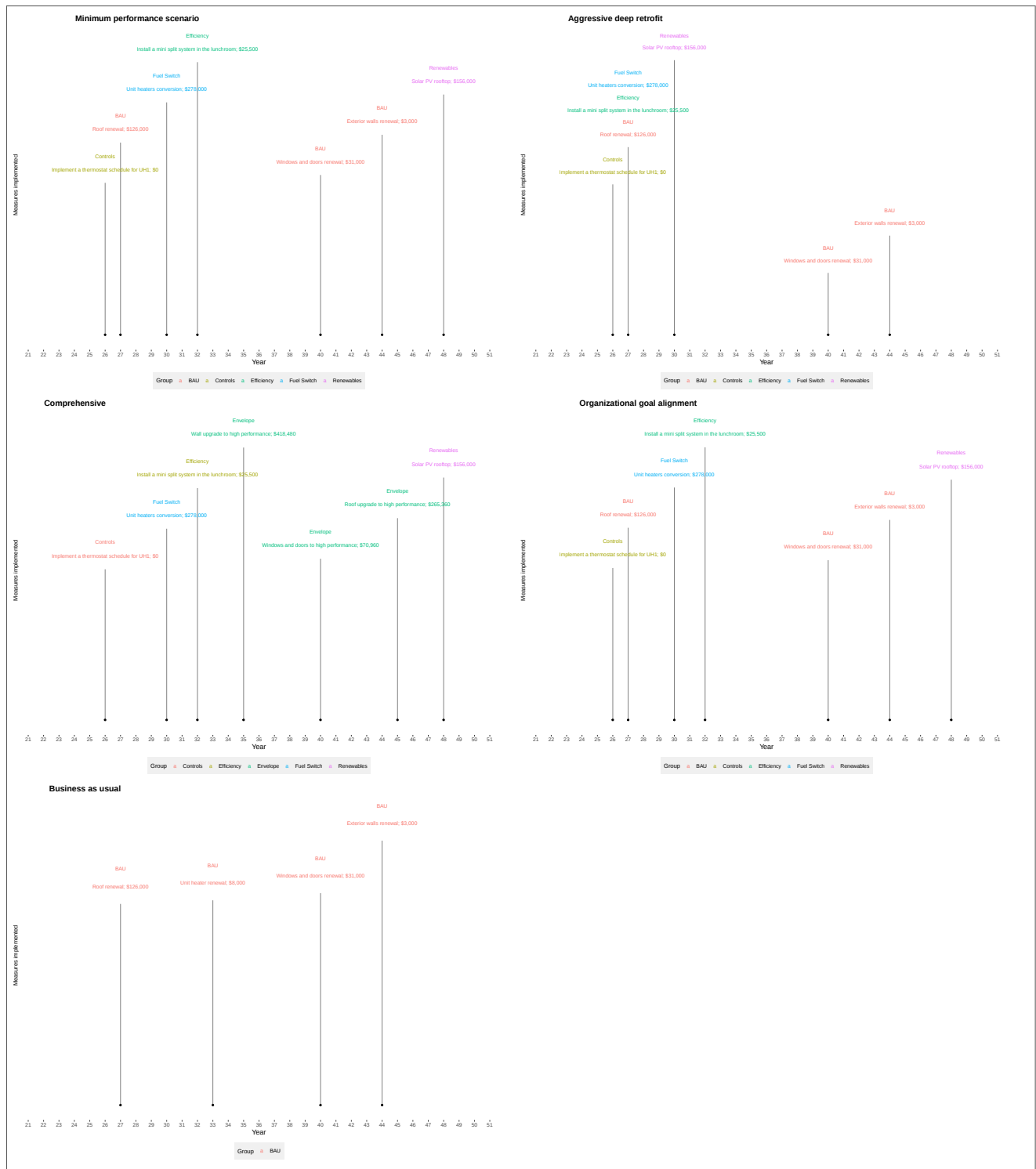


Figure 96: Plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

Table 43: Scenario composition summary

Measure	Minimum performance scenario	Aggressive deep retrofit	Comprehensive	Organizational goal alignment
Carbon offsets 20	✗	✗	✗	✗
Implement a thermostat schedule for UH1	✓	✓	✓	✓
Install a mini split system in the lunchroom	✓	✓	✓	✓
Roof upgrade to high performance	✗	✗	✓	✗
Solar PV rooftop	✓	✓	✓	✓
Unit heaters conversion	✓	✓	✓	✓
Wall upgrade to high performance	✗	✗	✓	✗
Windows and doors to high performance	✗	✗	✓	✗
Exterior walls renewal	✓	✓	✗	✓
Roof renewal	✓	✓	✗	✓
Unit heater renewal	✗	✗	✗	✗
Windows and doors renewal	✓	✓	✗	✓

Table 44: Minimum performance scenario measure implementation timeline

Measure	Year
Implement a thermostat schedule for UH1	2026
Roof renewal	2027
Unit heaters conversion	2030
Install a mini split system in the lunchroom	2032
Windows and doors renewal	2040
Exterior walls renewal	2044
Solar PV rooftop	2048

Table 45: Aggressive deep retrofit measure implementation timeline

Measure	Year
Implement a thermostat schedule for UH1	2026
Install a mini split system in the lunchroom	2027
Roof renewal	2027
Unit heaters conversion	2027
Solar PV rooftop	2030
Windows and doors renewal	2040
Exterior walls renewal	2044

Table 46: Comprehensive measure implementation timeline

Measure	Year
Implement a thermostat schedule for UH1	2026
Unit heaters conversion	2030
Install a mini split system in the lunchroom	2032
Wall upgrade to high performance	2035
Windows and doors to high performance	2040
Roof upgrade to high performance	2045
Solar PV rooftop	2048

Table 47: Organizational goal alignment measure implementation timeline

Measure	Year
Implement a thermostat schedule for UH1	2026
Roof renewal	2027
Unit heaters conversion	2030
Install a mini split system in the lunchroom	2032
Windows and doors renewal	2040
Exterior walls renewal	2044
Solar PV rooftop	2048

Table 48: Business as usual measure implementation timeline

Measure	Year
Roof renewal	2027
Unit heater renewal	2033
Windows and doors renewal	2040
Exterior walls renewal	2044

6.6 Plan performance analysis

Figures 97 through 100 present the projected yearly electricity use, natural gas use, GHG emissions and life cycle costs associated with each plan scenario.



Figure 97: Electricity yearly utility use projection for each scenario



Figure 98: Natural gas yearly utility use projection for each scenario

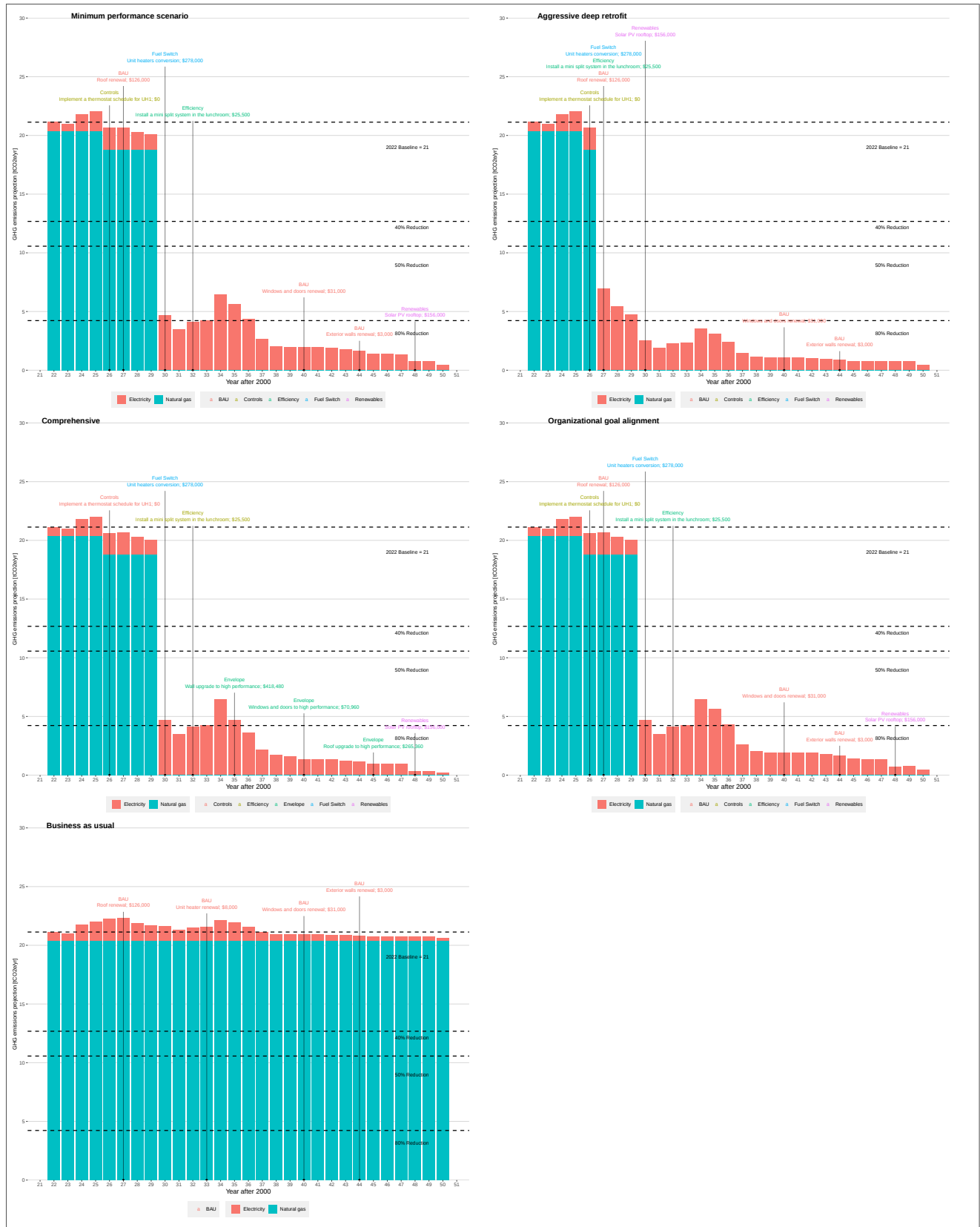


Figure 99: GHG yearly emissions projection for each scenario

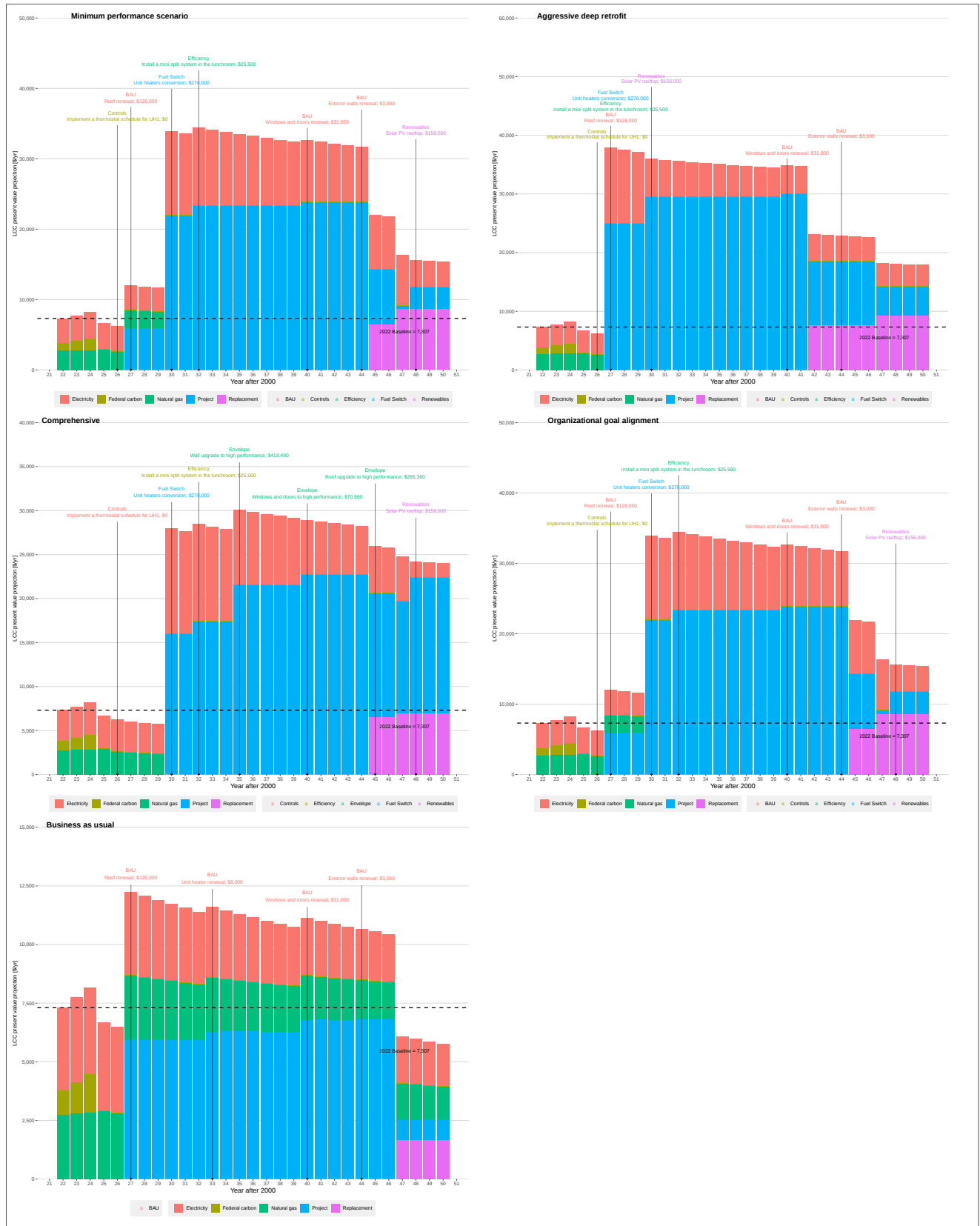


Figure 100: Life cycle yearly cost (after discounting to present value) projection for each scenario

6.7 Plan performance summary

Plan performance summary

Table 49 summarizes the performance of each plan scenario with respect to utility use, GHG emissions, utility cost, and financial metrics. The first half of Table 49 represents the estimated performance in the final year (2050) of the evaluation period. The second half of Table 49 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 49 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 100).

Table 49: 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]	50,219	50,219	23,301	50,219	25,350
	Electricity monthly peak (av)	[kW]	20.0	20.0	14.3	20.0	6.5
	Electricity yearly peak (max)	[kW]	37.4	37.4	26.8	37.4	7.3
	Natural gas use	[m3/yr]	0	0	0	0	10,539
GHG emissions final	Electricity GHGs	[tCO2e/yr]	0.48	0.48	0.22	0.48	0.24
	Natural gas GHGs	[tCO2e/yr]	0.0	0.0	0.0	0.0	20.4
	Carbon offsets GHGs	[tCO2e/yr]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e/yr]	0.5	0.5	0.2	0.5	20.6
Utility cost final	Electricity utility cost	[\$/yr]	12,243	12,243	5,681	12,243	6,180
	Natural gas utility cost	[\$/yr]	0	0	0	0	4,770
	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]	12,243	12,243	5,681	12,243	10,950
Utility use cumulative	Electricity use	[kWh]	1,999,930	1,455,155	1,628,645	1,999,930	735,164
	Natural gas use	[m3]	81,009	51,869	81,009	81,009	305,628
GHG emissions cumulative	Electricity GHGs	[tCO2e]	66.2	54.6	58.4	66.2	26.8
	Natural gas GHGs	[tCO2e]	157	100	157	157	591
	Carbon offsets GHGs	[tCO2e]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e]	223	155	215	223	617
Utility cost cumulative	Electricity utility cost	[\$]	387,800	274,114	308,121	387,800	137,714
	Natural gas utility cost	[\$]	22,558	14,027	22,558	22,558	106,280
	Carbon offsets utility cost	[\$]	0.00	0.00	0.00	0.00	0.00
	Federal carbon charge	[\$]	3,971	3,971	3,971	3,971	3,971
	Total utility cost	[\$]	414,329	292,112	334,650	414,329	247,965
Financial cumulative	Project cost	[\$]	897,638	780,548	1,970,378	897,638	186,556
	Replacement cost	[\$]	375,291	358,542	277,895	375,291	97,397
	Life cycle cost	[\$]	673,710	756,979	633,842	673,710	284,476

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 and solar PV 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 envelope upgrades.

Comprehensive

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

7 END