

PATHWAY TO DECARBONIZATION FEASIBILITY STUDY

CITY OF TEMISKAMING SHORES

DYMOND COMPLEX
181 Drive in Theatre Road, New Liskeard, ON

WalterFedy Project No: 2023-0734-10

July 21, 2025



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Project Number: 2023-0734-10

July 21, 2025

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

Dear Mathew,

RE: Pathway to Decarbonization Feasibility Study

WalterFedy is pleased to submit the attached Pathway to Decarbonization Feasibility Study report to the City of Temiskaming Shores. This study covers the agreed-upon scope and provides a Pathway to Decarbonization Feasibility Study for the Dymond Complex, which is located at 181 Drive in Theatre Road in New Liskeard, ON. Certain parts of this report are designed to be viewed in digital/PDF format. This approach will enable the reader to zoom in on images and navigate the document using the provided hyperlinks.

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

All of which is respectfully submitted,

WALTERFEDY



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EXECUTIVE SUMMARY

WalterFedy was engaged by the City of Temiskaming Shores to complete a Pathway to Decarbonization Feasibility Study for the Dymond Complex. The objective of this engagement is to identify and analyze measures that reduce utility use, GHG emissions, and utility costs at the Dymond Complex, 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 2024-04-16 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 Dymond Complex. 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 Dymond Complex 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.

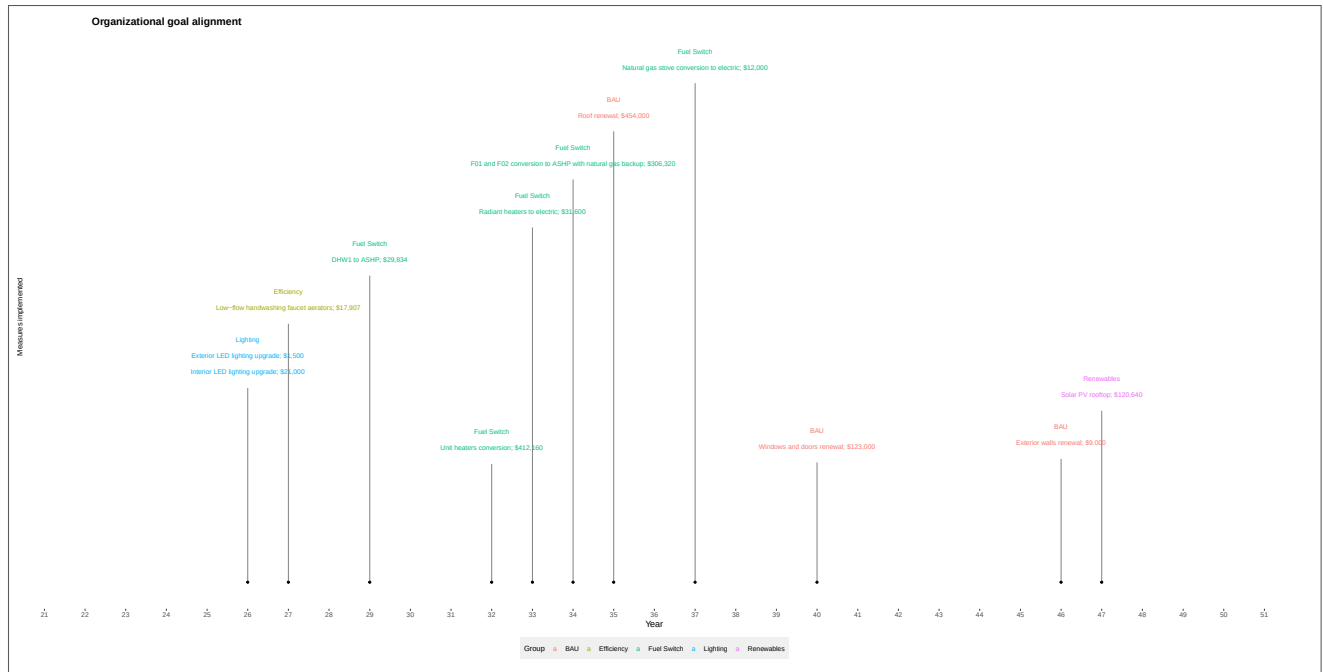


Figure 1: Recommended plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

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

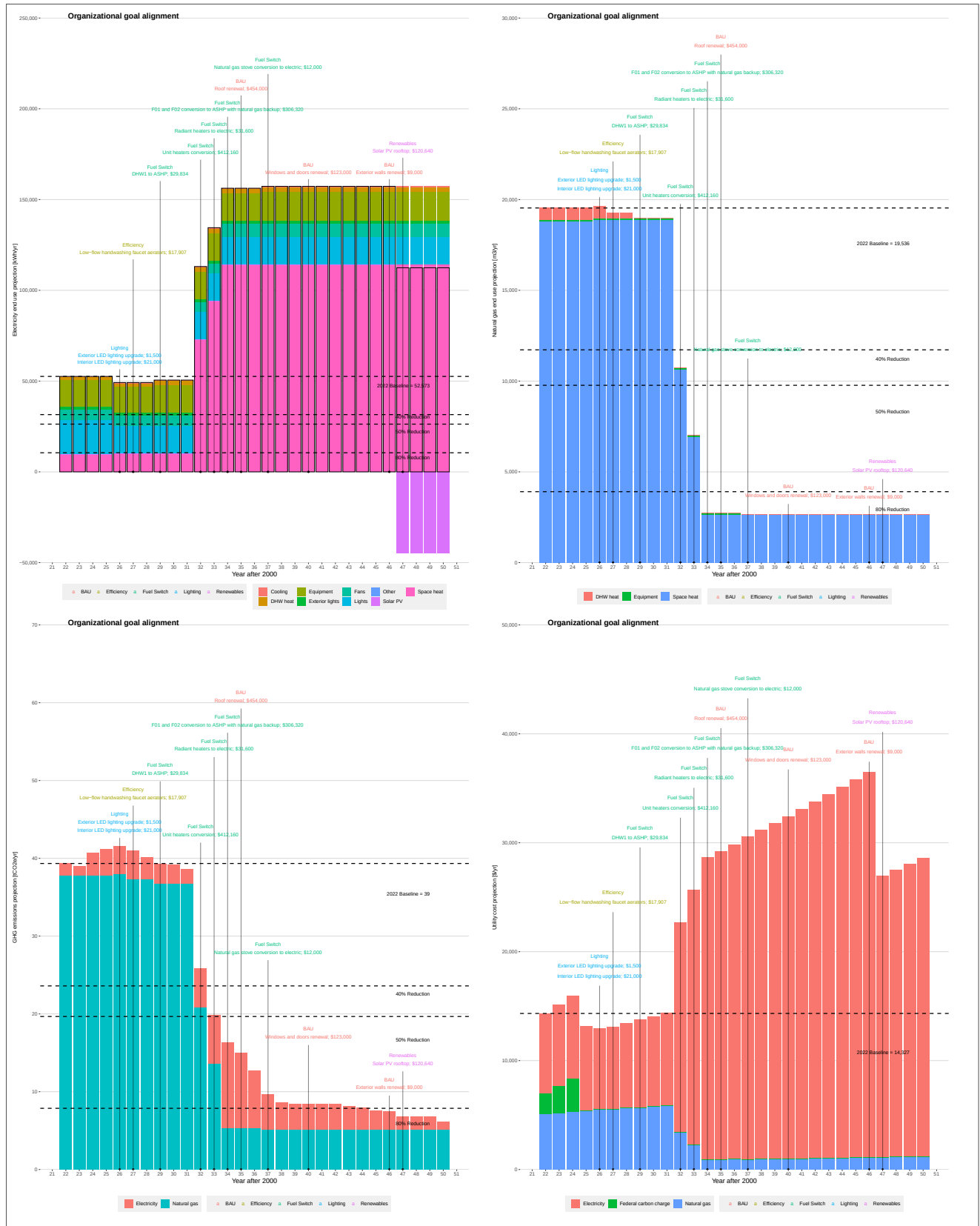


Figure 2: Recommended scenario performance

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]	137,188	137,188	89,767	112,410	52,573
	Electricity monthly peak (av)	[kW]	39.7	39.7	29.5	30.4	14.1
	Electricity yearly peak (max)	[kW]	85.8	85.8	65.0	57.1	15.7
	Natural gas use	[m3/yr]	0	0	0	2,637	19,536
GHG emissions final	Electricity GHGs	[tCO2e/yr]	1.3	1.3	0.9	1.1	0.5
	Natural gas GHGs	[tCO2e/yr]	0.0	0.0	0.0	5.1	37.8
	Carbon offsets GHGs	[tCO2e/yr]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e/yr]	1.3	1.3	0.9	6.2	38.3
Utility cost final	Electricity utility cost	[\$/yr]	33,446	33,446	21,885	27,405	12,817
	Natural gas utility cost	[\$/yr]	0	0	0	1,194	8,842
	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]	33,446	33,446	21,885	28,599	21,659
Utility use cumulative	Electricity use	[kWh]	3,669,745	3,622,992	3,265,436	3,248,517	1,524,610
	Natural gas use	[m3]	211,336	105,749	211,336	256,168	566,546
GHG emissions cumulative	Electricity GHGs	[tCO2e]	115	127	109	105	56
	Natural gas GHGs	[tCO2e]	408	204	408	495	1,095
	Carbon offsets GHGs	[tCO2e]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e]	524	332	517	600	1,150
Utility cost cumulative	Electricity utility cost	[\$]	724,841	694,486	633,464	636,775	285,596
	Natural gas utility cost	[\$]	60,755	28,750	60,755	78,155	197,011
	Carbon offsets utility cost	[\$]	0.00	0.00	0.00	0.00	0.00
	Federal carbon charge	[\$]	7,361	7,361	7,361	7,361	7,361
	Total utility cost	[\$]	792,958	730,597	701,581	722,291	489,969
Financial cumulative	Project cost	[\$]	2,214,492	2,026,011	10,812,980	2,150,793	816,982
	Replacement cost	[\$]	856,395	784,160	856,395	813,530	62,649
	Life cycle cost	[\$]	1,510,282	1,795,824	1,769,925	1,444,663	664,109

1 INTRODUCTION

1.1 Overview

WalterFedy was engaged by the City of Temiskaming Shores to complete a Pathway to Decarbonization Feasibility Study for the Dymond Complex. 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 Dymond Complex 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 Dymond Complex represented 42 tCO₂e in 2019, or 2.1% 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 Dymond Complex.

Table 2: Asset management summary for this facility

Group	Metric	Unit	Value
Financial	Content Value Estimated	[\$]	328,198
	Building Land Tank	[\$]	2,490,473
	Replacement Cost	[\$]	2,818,671
Information	Install Date	[yr]	1971
	Age	[yrs]	54
Condition Rating	Structure Condition Score	[-]	3.9
	Final Condition Score	[-]	3.9
Risk	Probability of Failure	[-]	2
	Consequence of Failure	[-]	5
	Risk Score	[-]	2.6

1.3 Contact information

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

Table 3: Contact information

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

2 FACILITY DESCRIPTION

2.1 Facility description methodology

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

1. **Facility document review.** Facility documents from the following list were reviewed, if available. Further information on available documentation are available in Section 2.3.
 - Building drawings.
 - Building automation system graphics and points lists.
 - Previously completed Engineering studies, including Energy Audits, Feasibility Studies, and Building Condition Assessments.
 - Historical utility use data.
 - Other documentation made available by the City of Temiskaming Shores.
2. **Site survey.** A site survey was completed on 2024-04-16 to review the energy systems applicable to the desired retrofit scenario.

2.2 Facility overview

An overview of the Dymond Complex is provided in Table 4.

Table 4: Facility overview

Description	Unit	Value
Name	[-]	Dymond Complex
Address	[-]	181 Drive in Theatre Road
Location	[-]	New Liskeard, ON
Type	[-]	Community centre/Public works
Construction year	[-]	1971
Gross floor area	[m2]	1,500
Gross floor area	[ft2]	16,150

An aerial view of the Dymond Complex is provided in Figure 3.



Figure 3: Dymond Complex aerial view

2.3 Building information

Renovations

The following renovations are known:

- **Part 9 Retrofit (2009):** the building was retrofitted to be compliant with Part 9 changes to the OBC.
- **Community Hall Washrooms (2013):** the cloak room in the community hall was converted to a barrier-free washroom.
- **Roof replacement (2013):** the asphalt shingles were replaced.

Additions

It appears that the community hall was an addition. However, drawings are not available to confirm this notion.

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
- Cold storage building

Utility bill responsibility

Utility bill responsibility is as follows:

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

Commissioning history

No commissioning history has been documented.

Previous studies

The following is a summary of known previous studies:

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

Documentation availability

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

- Fire alarm drawings
- Dymond Complex Floor Plans (CAD)
- Barrier-free washroom drawings

2.4 Space use

Type summary

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

- Residential apartment (not accessible)
- Washroom
- Maintenance room
- Locker room
- Apparatus bay
- Meeting room
- Electrical/Mechanical room
- Lunchroom
- Offices
- Multipurpose room
- Storage
- Kitchen
- Drying tower
- Garage

Occupancy scheduling

The facility operation hours are as follows:

- **Residential apartment:** 00:00-08:00, 17:00-00:00 (M-F); continuous S-S (assumption)
- **Fire station:** 08:30-16:30 M-F (office); as required in the apparatus bay
- **Public works:** 07:00-08:00, 14:00-15:00 (M-F). Hours can vary dependent on winter storm event and summer hours.
- **Community Hall:** Rentals as required. Assume evenings and weekends.

There is an estimated max capacity of 197 people based on the community hall capacity, the number of firefighter lockers, staff members present, and the number of public works bays.

2.5 Building Envelope

Building envelope area data summary

Building envelope areas are summarized in Table 5.

Table 5: 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]
1,744	1,578	1,415	41.6	122

Overview

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

Roof

- The exterior layer of the roof is asphalt shingles, which were replaced in 2013. It's assumed that no additional insulation was added at this time.
- The overall roof assembly is assumed to have a U-Value of 0.2271 W/m2K.
- The roof was in good condition, as it was replaced in 2013.

Opaque Walls (above ground)

- The exterior walls comprised either an outer layer of metal siding, brick veneer, or concrete block.
- The overall wall assembly is assumed to have a U-Value of 0.3785 W/m2K.
- The wall condition of the brick was good. However, there was some damage to the metal siding.

Fenestration

Windows

- It appears most windows are double-pane aluminum windows.
- Windows appear to be in poor condition, with several windows having cracked framing.
- The overall U-Value is assumed to be 4.62 W/m2K for the window system with a SHGC of 0.35.

Doors

- The overall fenestration-to-wall ratio is estimated to be 10%.

Overall Enclosure Tightness

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

Building Envelope documentation

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



Figure 4: Asphalt shingle roof



Figure 5: Bay 1 door not sealed properly



Figure 6: Bay 5 not properly sealing



Figure 7: Community hall windows



Figure 8: Damaged metal siding on the east elevation



Figure 9: Damaged window

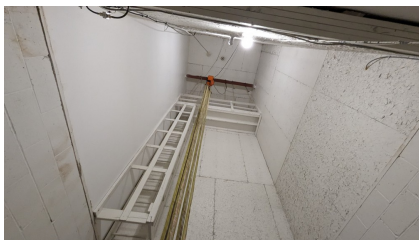


Figure 10: Drying tower

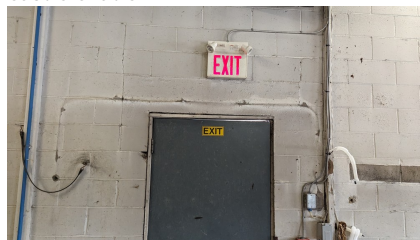


Figure 11: Entry door with gaps in Public Works bays



Figure 12: Fire station entrance



Figure 13: Metal siding



Figure 14: Office window



Figure 15: Office windows



Figure 16: Overhead door to storage and entry door



Figure 17: Overhead doors



Figure 18: South elevation



Figure 19: Training room windows



Figure 20: West elevation

2.6 HVAC

HVAC equipment summary

HVAC systems are summarized in Table 6, Table 7, and Table 8.

Table 6: Air distribution systems summary

Tag	Make	Model	Serves	Design flow	Motor output	Data source
-	-	-	-	[cfm]	[hp]	-
F1	Payne	PG92SBS66120 DAAA	Community Hall	1,800	1.00	Nameplate.
F2	Lennox	EL195UH070P 36B	Offices	1,100	0.33	Nameplate.
EF1	-	-	Tail pipe exhaust	-	-	-

Table 7: Heating systems summary

Tag	Serves	Utility	Efficiency	Output	Data source
-	-	-	[decimal]	[btuh]	-
UH1	Bays 2-3	Natural gas	0.80	150,000	City staff.
UH2	Bays 6-9	Natural gas	0.80	80,000	Assumption.
IH1	Bays 4-5	Natural gas	0.60	60,000	Nameplate.
F1_HEAT	Community Hall	Natural gas	0.93	112,000	Nameplate.
F2_HEAT	Offices/apartment	Natural gas	0.97	64,000	Nameplate.
DHW1	Community Hall and offices	Natural gas	0.85	38,250	Nameplate.
DHW2	Public works area	Electricity	1.00	15,355	Nameplate.
Elect_BB	Various	Electricity	1.00	-	Assumption.
MS1_HEAT	Apartment kitchen and living room	Electricity	2.50	-	City staff.

Table 8: Cooling systems summary

Tag	Serves	Efficiency	Output	Data source
-	-	[decimal]	[ton]	-
CU1	F1	4	-	Assumption.
CU2	F2	4	-	Assumption.
MS1	Apartment	4	-	Assumption.

System type

The facility utilizes two natural gas-fired furnaces with DX cooling, natural gas-fired unit heaters, natural gas-fired infrared heaters, electric baseboards, and a mini-split. A summary of this system is as follows:

- F1 is a forced air furnace with DX cooling for the community hall, but its condenser unit was inaccessible due to a gate enclosure. F2, serving the fire station offices and an apartment, is also a forced air furnace with DX cooling, and its condenser unit was similarly blocked by an enclosure. The condenser units were not available for review as they were behind a gate and had enclosures over them.
- Bay 1 contained the lockers. However, there was no heat present in this space.

- During the site visit, Bays 2 and 3 were heated by a Reznor unit (UH1). However, this unit has since been replaced with a Modine PTP150AS, which has a higher heating capacity than the previous unit. Additionally, EF1, which serves the tailpipe exhaust, is also present.
- Bays 4-5 is heated by IH-1.
- UH-2 heats Bays 6-9.
- Electric heating is present on the second floor.
- A mini-split unit provides heating and cooling to the kitchen and living room of the apartment per City staff.
- The equipment storage room behind bays 6-9 is not conditioned.

Central Plant

There is no centralized plant at this facility.

Distribution system

The air distribution throughout the offices and the community hall uses a single-duct approach to registers.

There are no pumps present at this site.

Controls

F1 and F2

- Its assumed that F1 and F2 are controlled by programmable thermostats. The thermostats for these units were not inspected.

UH1 and UH2

- UH1 had a programmable thermostat. However, the schedule was not in use. The temperature was set to 63F.
- UH2 had a programmable thermostat. However, the schedule was not in use. The temperature was set to 63F, and the fan was set to ON.

IH1

- IH1 had a non-programmable thermostat, and was set to 15C.

Electric heating

- The electric baseboards in the training room on the second floor were controlled by two programmable thermostats. The first one had no power to it, and the second was set to 69F without a schedule.

Mini-split

- We were not able to access the apartment and the temperature setpoint is unknown.

HVAC system documentation

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

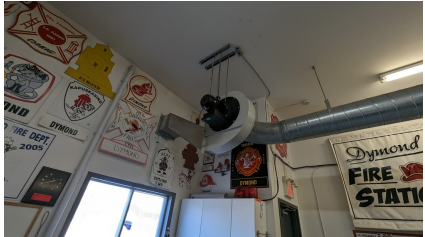


Figure 21: EF1 - located in Bays 2 and 3



Figure 22: Electric baseboards in fire training room



Figure 23: Electric heater in main entrance



Figure 24: Electric heater in the community hall vestibule



Figure 25: F1 - rust inside unit



Figure 26: F1



Figure 27: F2



Figure 28: Fire training thermostat for electric baseboard heaters



Figure 29: IH-1 thermostat



Figure 30: IH1 - Bay 4



Figure 31: Mini split for the apartment



Figure 32: Range hood in the kitchen



Figure 33: Return grille

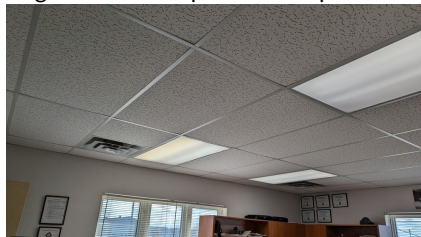


Figure 34: Supply diffusers



Figure 35: UH1 (recently replaced)



Figure 36: UH1 thermostat



Figure 37: UH2



Figure 38: UH2 thermostat

2.7 Domestic hot water

Overview

Two DHW heaters are serving this building. DHW1 serves the office and the community hall and is a natural gas-fired unit. DHW2 is an electric unit located in the public works bay. DHW1 and DHW2 capacities are 50 USG and 48.6 USG, respectively.

Domestic Hot Water documentation

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



Figure 39: DHW1

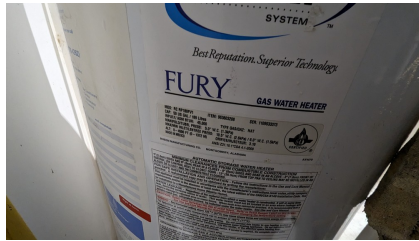


Figure 40: DHW1 nameplate

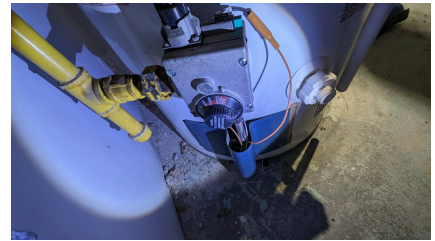


Figure 41: DHW1 thermostat set to very hot



Figure 42: DHW2



Figure 43: DHW2 nameplate

2.8 Lighting

Lighting system summary

Lighting systems are summarized in Table 9.

Table 9: Lighting systems summary

Space name	Floor area of space	Light power density	Light power input	Data source
-	[m2]	[W/m2]	[W]	-
Community Hall	325.1	4.8	1,561	Assumption.
Mechanical/Electrical	14.9	8.0	119	Assumption.
Fire Station Offices	125.7	6.4	804	Assumption.
Apparatus Bays	387.6	8.0	3,101	Assumption.
Public Works Bays	312.9	8.0	2,503	Assumption.
Cold Storage	84.0	8.0	672	Assumption.
Public Works - Lunch room	12.2	8.0	98	Assumption.
Apartment	84.7	4.8	406	Assumption.
Fire Station - Second floor	203.9	6.4	1,305	Assumption.

Interior lighting

Fixtures

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

- Type A: 1'x4' recessed, LED integrated fixture
- Type B: pendant, assumed LED lamp
- Type C: 1'x4' recessed, 2 lamp, T8
- Type D: 2'x4' recessed, 4 lamp, T8
- Type E: strip, surface-mounted, 2 lamp, 4' T8
- Type E1: strip, surface-mounted, 2 lamp, 8' T12
- Type F: standard light socket, LED lamp, ceiling-mounted
- Type G: strip, surface-mounted, 2 lamp, 8' T12
- Type H: standard light socket, LED lamp, wall-mounted
- Type I: 1'x4' surface-mounted, 2 lamp, T8
- Type J: 2'x4' recessed, integrated LED panel

Staff indicated that there are plans to retrofit fixtures to LED through the LAS program.

Controls

Interior lighting control is done through ceiling-mounted occupancy sensors (community hall washrooms only) and manual switches. The lights were on in the office space and fire hall while no one was present.

Exterior lighting

Fixtures

- Type K: canopy fixture, 40W, LED
- Type L: LED downlight with photocell control
- Type M: LED flood light with photocell control

- Type N: CFL wallpack with photocell control
- Type O: LED pole light with photocell control
- Type P: wall sconce (may no longer be in use)
- Type Q: metal halide pole light with photocell control

Controls

Each fixture has a dedicated photocell.

Lighting system documentation

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



Figure 44: Manual light switch



Figure 45: Occupancy sensor in men's washroom



Figure 46: Type A - 1x4 LED



Figure 47: Type A - located in the kitchen



Figure 48: Type B - office washroom fixture



Figure 49: Type C - 1x4 fixture in office hallway



Figure 50: Type D - 2x4 fixture

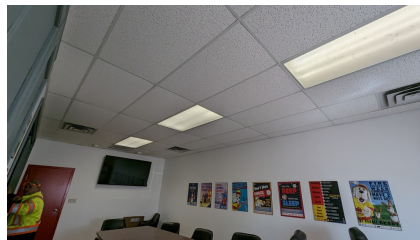


Figure 51: Type D - meeting room



Figure 52: Type E1 - mezzanine



Figure 53: Type E1 - T12 lamps



Figure 54: Type E - fire training room



Figure 55: Type E - tool room with T8 lamps



Figure 56: Type E - 2-lamp T8 strip fixtures



Figure 57: Type F - storage



Figure 58: Type G - Bays 4 and 5



Figure 59: Type H - washroom LED lamp



Figure 60: Type I - T8 lamps in upstairs washroom



Figure 61: Type J - 2x4 LED panel



Figure 62: Type K - canopy light on during the day



Figure 63: Type L - LED fixture with builtin photocell



Figure 64: Type M - flood light with photocell



Figure 65: Type N - wall pack



Figure 66: Type O - pole light



Figure 67: Type P - sconce and Type Q - pole

2.9 Process and plug loads

Process

Various process loads are present at the facility, including:

- Breathable air compressors
- Power equipment (e.g., drill press, grinder)
- Washing machine
- Two natural gas stoves
- IT equipment
- Portable generators

Plug loads

Various plug loads are present at the facility, including:

- Office equipment (e.g., photocopier)
- Personal computers
- Appliances (e.g., cooler, refrigerator, dishwasher, kettle, etc.)
- Gas-fired stoves in the community hall kitchen

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 68: Breathable air compressors



Figure 69: Cooler in kitchen



Figure 70: Drill press



Figure 71: Grinder wheel



Figure 72: Kitchen refrigerator



Figure 73: Microwave and coffee maker



Figure 74: Microwave in kitchen



Figure 75: Natural gas stoves



Figure 76: Office equipment



Figure 77: Portable generators

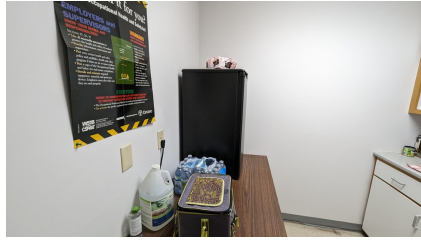


Figure 78: Refrigerator



Figure 79: Refrigerator on mezzanine



Figure 80: Television in meeting room



Figure 81: Washing machine



Figure 82: Entry to the apartment (not accessible)

2.10 Water fixtures

Water fixture summary

Water fixtures at Dymond Complex are summarized in Table 10.

Table 10: Water fixture summary				
Serves	Unit count	Flow	Volume	Data source
-	-	[gpm]	[gpc]	-
Kitchen faucets	4	2.2	-	Assumption.
Showers	2	2.5	-	Assumption.
Washroom faucets	10	2.0	-	Assumption.
Toilets	12	-	1	Assumption.
Urinals	3	-	1	Assumption.

Overview

A summary of water fixtures is as follows:

- 10 handwashing faucets.
- 2 showers. One for the residence and the other for the fire station. The fire station one does not appear to be used.
- 4 kitchen sinks.
- 12 toilets.
- 3 urinals.

Water fixture documentation

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



Figure 83: Bay 1 shower does not appear to be used



Figure 84: Faucet in second floor washroom



Figure 85: Handwashing faucet on mezzanine



Figure 86: Handwashing faucet - office washroom



Figure 87: Men's handwashing faucet in community hall

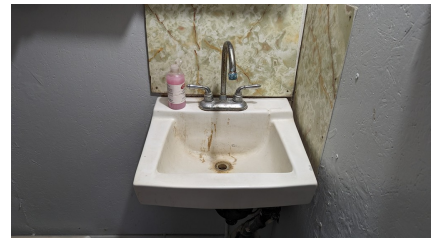


Figure 88: Public works sink



Figure 89: Public works toilet



Figure 90: Showerhead



Figure 91: Small kitchen sink



Figure 92: Toilet - Fire station office washroom



Figure 93: Urinal in second floor washroom



Figure 94: Urinal nameplate



Figure 95: Urinals in men's washroom

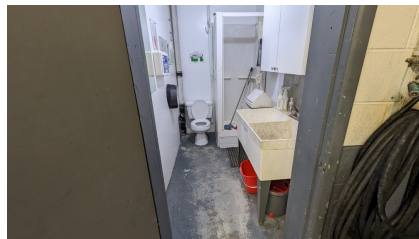


Figure 96: Washroom outside Bay 1

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 are two natural gas meters at this facility. The first serves the community hall, and the second serves the public works complex.

Utility services documentation

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



Figure 97: Electricity meter



Figure 98: Natural gas meter

2.12 Onsite energy sources

Overview

There are no stationary generators or renewable energy systems present at this facility. However, the building is set up to have a portable generator hook up.

2.13 Electrical infrastructure

Overview

The building is fed from a pole-mounted transformer south of the building. The existing system is 200A at 240V service running at a maximum load of 17.594 kW, which is approximately 46% of the full load of 38.4 kW of the building. The main incoming panel, Panel A, has 17 available breaker spaces. Panel F also contains plenty of physical breaker spaces. Panel A can provide the physical space for the measures below, unless otherwise specified.

The peak hourly electrical consumption of the building since 2019 is 17.594 kWh.

Panel summary

Eight panels at this site were observed and are summarized below:

- Panel A, 200A, 120/240V, single ph, 3 W. Serves the photo copier, emergency light, heaters, laundry machine, ductless split for the apartment, generator panel, refrigerator, receptacles, fire alarm panel, and compressor.
- Panel B, 100A, 120/240V, single ph, 3 W. Serves community hall condensing unit, receptacles, Panel D, vacuum cleaner, and furnace.
- Panel C- Generator, 60A, 120/240V, single ph, 3 W. Serves bay door no. 4, exhaust fans, receptacles, lights, pressure washer, shop heat, and shop furnace.
- Panel C, 60A, 120/240V, single ph, 3 W. Serves the hot water tank, exhaust fan, welder, compressor, and lights.
- Generator Panel, 60A, 120/240V, single ph, 3 W. Contains multiple supplies (generator and grid).
- Panel D, 40A, 120/240V, single ph, 3 W. Serves unit heater, lights, receptacles, diesel pumps, gasoline pump, cold storage, welder, and heater.
- Panel E. Serves lights, exhaust fan, refrigerators, stove, receptacles, and flood lights.
- Panel F. Serves receptacles in the community hall.

Electrical infrastructure documentation

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



Figure 99: Generator Panel and Panel B



Figure 100: Incoming lines

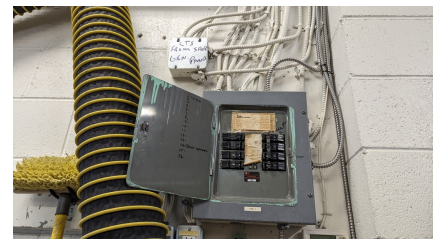


Figure 101: Panel D

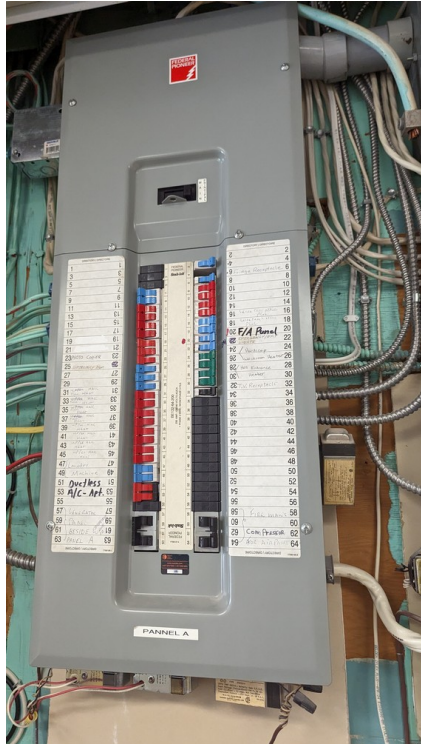


Figure 102: Panel A



Figure 103: Panel C

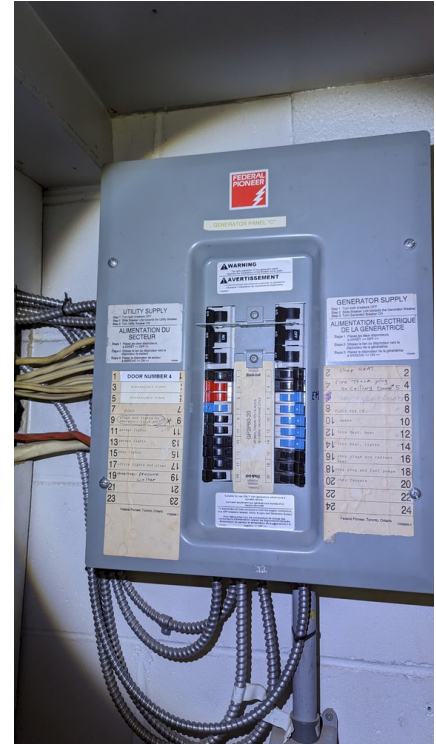


Figure 104: Panel C - Generator



Figure 105: Panel E



Figure 106: Panel F

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 Dymond Complex.
 - 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 11 summarizes the data source of the baseline performance for each utility.

Table 11: 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 Dymond Complex 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 Dymond Complex.
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 12.

Table 12: 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 13. 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 13: 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 107.

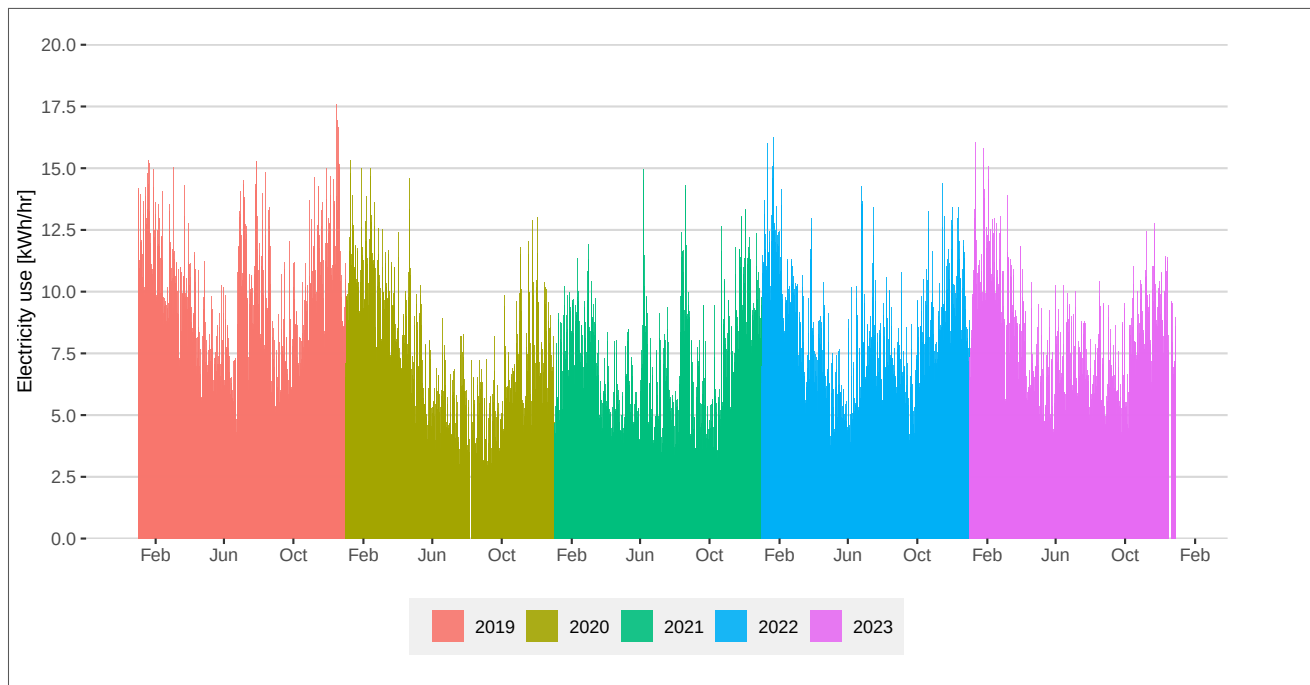


Figure 107: Hourly electricity use

The same hourly electricity use data is plotted in Figure 108, which highlights how electricity use is influenced by year, season, day of week and hour of day. The vertical axis on Figure 108 may be rescaled relative to in Figure 107 for greater resolution.

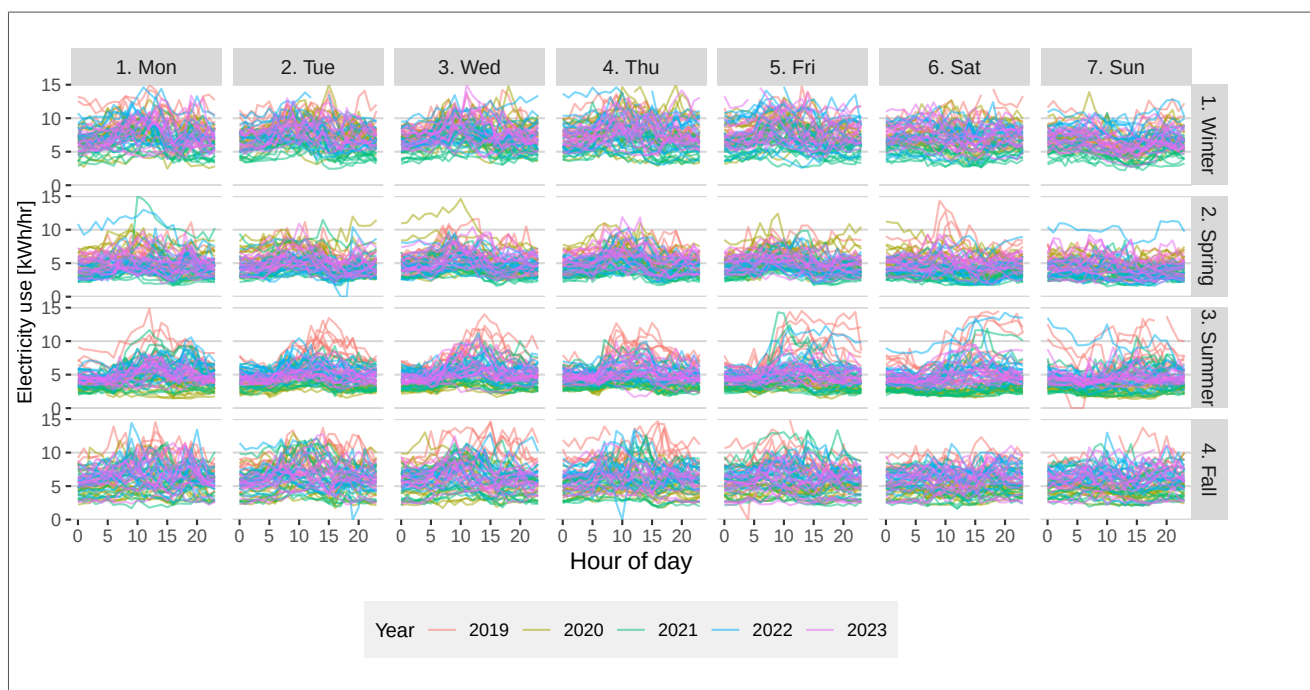


Figure 108: Hourly electricity use hairball plot

Monthly electricity use is plotted in Figure 109.

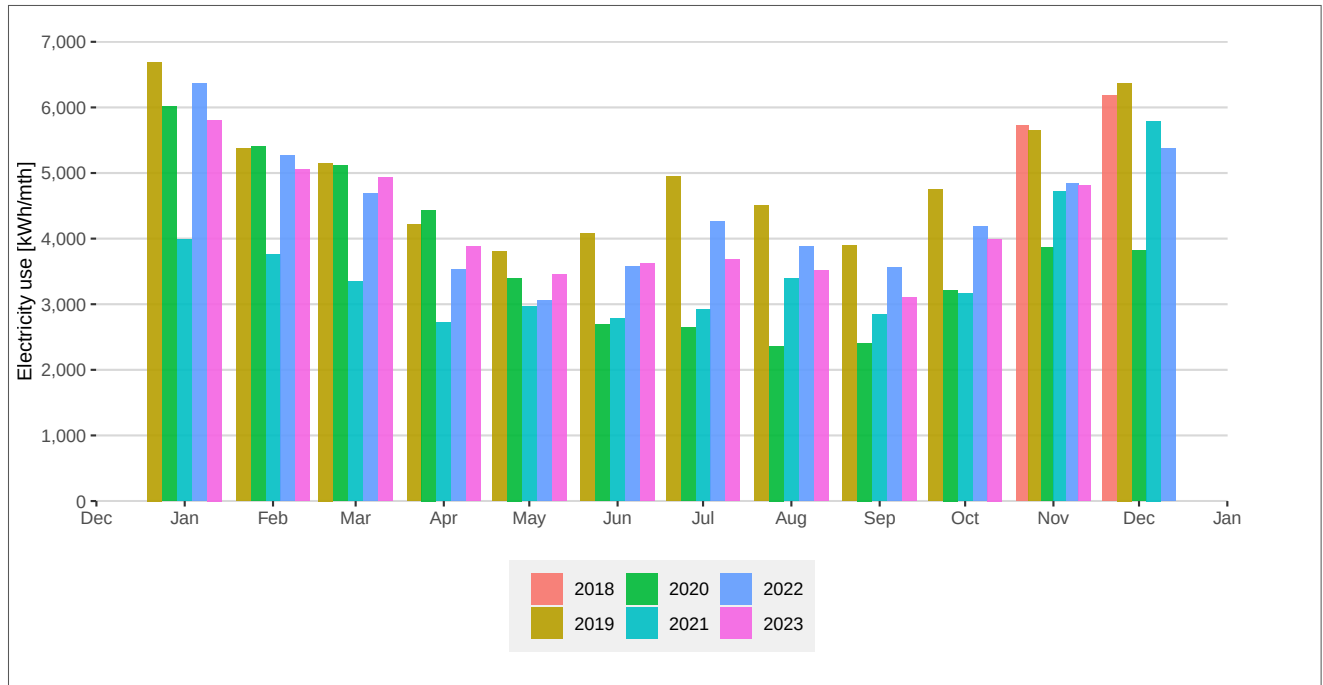


Figure 109: Monthly electricity use

3.4 Natural gas metered utility use

Monthly natural gas use is plotted in Figure 110.

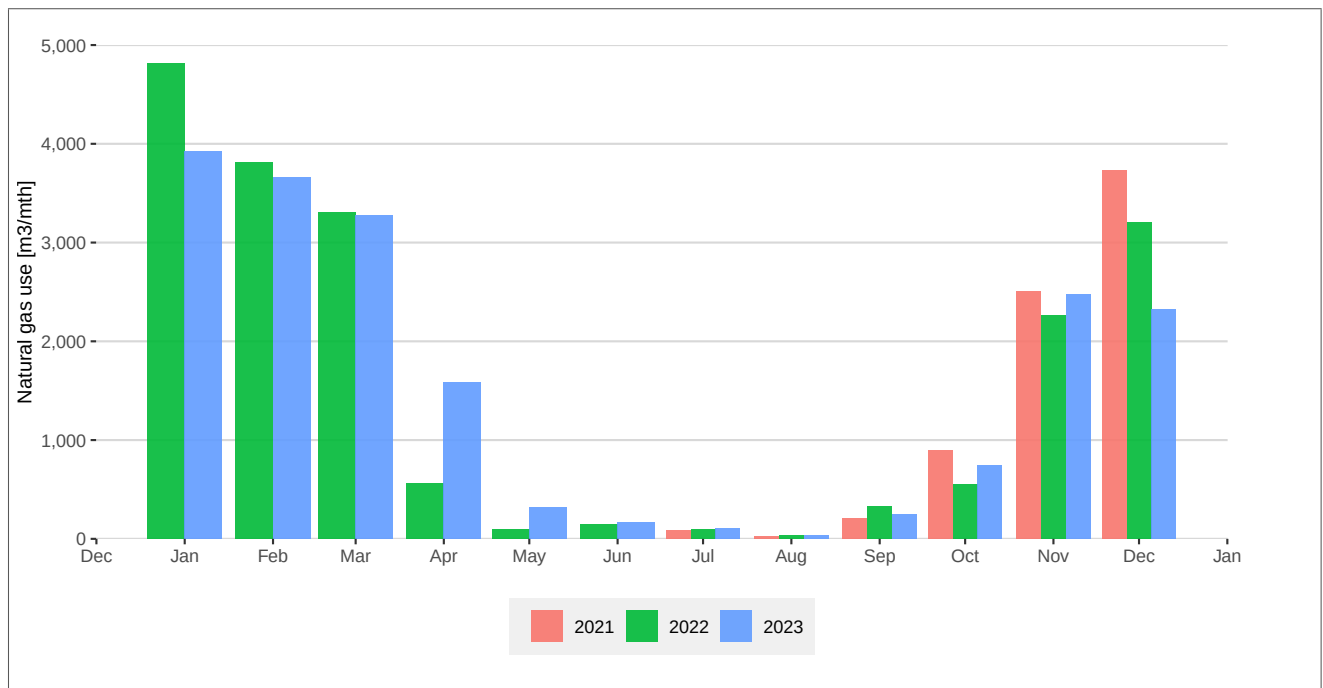


Figure 110: Monthly natural gas use

3.5 Utility use baseline

Baseline year

The baseline year for Dymond Complex, 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 14.

Table 14: Baseline utility use performance

Category	Utility	Unit	Value
Utility use	Electricity use	[kWh/yr]	52,573
	Natural gas use	[m3/yr]	19,536
	Carbon offset use	[tCO2e/yr]	0
Equivalent energy use	Electricity energy	[kWh/yr]	52,573
	Natural gas energy	[kWh/yr]	206,237
	Total energy	[kWh/yr]	258,809
GHG emissions	Electricity GHGs	[tCO2e/yr]	2
	Natural gas GHGs	[tCO2e/yr]	38
	Carbon offsets GHGs	[tCO2e/yr]	0
	Total GHGs	[tCO2e/yr]	39
Utility cost	Electricity utility cost	[\$/yr]	5,215
	Natural gas utility cost	[\$/yr]	5,079
	Carbon offsets utility cost	[\$/yr]	0
	Federal carbon charge	[\$/yr]	1,888
	Total utility cost	[\$/yr]	12,182

3.6 Benchmarking analysis

Benchmarking analysis results are presented in the following figures.

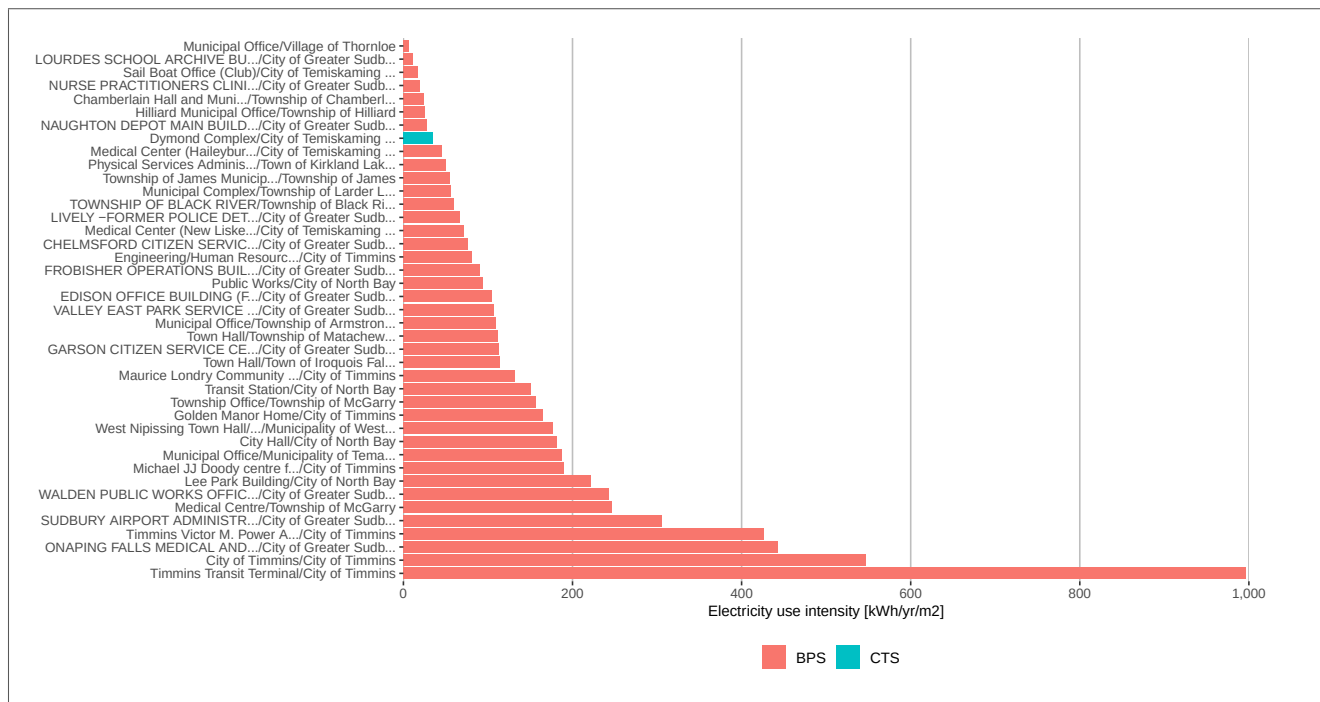


Figure 111: Electricity use intensity benchmarking analysis comparison

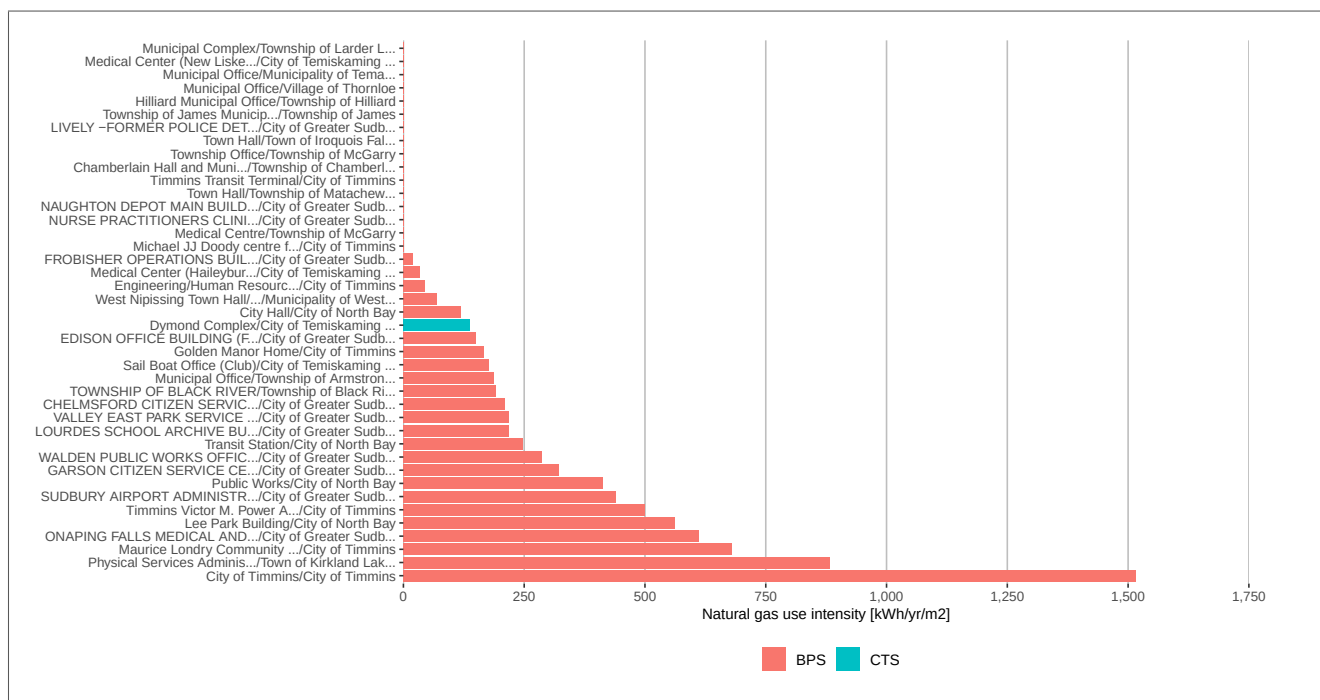


Figure 112: Natural gas use intensity benchmarking analysis comparison

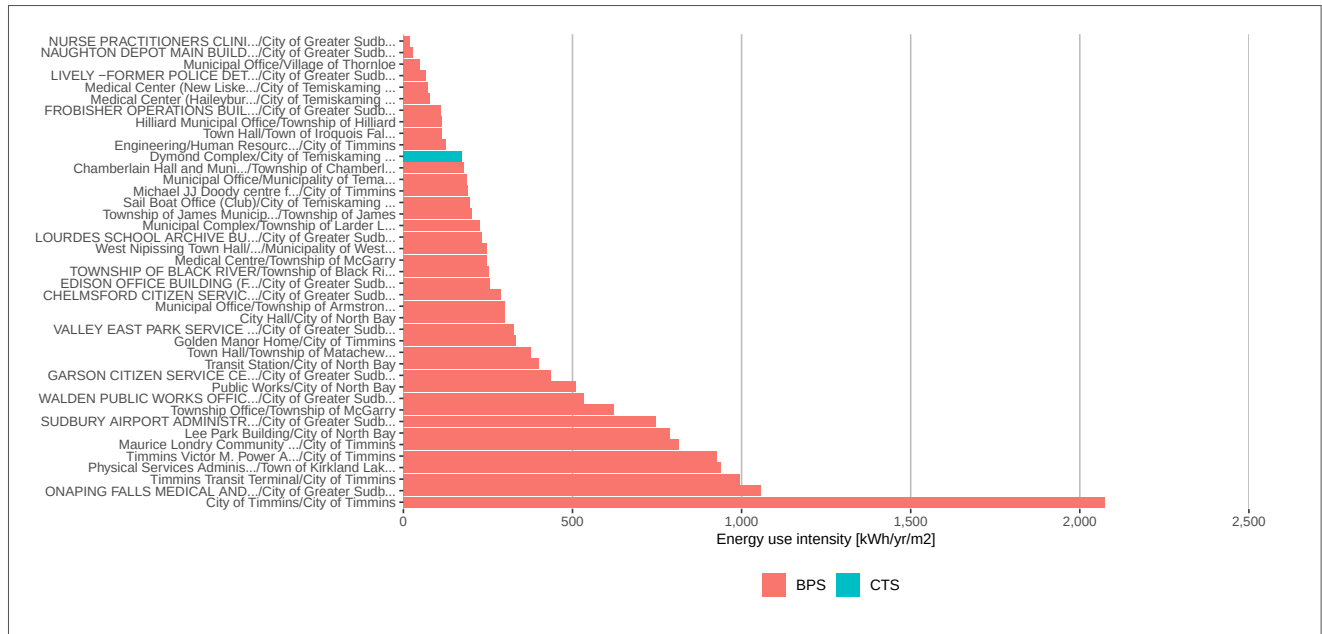


Figure 113: Total energy use intensity benchmarking analysis comparison

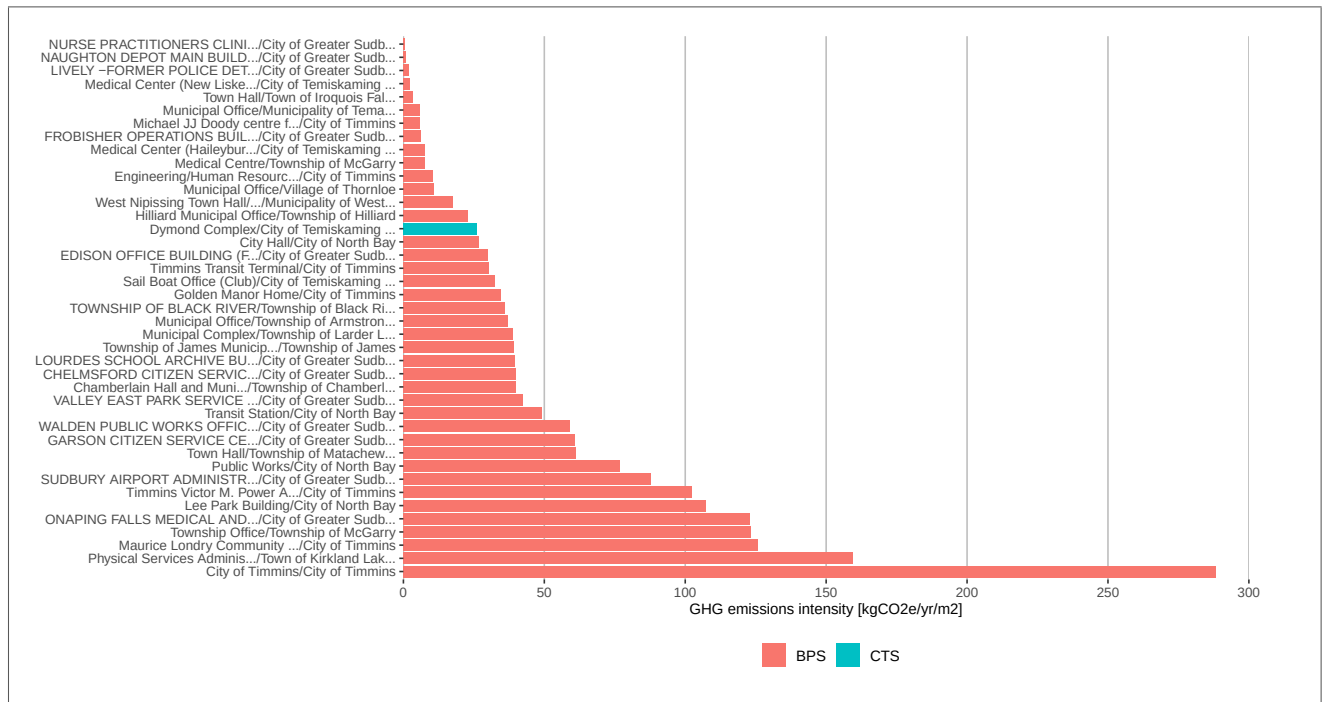
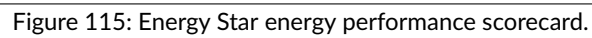


Figure 114: GHG emissions intensity benchmarking analysis comparison

The scorecard is shown in Figure 115.



3.8 Utility use analysis discussion

General

The following discussion seeks to explain utility use trends observed in the metered data, based on the understanding of the building systems and their operations presented in Section 2.

Electricity - Hourly

- Hourly electricity consumption typically peaks during the winter and summer, most likely due to heating and cooling.
- Hourly consumption is typically under 15 kWh and above 3 kWh.
- A "W-shape" profile suggests heating in the winter and cooling in the summer.

Electricity - Monthly

- **2018:** The dataset provided started in November 2018 and did not allow for a full year of comparison.
- **2019:** Peak consumption occurred in winter and summer due to space heating and cooling, respectively, with summer consumption higher than in future years.
- **2020:** Similar consumption to 2019 until June, at which point electricity consumption is lower for the remainder of 2020, likely due to reduced operations during the COVID-19 pandemic.
- **2021:** Reduced consumption until August, likely due to reduced operations during the COVID-19 pandemic.
- **2022:** Similar consumption profile to 2019.
- **2023:** Similar consumption to 2019 and 2022.

Natural gas

- Natural gas consumption has maintained a relatively consistent profile year over year. It is highest during the heating season and very low during the cooling season. However, consumption in April and May 2022 appears to be lower than what would be expected in the season.
- This building has three end uses: space heating, cooking equipment, and domestic hot water heating.

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 15.

Table 15: 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	DHW heat	Domestic hot water heating energy use.
	Equipment	Equipment energy use.
	Space heat	Space heating energy use.

- (b) *Weather data.* Hourly weather data was obtained from the Earlton-Cimate weather station, ID 712130S.

- (c) *Facility spaces.* Facility spaces were grouped according to activities in the spaces and HVAC systems serving them. The thermal characteristics of the exterior building envelope components for each space were assumed based on findings documented in Section 2.7. Thermal loads within each space were calculated based on assumed space temperature and humidity setpoints, hourly weather data, and activities in the space that affect thermal conditions (e.g. lighting or equipment that generates heat).

- (d) *Primary systems.* Primary systems are defined as systems whose utility use can be predicted independent from other systems; examples include lighting, equipment (e.g. office and process equipment), pumps, etc. The hourly utility demand of primary systems was modelled based on assumed time-of-day operating schedules, peak power input and average loads relative to the peak power input. Peak power input was estimated from findings documented throughout Section 2, including lighting power or power density, nameplate horsepower of motors, etc.

- (e) *HVAC systems.* HVAC system energy use was modelled based on hourly weather data and space condition setpoints defined for the various spaces. The analysis also accounted for system-specific ventilation controls and activities and primary systems that have thermal influences on spaces (e.g. occupancy, lighting, equipment, processes that add heat to spaces). The analysis quantified

hourly energy use of fans, heating (e.g. sensible, humidification, reheat) and cooling (e.g. sensible, dehumidification).

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

4.2 Hourly utility use profiles

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

Electricity

The hourly electricity utility use profile by end use made by the energy model is plotted in Figure 116. See Table 15 for end use definitions.

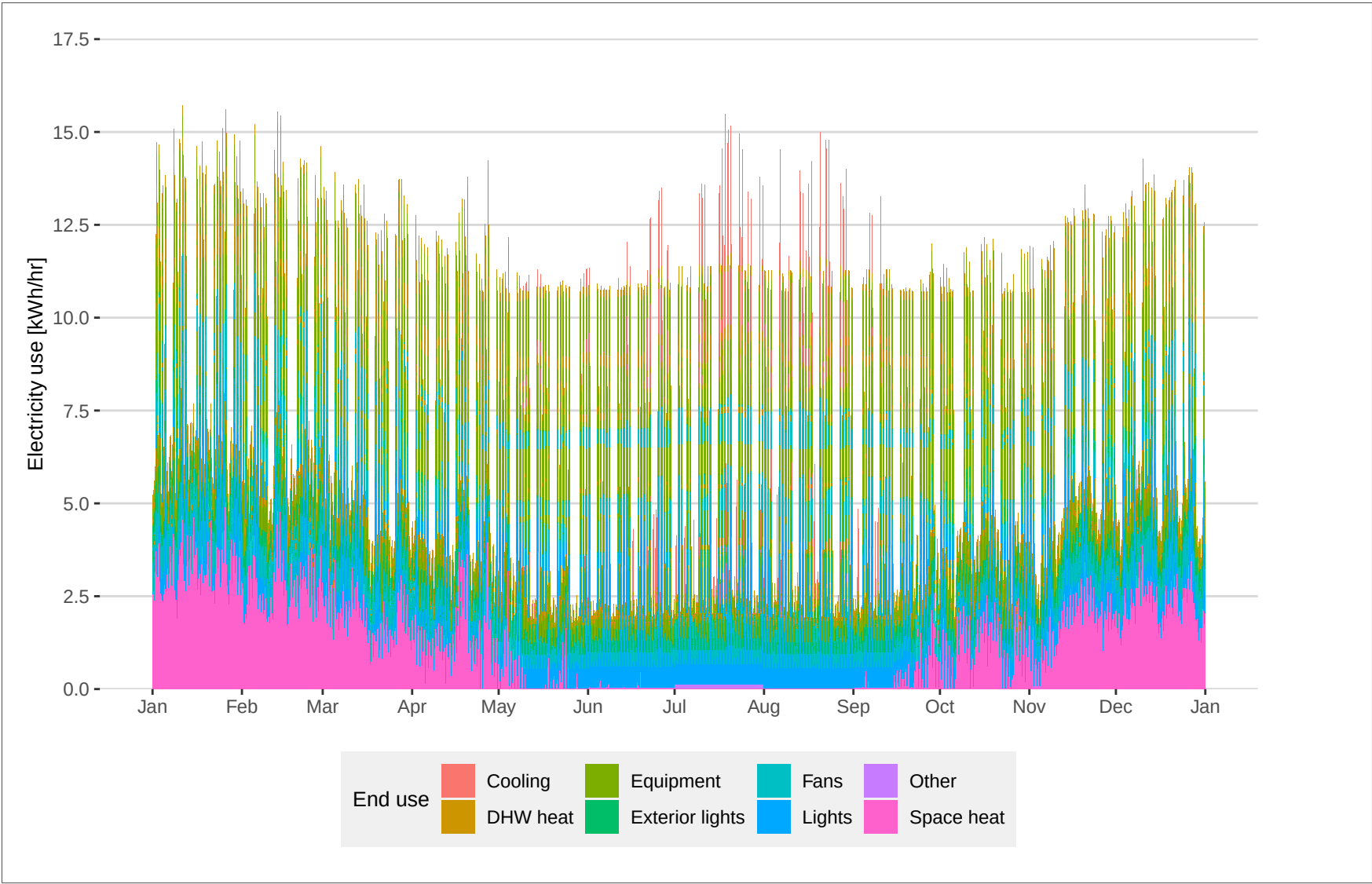


Figure 116: Hourly electricity utility use by end use (made by calibrated energy model)

Natural gas

The hourly natural gas utility use profile by end use made by the energy model is plotted in Figure 117. See Table 15 for end use definitions.

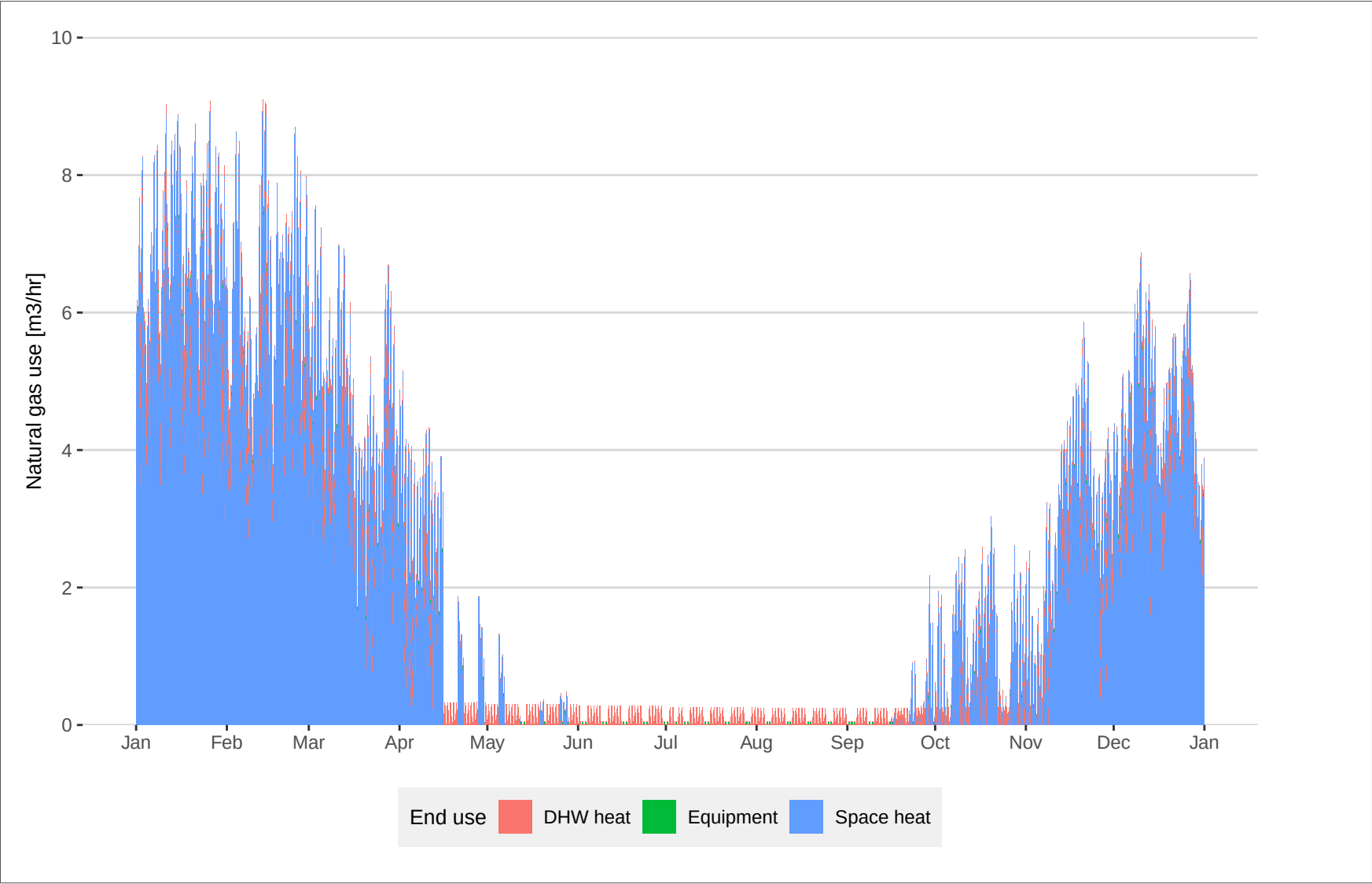


Figure 117: Hourly natural gas utility use by end use (made by calibrated energy model)

4.3 Monthly utility use profiles

Monthly utility use profiles for each modelled utility are presented in Figure 118.

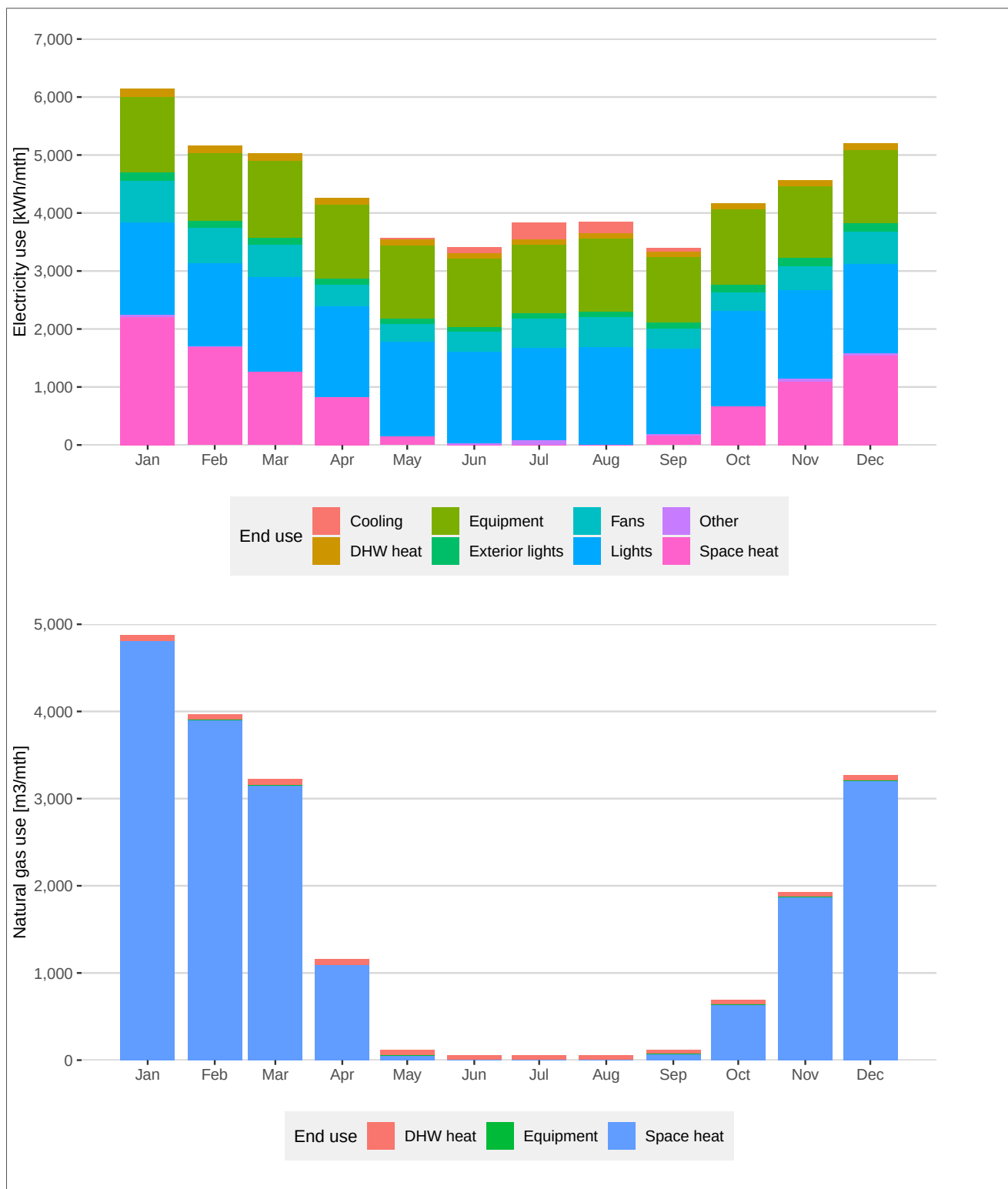


Figure 118: Monthly utility use profiles for each modelled utility

4.4 Calibration analysis

Electricity

Figure 119 compares the metered utility use with the modelled use to check how well the model is calibrated.



Figure 119: Electricity calibration analysis (metered vs modelled utility use)

Natural gas

Figure 120 compares the metered utility use with the modelled use to check how well the model is calibrated.

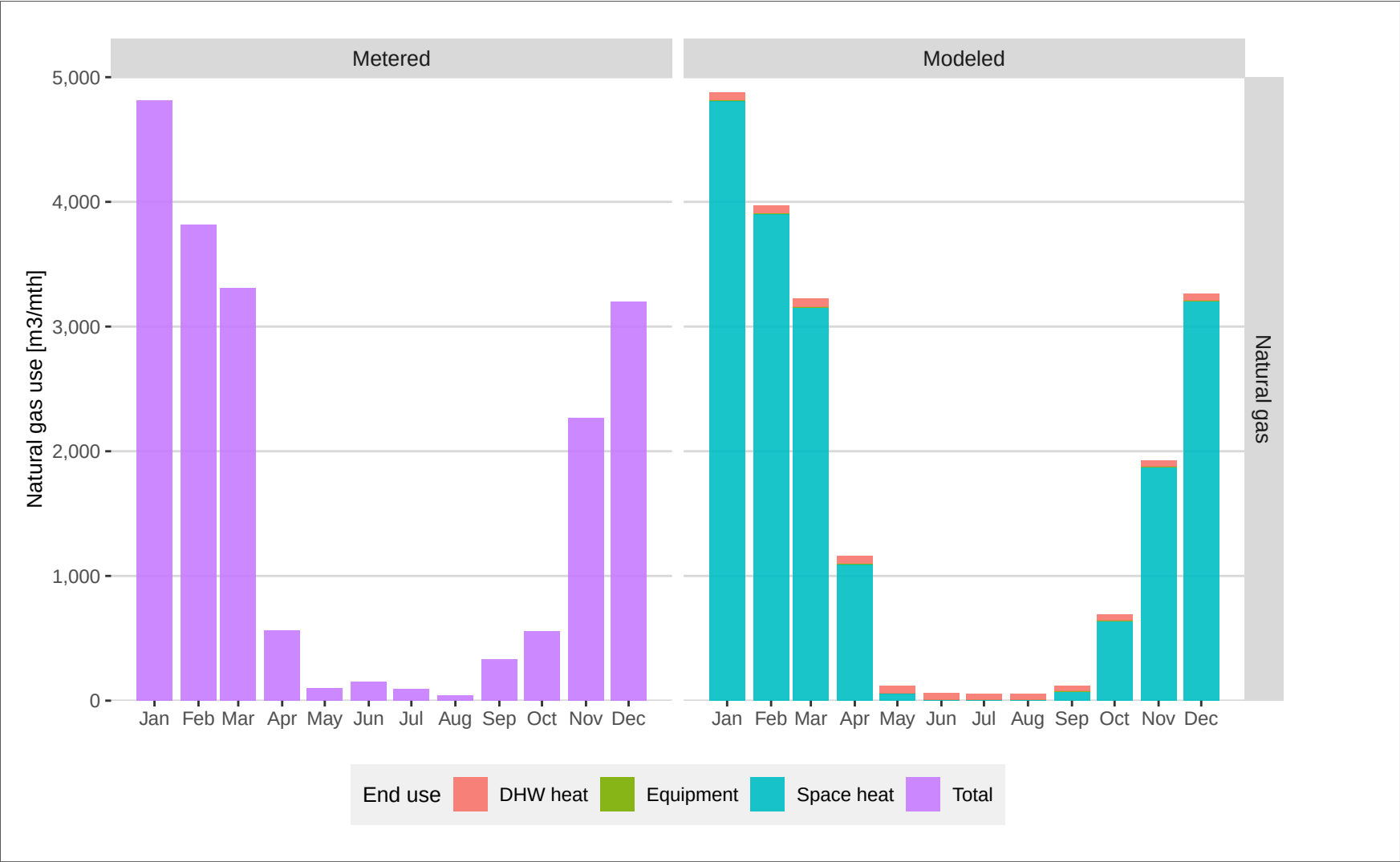


Figure 120: Natural gas calibration analysis (metered vs modelled utility use)

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 16.

Table 16: 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	7.9	Pass
Natural gas	Mean bias error	[%]	< +/- 5	-1.7	Pass
	Root mean square error	[%]	< 15	14.3	Pass

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

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

- Figures 119 and 120 both demonstrate a strong agreement between monthly trends observed in the metered utility use data and the monthly utility use predicted by the calibrated energy model.
- Electricity use was successfully calibrated according to the standards of ASHRAE Guideline 14. Note that the mean bias error is zero for electricity because the Other end-use ensures that the yearly modelled utility use matches the yearly metered utility use. This process also maintains consistency between the baseline utility use derived from the metered utility data and all measure and scenario analyses.
- Natural gas consumption was successfully calibrated to ASHRAE Guideline 14. It should be noted that only 4 of 12 natural gas readings are actual readings. This issue makes it difficult to calibrate the model, especially against estimated data that the LDC typically underestimates.
- The successful energy model calibration is largely due to the methodology used in developing the calibrated energy model. Under this methodology, the major systems affecting utility use were studied in detail (see Section 2), so that these systems could be explicitly modelled one-to-one, precisely reflecting the unique operations associated with each system. Examples of such major systems include all HVAC systems (F1 and F2) and heaters (UH1, UH2, and IH1).
- 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 119 indicates strong agreement between modelled and metered data.
- The peak and trough hourly consumption align with the metered interval data.

Natural gas

- Figure 120 indicates good agreement between modelled and metered data.
- The annual amount of natural gas consumption in the model is very close to the annual amount of the metered data. However, there are variances within several months. That being said, there are several estimated readings for this particular dataset.
- The largest discrepancies between the metered and modelled data occur in April and October. Based on the actual consumption in these months, it is thought that some of the bay heaters might have been turned off for the summer starting in April and lasting until the end of October, which would be consistent with the metered consumption.

4.5 End use analysis

Electricity

The yearly electricity end use breakdown calculated by the energy model is plotted in Figure 121. See Table 15 for end use definitions.

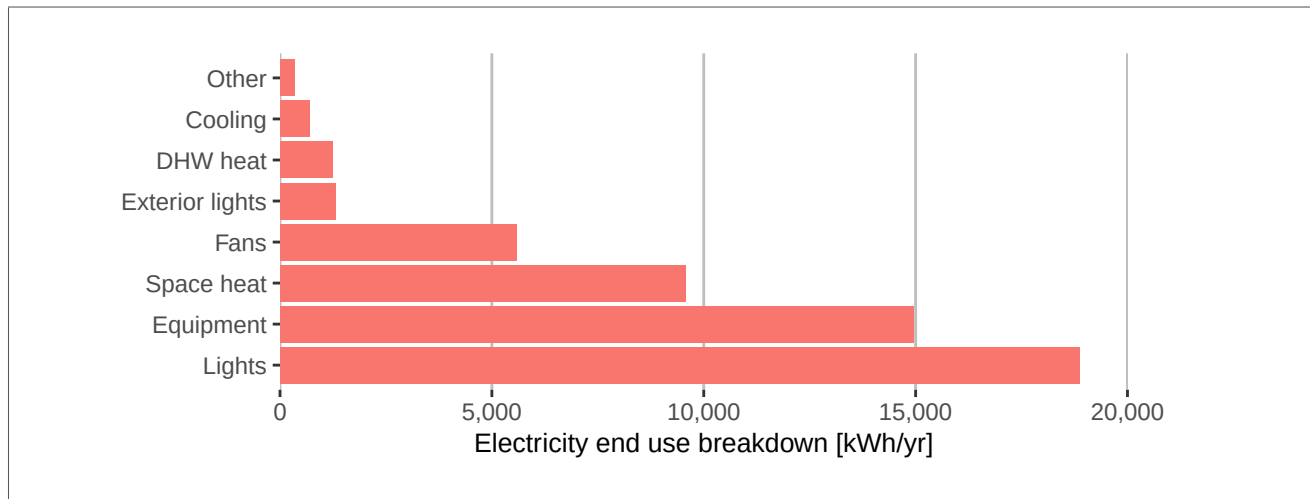


Figure 121: Electricity end use breakdown (calculated by calibrated energy model)

Natural gas

The yearly natural gas end use breakdown calculated by the energy model is plotted in Figure 122. See Table 15 for end use definitions.

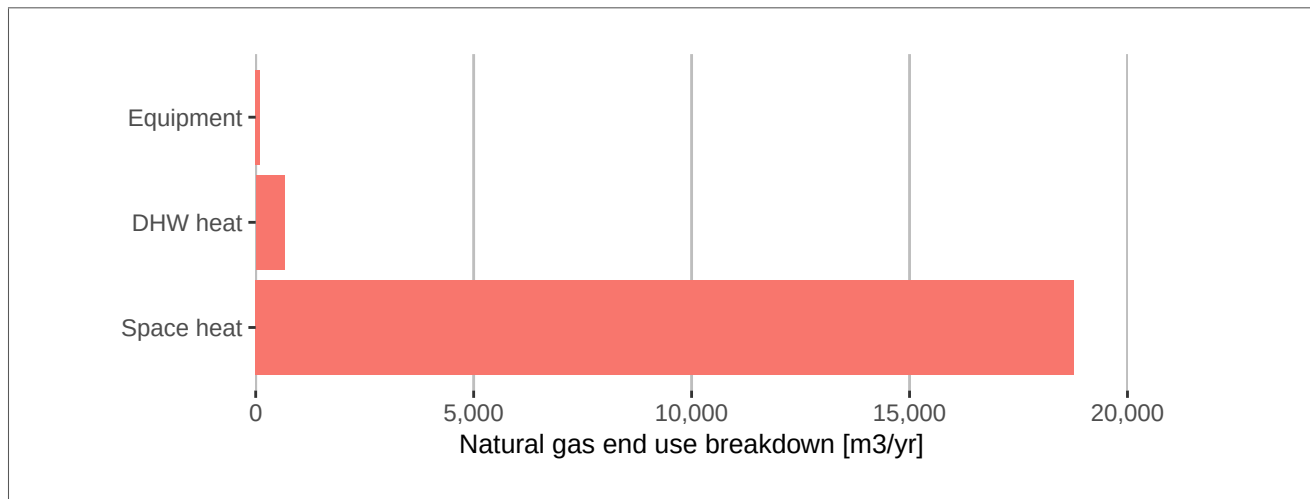


Figure 122: Natural gas end use breakdown (calculated by calibrated energy model)

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 5.17). 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 13 and 19 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 19, 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 19. 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 19. 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 17 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 20 was tested under each risk case also defined in Table 20 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 5.18.

4. **Measure analysis summary.** Measure analysis results for all measures were summarized in table format in Section 5.19.

5.2 Measure analysis assumptions

Assumptions general to all measures are as follows.

- GHG emissions factor assumptions are summarized in Table 12, in Section 3.2.
- Utility cost rate assumptions applied to quantify yearly utility cost impacts relative to the baseline are summarized in Table 13, in Section 3.2. Utility cost rate future assumptions applied in the life cycle analysis for each measure are summarized in Table 17. 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 17: 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 18.

Table 18: 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 19.

Table 19: 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 20.

Table 20: 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 21.

Table 21: Measure identification and triaging summary

Measure name	Triage for analysis
Baseline	
Carbon offsets 20	Analyzed.
DHW1 to ASHP	Analyzed.
Exterior LED lighting upgrade	Analyzed.
F01 and F02 conversion to ASHP with electric backup	Analyzed.
F01 and F02 conversion to ASHP with natural gas backup	Analyzed.
Interior LED lighting upgrade	Analyzed.
Low-flow handwashing faucet aerators	Analyzed.
Natural gas stove conversion to electric	Analyzed.
Radiant heaters to electric	Analyzed.
Roof upgrade to high performance	Analyzed.
Solar PV rooftop	Analyzed.
Unit heaters conversion	Analyzed.
Wall upgrade to high performance	Analyzed.
Windows and doors to high performance	Analyzed.
DHW1 renewal	Business as usual.
Exterior lighting renewal	Business as usual.
Exterior walls renewal	Business as usual.
F01 and F02 renewal	Business as usual.
Interior lighting renewal	Business as usual.
Natural gas stove renewal	Business as usual.
Roof renewal	Business as usual.
Sinks renewal	Business as usual.
Unit heaters renewal	Business as usual.
Windows and doors renewal	Business as usual.
DHW2 to ASHP	Not analyzed: already electric.
Solar PV canopy	Not analyzed: interference issues with snow plow and fire trucks.

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 percent 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 22: Carbon offsets 20 analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	52,573	0	0
	Natural gas use	[m3/yr]	19,536	19,536	0	0
	Carbon offset use	[tCO ₂ e/yr]	0	7.9	-7.9	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	52,573	0	0
	Natural gas energy	[kWh/yr]	206,237	206,237	0	0
	Total energy	[kWh/yr]	258,809	258,809	0	0
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	1.6	1.6	0	0
	Natural gas GHGs	[tCO ₂ e/yr]	37.8	37.8	0	0
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	-7.9	7.9	—
	Total GHGs	[tCO ₂ e/yr]	39.3	31.5	7.9	20.0
Utility cost	Electricity utility cost	[\$/yr]	5,215	5,215	0	0
	Natural gas utility cost	[\$/yr]	5,079	5,079	-0.00	-0.00
	Carbon offsets utility cost	[\$/yr]	0	236	-236	—
	Federal carbon charge	[\$/yr]	1,888	1,888	0	0
	Total utility cost	[\$/yr]	12,182	12,418	-236	-1.9
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	—	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	—	—	—
	Life cycle cost	[\$]	290,048	294,352	—	—
	Net present value	[\$]	0	-4,304	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	—	—	—
	Simple payback period	[yr]	—	—	—	—

5.5 DHW1 to ASHP

Measure description

Existing condition

Two DHW heaters are serving this building. DHW1 serves the office and the community hall and is a natural gas-fired unit.



Opportunity

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

Utility-savings mechanism

This measure will convert the heat fuel from natural gas to electricity. This will result in an overall energy reduction due to the higher efficiency of the heat pump compared to that of the natural gas DHW tanks and a reduction in GHG intensity.

Design description

Design concept

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

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

- Rheem Proterra 50 USG - Replaces the 50USG Rheem Guardian Fury
- The existing 3kW electric heater will remain

Electrical

The ASHP will add approximately 4 kW of power to the existing system, which will put the system at 21.594 kW, which is approximately 56 percent of the full load of the electrical capacity of the building.

Project cost estimate

Table 23: Project cost estimate (DHW1 to ASHP)

Category	Line item	Unit	Value
Materials and labour	Supply	[\$]	4,000
	Installation	[\$]	4,000
	Electrical work	[\$]	12,000
Contingency	Subtotal after Materials and labour	[\$]	20,000
	General Contingency (50%)	[\$]	10,000
Total	Total	[\$]	30,000

Utility analysis

Utility analysis methodology

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

- **Baseline.** DHW1 is gas-fired and operates at an efficiency of 85%.
- **Proposed.** DHW1 is replaced by an ASHP at a COP of 3.5.

Utility analysis results

Table 24: DHW1 to ASHP analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	55,027	-2,455	-4.7
	Natural gas use	[m3/yr]	19,536	18,874	663	3.4
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	55,027	-2,455	-4.7
	Natural gas energy	[kWh/yr]	206,237	199,243	6,994	3.4
	Total energy	[kWh/yr]	258,809	254,270	4,539	1.8
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.6	1.7	-0.07	-4.7
	Natural gas GHGs	[tCO2e/yr]	37.8	36.5	1.3	3.4
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	39.3	38.1	1.2	3.1
Utility cost	Electricity utility cost	[\$/yr]	5,215	5,459	-243	-4.7
	Natural gas utility cost	[\$/yr]	5,079	4,907	172	3.4
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,824	64.0	3.4
	Total utility cost	[\$/yr]	12,182	12,189	-7.2	-0.06
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	30,000	—	—
	Incentive amount	[\$]	0	166	—	—
	Incremental project cost	[\$]	0	29,834	—	—
	Life cycle cost	[\$]	290,048	328,509	—	—
	Net present value	[\$]	0	-38,461	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	24,737	—	—
	Simple payback period	[yr]	—	—	—	—

5.6 Exterior LED lighting upgrade

Measure description

Existing condition

The building exterior lighting utilizes LED and CFL lighting.



Opportunity

Replace all non-LED fixtures with LED equivalent fixtures.

Utility-savings mechanism

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

Design description

Overview

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

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

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

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

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

Project cost estimate

Table 25: Project cost estimate (Exterior LED lighting upgrade)

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

Utility analysis

Utility analysis methodology

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

- **Baseline:** Exterior lighting is assumed to consume 0.3 kW. There is one fixture (type N) to be replaced, which is assumed to consume 30 W.
- **Proposed:** It is assumed that the type N fixture is replaced with an LED equivalent which consumes 15 W, resulting in exterior lighting consuming 0.285 kW.

Utility analysis results

Table 26: Exterior LED lighting upgrade analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	52,507	65.4	0.12
	Natural gas use	[m3/yr]	19,536	19,536	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	52,507	65.4	0.12
	Natural gas energy	[kWh/yr]	206,237	206,237	0	0
	Total energy	[kWh/yr]	258,809	258,744	65.4	0.03
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.6	1.6	0.00	0.12
	Natural gas GHGs	[tCO2e/yr]	37.8	37.8	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	39.3	39.3	0.00	0.01
Utility cost	Electricity utility cost	[\$/yr]	5,215	5,209	6.5	0.12
	Natural gas utility cost	[\$/yr]	5,079	5,079	0	0
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,888	0	0
	Total utility cost	[\$/yr]	12,182	12,176	6.5	0.05
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	1,500	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	1,500	—	—
	Life cycle cost	[\$]	290,048	291,437	—	—
	Net present value	[\$]	0	-1,389	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	759,109	—	—
	Simple payback period	[yr]	—	>20	—	—

5.7 F01 and F02 conversion to ASHP with electric backup

Measure description

Existing condition

Two gas-fired furnaces with DX cooling serve the community hall (F01), apartment (F02), and the fire station office (F02).



Opportunity

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

Utility-savings mechanism

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

Design description

Overview

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

- Moovair - Central-Moov 3T Capacity with 10kW backup electric
- Moovair - Central-Moov 5T Capacity with 20kW backup electric

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

Electrical

The ASHP with the electric backup will add approximately 42 kW of power to the existing system, which will put the system at 60 kW, which is approximately 155 percent of the full load of the electrical capacity of the building. A system upgrade would be required to at least a 75 kVA transformer, with a 400A 208V-3P panel. The existing 200A 240A panel can be powered from the new 400A panel.

Project cost estimate

Table 27: Project cost estimate (F01 and F02 conversion to ASHP with electric backup)

Category	Line item	Unit	Value
Construction	Supply	[\$]	24,000
	Install	[\$]	16,000
	Electrical contingency	[\$]	181,000
	General requirements (25%)	[\$]	55,200
Contingency	Subtotal after Construction	[\$]	276,200
	Design Contingency (25%)	[\$]	69,000
	Construction Contingency (10%)	[\$]	27,600
Design, Contractors, PM	Subtotal after Contingency	[\$]	372,800
	Engineering Design and Field Review (10%)	[\$]	37,300
	Contractor Fee (7%)	[\$]	26,100
Total	Total	[\$]	436,200

Utility analysis

Utility analysis methodology

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

- **Baseline:** These furnaces provide space heating and cooling through natural gas-fired burners and DX, respectively. The existing heating efficiencies are 93% (for F1) and 97% (for F2), and the cooling COPs are 4.
- **Proposed:** These furnaces provide space heating and cooling through air-source heat pumps. The proposed average heating and cooling COPs are 3 and 4.1 (14 EER), respectively. Backup heating is provided through electric resistance when the outdoor air temperature is below -15 C.

Utility analysis results

Table 28: F01 and F02 conversion to ASHP with electric backup analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	99,144	-46,571	-88.6
	Natural gas use	[m3/yr]	19,536	12,595	6,941	35.5
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	99,144	-46,571	-88.6
	Natural gas energy	[kWh/yr]	206,237	132,960	73,276	35.5
	Total energy	[kWh/yr]	258,809	232,104	26,705	10.3
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.6	3.0	-1.4	-88.6
	Natural gas GHGs	[tCO2e/yr]	37.8	24.3	13.4	35.5
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	39.3	27.3	12.0	30.5
Utility cost	Electricity utility cost	[\$/yr]	5,215	9,835	-4,620	-88.6
	Natural gas utility cost	[\$/yr]	5,079	3,275	1,805	35.5
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,217	671	35.5
	Total utility cost	[\$/yr]	12,182	14,327	-2,145	-17.6
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	436,200	—	—
	Incentive amount	[\$]	0	87,240	—	—
	Incremental project cost	[\$]	0	348,960	—	—
	Life cycle cost	[\$]	290,048	808,229	—	—
	Net present value	[\$]	0	-518,181	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	29,064	—	—
	Simple payback period	[yr]	—	—	—	—

5.8 F01 and F02 conversion to ASHP with natural gas backup

Measure description

Existing condition

Two gas-fired furnaces with DX cooling serve the community hall (F01), apartment (F02), and the fire station office (F02).



Opportunity

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

Utility-savings mechanism

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

Design description

Overview

This measure adds a heat pump section to each of the gas-fired furnaces located in the building with an air-source heat pump (ASHP) option. The available heating output from an air source heat pump decreases as the outdoor air temperature decreases. The following units shall be provided:

- Moovair indoor unit model CUB60 and outdoor unit model DMA60 added to the the 120kBTU Payne furnace
- Moovair indoor unit model CUB36 and outdoor unit model DMA36 added to the the 66kBTU Lennox furnace

Electrical

The ASHP with the electric backup will add approximately 24 kW of power to the existing system, which will put the system at 42 kW, which is approximately 108 percent of the full load of the electrical capacity of the building. A system upgrade would be required to at least a 75 kVA transformer, with a 400A 208V-3P panel. The existing 200A 240A panel can be powered from the new 400A panel.

Project cost estimate

Table 29: Project cost estimate (F01 and F02 conversion to ASHP with natural gas backup)

Category	Line item	Unit	Value
Construction	Equipment	[\$]	16,000
	Installation	[\$]	12,000
	Electrical contingency	[\$]	166,000
	General requirements (25%)	[\$]	48,500
Contingency	Subtotal after Construction	[\$]	242,500
	Design Contingency (25%)	[\$]	60,600
	Construction Contingency (10%)	[\$]	24,200
Design, Contractors, PM	Subtotal after Contingency	[\$]	327,300
	Engineering Design and Field Review (10%)	[\$]	32,700
	Contractor Fee (7%)	[\$]	22,900
Total	Total	[\$]	382,900

Utility analysis

Utility analysis methodology

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

- **Baseline:** These furnaces provide space heating and cooling through natural gas-fired burners and DX, respectively. The existing heating efficiencies are 93% (for F1) and 97% (for F2), and the cooling COPs are 4.
- **Proposed:** These furnaces provide space heating and cooling through air-source heat pumps. The proposed average heating and cooling COPs are 3 and 4.1 (14 EER), respectively. Backup heating is provided from the existing gas-fired furnaces when the outdoor air temperature is below -15 C.

Utility analysis results

Table 30: F01 and F02 conversion to ASHP with natural gas backup analysis results summary

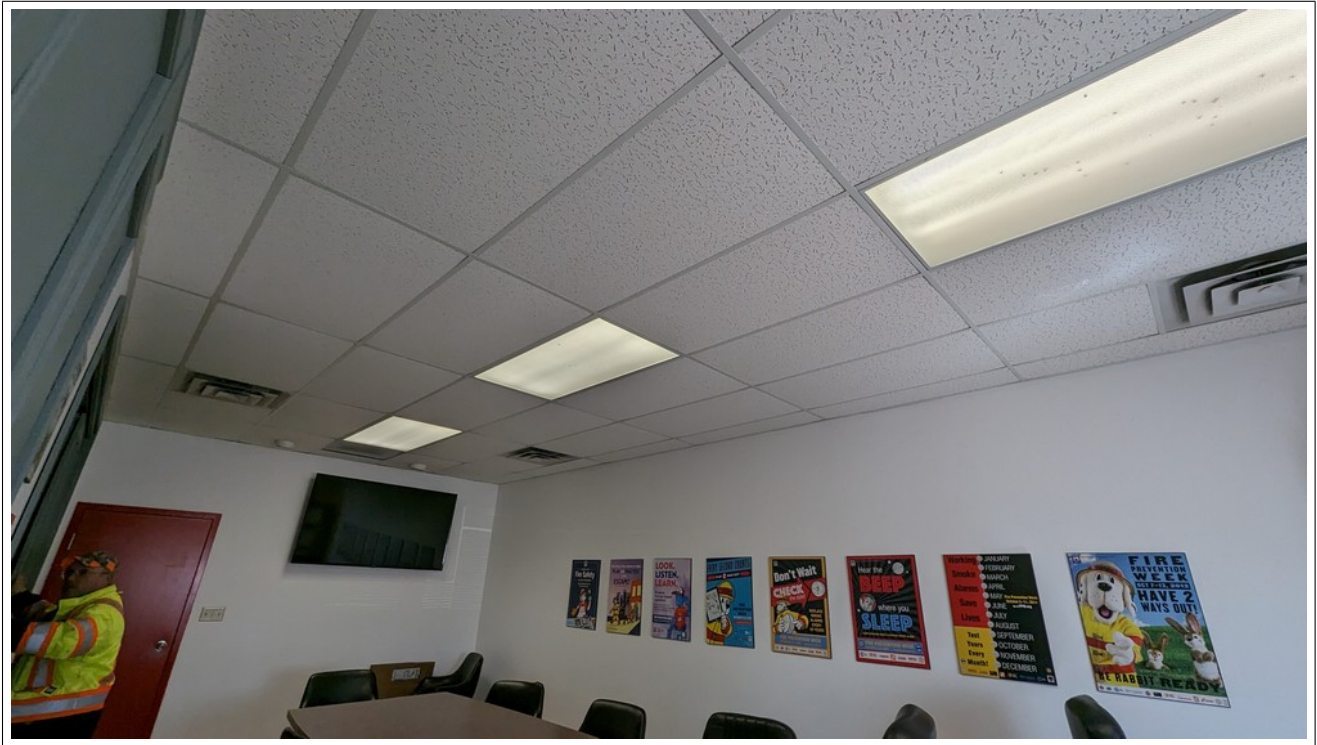
Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	73,959	-21,386	-40.7
	Natural gas use	[m3/yr]	19,536	15,275	4,261	21.8
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	73,959	-21,386	-40.7
	Natural gas energy	[kWh/yr]	206,237	161,256	44,981	21.8
	Total energy	[kWh/yr]	258,809	235,215	23,595	9.1
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.6	2.2	-0.65	-40.7
	Natural gas GHGs	[tCO2e/yr]	37.8	29.5	8.2	21.8
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	39.3	31.8	7.6	19.3
Utility cost	Electricity utility cost	[\$/yr]	5,215	7,337	-2,122	-40.7
	Natural gas utility cost	[\$/yr]	5,079	3,972	1,108	21.8
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,476	412	21.8
	Total utility cost	[\$/yr]	12,182	12,784	-602	-4.9
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	382,900	—	—
	Incentive amount	[\$]	0	76,580	—	—
	Incremental project cost	[\$]	0	306,320	—	—
	Life cycle cost	[\$]	290,048	702,990	—	—
	Net present value	[\$]	0	-412,942	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	40,371	—	—
	Simple payback period	[yr]	—	—	—	—

5.9 Interior LED lighting upgrade

Measure description

Existing condition

Some areas of the building currently operate with LED fixtures (e.g. some office space, the kitchen, and washrooms). The remaining areas of the building primarily utilize T8 or T12 lamps.



Opportunity

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

Utility-savings mechanism

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

Design description

Overview

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

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

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

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

the fixtures. It would be recommended that an annual lighting review is conducted to measure the lighting levels within each space of the facility. At the 70 percent output level, the owner would expect a much quicker decline in the loss of lighting output in each fixture. As such, at the 70 percent lighting level, it would be recommended that the fixtures within that room be replaced.

Type C, D, E, E1, G, and I fixtures should be replaced.

Project cost estimate

Table 31: Project cost estimate (Interior LED lighting upgrade)

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

Utility analysis

Utility analysis methodology

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

- **Baseline:** The lighting power density for each space is summarized in Table 9.
- **Proposed:** It is assumed that the lpd for each space type is reduced by 20%. Operation schedules are maintained.

Utility analysis results

Table 32: Interior LED lighting upgrade analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	49,265	3,308	6.3
	Natural gas use	[m3/yr]	19,536	19,641	-105	-0.54
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	49,265	3,308	6.3
	Natural gas energy	[kWh/yr]	206,237	207,341	-1,105	-0.54
	Total energy	[kWh/yr]	258,809	256,606	2,204	0.85
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.6	1.5	0.10	6.3
	Natural gas GHGs	[tCO2e/yr]	37.8	38.0	-0.20	-0.54
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	39.3	39.4	-0.10	-0.26
Utility cost	Electricity utility cost	[\$/yr]	5,215	4,887	328	6.3
	Natural gas utility cost	[\$/yr]	5,079	5,107	-27.2	-0.54
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,898	-10.1	-0.54
	Total utility cost	[\$/yr]	12,182	11,891	291	2.4
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	21,000	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	21,000	—	—
	Life cycle cost	[\$]	290,048	303,765	—	—
	Net present value	[\$]	0	-13,717	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	-205,295	—	—
	Simple payback period	[yr]	—	>20	—	—

5.10 Low-flow handwashing faucet aerators

Measure description

Existing condition

Handwashing faucets were mostly manually controlled, and aerators were assumed to be 2.0 gpm.



Opportunity

Install low flow faucets aerators on handwashing faucets throughout the facility.

Utility-savings mechanism

Reduced water use and reduced natural gas required for DHW heating.

Design description

Overview

Remove existing handwashing faucet aerators and replace them with low-flow aerators. The proposed flow rate for the new aerators would be 0.5 to 1 gallons per minute (gpm), depending on user preferences.

Project cost estimate

Project cost estimate

The project cost estimate is summarized in the following table.

Table 33: Project cost estimate (Low-flow handwashing faucet aerators)

Category	Line item	Unit	Value
Materials and labour	New aerator materials (Qty 10)	[\$]	2,400
	New aerator installation (Qty 10)	[\$]	9,600
Contingency	Subtotal after Materials and labour	[\$]	12,000
	General Contingency (50%)	[\$]	6,000
Total	Total	[\$]	18,000

Utility analysis

Utility analysis methodology

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

- **Baseline.** Faucet flow rate of 2.0 GPM. It is assumed that washroom faucets account for 80% of DHW used at the facility.
- **Proposed.** Faucet flow rate of 0.5 GPM.

Utility analysis results

Table 34: Low-flow handwashing faucet aerators analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	52,573	0	0
	Natural gas use	[m3/yr]	19,536	19,164	373	1.9
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	52,573	0	0
	Natural gas energy	[kWh/yr]	206,237	202,304	3,932	1.9
	Total energy	[kWh/yr]	258,809	254,877	3,933	1.5
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.6	1.6	0	0
	Natural gas GHGs	[tCO2e/yr]	37.8	37.0	0.72	1.9
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	39.3	38.6	0.72	1.8
Utility cost	Electricity utility cost	[\$/yr]	5,215	5,215	0	0
	Natural gas utility cost	[\$/yr]	5,079	4,983	96.9	1.9
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,852	36.0	1.9
	Total utility cost	[\$/yr]	12,182	12,049	133	1.1
Financial	Assumed life	[yrs]	15	7	—	—
	Project cost	[\$]	0	18,000	—	—
	Incentive amount	[\$]	0	93.1	—	—
	Incremental project cost	[\$]	0	17,907	—	—
	Life cycle cost	[\$]	290,048	321,324	—	—
	Net present value	[\$]	0	-31,276	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	24,876	—	—
	Simple payback period	[yr]	—	>20	—	—

5.11 Natural gas stove conversion to electric

Measure description

Existing condition

There are gas-fired stoves in the community hall kitchen. Staff noted that this equipment is seldomly used.



Opportunity

Consider removing or replacing natural gas stoves with electric equivalent.

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.

Design description

Overview

Replace the existing natural gas stoves with energy-star-rated electric stoves. This measure assumes a new 240V circuit will be required.

Electrical

The proposed electric stoves will add approximately 15.4 kW of power to the existing system, which will put the system at 33 kW, which is approximately 86 percent of the full load of the electrical capacity of the building.

Project cost estimate

Table 35: Project cost estimate (Natural gas stove conversion to electric)

Category	Line item	Unit	Value
Materials and labour	2 x Electric Range - Supply and Delivery	[\$]	3,000
	Electrical	[\$]	5,000
Contingency	Subtotal after Materials and labour	[\$]	8,000
	General Contingency (50%)	[\$]	4,000
Total	Total	[\$]	12,000

Utility analysis

Utility analysis methodology

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

- **Baseline.** Stoves at this facility are gas-fired.
- **Proposed.** Stoves are converted to electrical models. There is no change in stove operation.

Utility analysis results

Table 36: Natural gas stove conversion to electric analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	53,615	-1,043	-2.0
	Natural gas use	[m3/yr]	19,536	19,435	101	0.52
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	53,615	-1,043	-2.0
	Natural gas energy	[kWh/yr]	206,237	205,173	1,064	0.52
	Total energy	[kWh/yr]	258,809	258,788	21.1	0.01
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.6	1.6	-0.03	-2.0
	Natural gas GHGs	[tCO2e/yr]	37.8	37.6	0.19	0.52
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	39.3	39.2	0.16	0.41
Utility cost	Electricity utility cost	[\$/yr]	5,215	5,319	-103	-2.0
	Natural gas utility cost	[\$/yr]	5,079	5,053	26.2	0.52
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,878	9.7	0.52
	Total utility cost	[\$/yr]	12,182	12,250	-67.5	-0.55
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	12,000	—	—
	Incentive amount	[\$]	0	0	—	—
	Incremental project cost	[\$]	0	12,000	—	—
	Life cycle cost	[\$]	290,048	306,450	—	—
	Net present value	[\$]	0	-16,402	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	73,512	—	—
	Simple payback period	[yr]	—	—	—	—

5.12 Radiant heaters to electric

Measure description

Existing condition

Bays 4-5 is heated by IH-1, a natural gas-fired infrared heater.



Opportunity

Replace the gas-fired heater with an electric resistance equivalent.

Utility-savings mechanism

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

Design description

Overview

Remove the ceiling-hung, gas-fired radiant tube heaters currently serving bays 4 and 5. To match the existing service area of the gas-fired units, two ceiling-hung 4.5 kW electric units will be required and located accordingly. The new unit controls are to implemented with a combination of occupancy/motion detection and manual enable. Electrical upgrades may be required to accommodate the new units.

Electrical

The radiant heaters will add approximately 9 kW of power to the existing system, which will put the system at 26.6 kW, which is approximately 69 percent of the full load of the electrical capacity of the building.

Project cost estimate

Table 37: Project cost estimate (Radiant heaters to electric)

Category	Line item	Unit	Value
Construction	Supply and install	[\$]	6,000
	Electrical	[\$]	14,000
	General requirements (25%)	[\$]	5,000
Contingency	Subtotal after Construction	[\$]	25,000
	Design Contingency (25%)	[\$]	6,200
	Construction Contingency (10%)	[\$]	2,500
Design, Contractors, PM	Subtotal after Contingency	[\$]	33,700
	Engineering Design and Field Review (10%)	[\$]	3,400
	Contractor Fee (7%)	[\$]	2,400
Total	Total	[\$]	39,500

Utility analysis

Utility analysis methodology

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

- **Baseline.** The infrared heaters are gas-fired with an average thermal efficiency of 60%.
- **Proposed.** The infrared heaters are electric, with an efficiency of 100%.

Utility analysis results

Table 38: Radiant heaters to electric analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	73,747	-21,175	-40.3
	Natural gas use	[m3/yr]	19,536	15,852	3,684	18.9
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	73,747	-21,175	-40.3
	Natural gas energy	[kWh/yr]	206,237	167,343	38,894	18.9
	Total energy	[kWh/yr]	258,809	241,090	17,719	6.8
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.6	2.2	-0.64	-40.3
	Natural gas GHGs	[tCO2e/yr]	37.8	30.6	7.1	18.9
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	39.3	32.9	6.5	16.5
Utility cost	Electricity utility cost	[\$/yr]	5,215	7,316	-2,101	-40.3
	Natural gas utility cost	[\$/yr]	5,079	4,121	958	18.9
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,532	356	18.9
	Total utility cost	[\$/yr]	12,182	12,969	-787	-6.5
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	39,500	—	—
	Incentive amount	[\$]	0	7,900	—	—
	Incremental project cost	[\$]	0	31,600	—	—
	Life cycle cost	[\$]	290,048	366,368	—	—
	Net present value	[\$]	0	-76,320	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	4,877	—	—
	Simple payback period	[yr]	—	—	—	—

5.13 Roof upgrade to high performance

Measure description

Existing condition

The exterior layer of the roof is asphalt shingles, which were replaced in 2013. It's assumed that no additional insulation was added at this time.



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 existing sloped roofs are finished with asphalt shingles, and we assume that there is some batt insulation inside the existing attic spaces. At a minimum, we recommend that some additional batt insulation be provided within the attic spaces. Ideally, the insulation layer on the walls is directly connected to and forms an extension of the insulating layer on the walls so that there are no thermal breaks or air leakage at the juncture between walls and the roof. In that case, the asphalt shingles on the roofs would be removed, new sheathing, air barrier, rigid insulation, and a new roof membrane (EPDM or PVC) would be installed (new batt insulation in the trusses would not be required).

In order to connect the air barrier on the roof to the air barrier on the walls, the soffits would need to be removed and replaced. Either of these approaches would significantly improve the thermal performance of the roof, anywhere from R30 to R60.

If the decision is made just to add batt insulation to the attics, the joints between walls and roof should be examined to ensure no air leakage or thermal bridging occurs. Sealants and/or spray foam should be provided where leaks are occurring, as they can significantly affect thermal performance, and the soffits may need to be removed and reinstalled in order to accomplish this.

Project cost estimate

Table 39: Project cost estimate (Roof upgrade to high performance)

Category	Line item	Unit	Value
Construction	Roof replacement	[\$]	1,753,000
	General requirements (25%)	[\$]	438,200
Contingency	Subtotal after Construction	[\$]	2,191,200
	Design Contingency (25%)	[\$]	547,800
	Construction Contingency (10%)	[\$]	219,100
Design, Contractors, PM	Subtotal after Contingency	[\$]	2,958,100
	Engineering Design and Field Review (10%)	[\$]	295,800
	Contractor Fee (7%)	[\$]	207,100
Total	Total	[\$]	3,461,000

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 0.04 BTU/hr.ft².F (R25) was assumed.
- **Proposed.** An average roof U-value of 0.025 BTU/hr.ft².F (R40) was assumed.

Utility analysis results

Table 40: Roof upgrade to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	52,276	297	0.56
	Natural gas use	[m ³ /yr]	19,536	19,026	510	2.6
	Carbon offset use	[tCO ₂ e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	52,276	297	0.56
	Natural gas energy	[kWh/yr]	206,237	200,851	5,386	2.6
	Total energy	[kWh/yr]	258,809	253,127	5,682	2.2
GHG emissions	Electricity GHGs	[tCO ₂ e/yr]	1.6	1.6	0.01	0.56
	Natural gas GHGs	[tCO ₂ e/yr]	37.8	36.8	0.99	2.6
	Carbon offsets GHGs	[tCO ₂ e/yr]	0	0	0	—
	Total GHGs	[tCO ₂ e/yr]	39.3	38.3	0.99	2.5
Utility cost	Electricity utility cost	[\$/yr]	5,215	5,186	29.4	0.56
	Natural gas utility cost	[\$/yr]	5,079	4,947	133	2.6
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,838	49.3	2.6
	Total utility cost	[\$/yr]	12,182	11,971	211	1.7
Financial	Assumed life	[yrs]	15	20	—	—
	Project cost	[\$]	0	3,461,000	—	—
	Incentive amount	[\$]	0	692,200	—	—
	Incremental project cost	[\$]	0	2,768,800	—	—
	Life cycle cost	[\$]	290,048	3,211,864	—	—
	Net present value	[\$]	0	-2,921,816	—	—
	Project cost per GHG reduction	[\$/tCO ₂ e]	—	2,783,307	—	—
	Simple payback period	[yr]	—	>20	—	—

5.14 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.

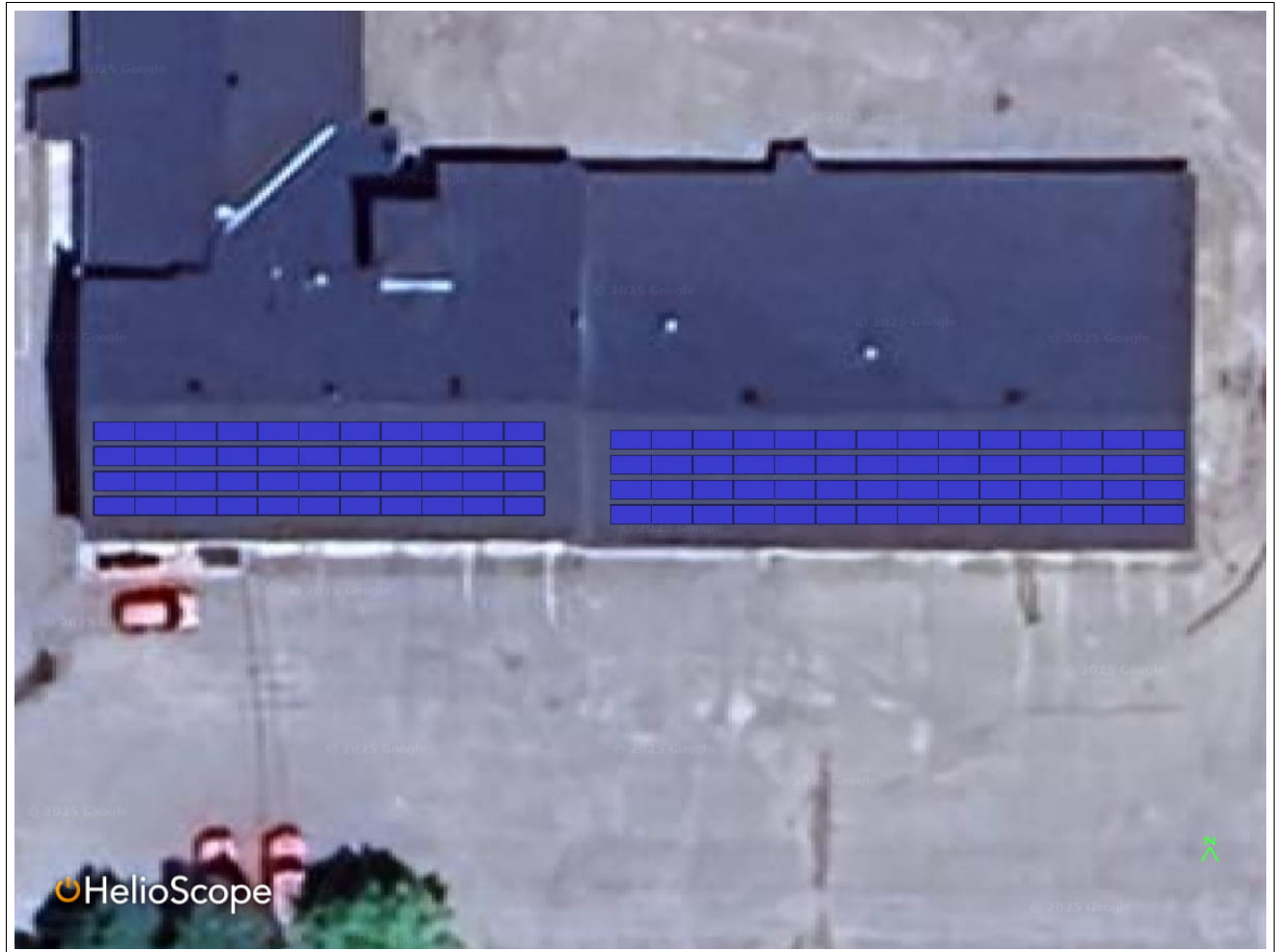
Utility-savings mechanism

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) = 43 kW.

Proposed scope

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

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

Electrical

With the existing system, the panel is rated not high enough to accommodate the additional 55 kW of the solar. The panel will need to be rated at least 400A to accommodate the solar.

Project cost estimate

Table 41: Project cost estimate (Solar PV rooftop)

Category	Line item	Unit	Value
Materials and labour	Solar PV electricity system installed (assuming 43 kW at 2000 \$/kW)	[\$]	86,000
	Electrical	[\$]	30,000
Contingency	Subtotal after Materials and labour	[\$]	116,000
	General Contingency (20%)	[\$]	23,200
	Design Contingency (10%)	[\$]	11,600
Total	Total	[\$]	150,800

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 42: Solar PV rooftop analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	7,690	44,883	85.4
	Natural gas use	[m3/yr]	19,536	19,536	0	0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	7,690	44,883	85.4
	Natural gas energy	[kWh/yr]	206,237	206,237	0	0
	Total energy	[kWh/yr]	258,809	213,926	44,883	17.3
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.6	0.23	1.4	85.4
	Natural gas GHGs	[tCO2e/yr]	37.8	37.8	0	0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	39.3	38.0	1.4	3.4
Utility cost	Electricity utility cost	[\$/yr]	5,215	763	4,452	85.4
	Natural gas utility cost	[\$/yr]	5,079	5,079	-0.00	-0.00
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,888	0	0
	Total utility cost	[\$/yr]	12,182	7,730	4,452	36.5
Financial	Assumed life	[yrs]	15	30	—	—
	Project cost	[\$]	0	150,800	—	—
	Incentive amount	[\$]	0	30,160	—	—
	Incremental project cost	[\$]	0	120,640	—	—
	Life cycle cost	[\$]	290,048	270,792	—	—
	Net present value	[\$]	0	19,256	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	89,002	—	—
	Simple payback period	[yr]	—	>20	—	—

5.15 Unit heaters conversion

Measure description

Existing condition

Natural gas-fired unit heaters serve bays 2-3 and 6-9. The Reznor unit shown below has recently been replaced with a Modine PTP150AS.



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 two (2) natural gas unit heaters with electric resistance unit heaters. UH1 and UH2 provide heating to service bays in the garage.

The new units shall be Reznor EUH 20kW units. The larger units shall be replaced with multiple smaller units such that three 20kW units will replace both existing unit heaters.

Electrical

The unit heaters will add approximately 60 kW of power to the existing system, which will put the system at 77.6 kW, which is approximately 200 percent of the full load of the electrical capacity of the building. A system

upgrade would be required to at least a 75 kVA transformer, with a 400A 208V-3P panel. The existing 200A 240A panel can be powered from the new 400A panel.

Project cost estimate

Table 43: Project cost estimate (Unit heaters conversion)

Category	Line item	Unit	Value
Construction	Unit heater supply	[\$]	47,500
	Installation of unit heaters	[\$]	47,500
	Electrical	[\$]	166,000
	General requirements (25%)	[\$]	65,200
Contingency	Subtotal after Construction	[\$]	326,200
	Design Contingency (25%)	[\$]	81,600
	Construction Contingency (10%)	[\$]	32,600
Design, Contractors, PM	Subtotal after Contingency	[\$]	440,400
	Engineering Design and Field Review (10%)	[\$]	44,000
	Contractor Fee (7%)	[\$]	30,800
Total	Total	[\$]	515,200

Utility analysis

Utility analysis methodology

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

- **Baseline.** UH1 and UH2 are gas-fired unit heaters with an average burner thermal efficiency of 80%.
- **Proposed.** UH1 and UH2 are electric unit heaters, with an efficiency of 100%.

Utility analysis results

Table 44: Unit heaters conversion analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	114,449	-61,877	-118
	Natural gas use	[m3/yr]	19,536	11,392	8,144	41.7
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	114,449	-61,877	-118
	Natural gas energy	[kWh/yr]	206,237	120,264	85,973	41.7
	Total energy	[kWh/yr]	258,809	234,713	24,096	9.3
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.6	3.5	-1.9	-118
	Natural gas GHGs	[tCO2e/yr]	37.8	22.0	15.7	41.7
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	39.3	25.5	13.9	35.3
Utility cost	Electricity utility cost	[\$/yr]	5,215	11,353	-6,138	-118
	Natural gas utility cost	[\$/yr]	5,079	2,962	2,117	41.7
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,101	787	41.7
	Total utility cost	[\$/yr]	12,182	15,416	-3,234	-26.5
Financial	Assumed life	[yrs]	15	15	—	—
	Project cost	[\$]	0	515,200	—	—
	Incentive amount	[\$]	0	103,040	—	—
	Incremental project cost	[\$]	0	412,160	—	—
	Life cycle cost	[\$]	290,048	920,237	—	—
	Net present value	[\$]	0	-630,189	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	29,720	—	—
	Simple payback period	[yr]	—	—	—	—

5.16 Wall upgrade to high performance

Measure description

Existing condition

The exterior walls comprised either an outer layer of metal siding, brick veneer, or concrete block.



Opportunity

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

Utility-savings mechanism

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

Design description

Overview

The performance of the existing walls is currently unknown. However, we assume that some walls are constructed with wood studs and have minimal insulation, finished with either a brick veneer or metal siding. Other walls may be made of concrete blocks that lack any insulation (notably, the fire station garage portion). The thermal performance of these walls is likely below the standards set by current building codes (which require R20 insulation).

To improve the thermal performance, we recommend applying an EIFS (External Insulation and Finish System) to the exterior of the existing structure, whether it consists of sheathing or concrete blocks. We suggest removing the existing siding and replacing it before the installation of the EIFS system. In areas where the building has exposed stucco, concrete block, or brick, the EIFS can be applied directly over these surfaces.

When applied directly to the concrete block, the EIFS system could provide an insulation value of almost R30, and it includes its own air barrier, which can be integrated with a new air barrier on the roof. If desired, the EIFS

can also be finished with a masonry veneer; however, the structural integrity of the building must be evaluated to determine if it can support the additional weight. Typically, adding 150mm of EIFS with an acrylic stucco finish over existing brick or block does not create structural issues concerning the brick ties.

Alternatively, new sheathing, a membrane air barrier, semi-rigid insulation with thermally broken girts, and new metal siding could be installed instead of the EIFS. However, this option would increase the weight on the existing structure and may exceed its load capacity, making it a more expensive choice.

If the decision is made not to add insulation to the exterior walls, we recommend performing thermal imaging and blower door testing. These tests can identify significant points of air leakage or thermal bridging that may be compromising the performance of the wall and roof. Any issues found can be addressed using sealants and spray foam locally.

Project cost estimate

Table 45: Project cost estimate (Wall upgrade to high performance)

Category	Line item	Unit	Value
Construction	Wall upgrade	[\$]	1,295,000
	General requirements (25%)	[\$]	323,800
Contingency	Subtotal after Construction	[\$]	1,618,800
	Design Contingency (25%)	[\$]	404,700
	Construction Contingency (10%)	[\$]	161,900
Design, Contractors, PM	Subtotal after Contingency	[\$]	2,185,400
	Engineering Design and Field Review (10%)	[\$]	218,500
	Contractor Fee (7%)	[\$]	153,000
Total	Total	[\$]	2,556,900

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 0.067 BTU/hr.ft².F (R15) was assumed.
- **Proposed.** An average wall U-value of 0.0345 BTU/hr.ft².F (R29) was assumed. Infiltration flow was assumed to be reduced by 10% in total relative to the Baseline for affected spaces.

Utility analysis results

Table 46: Wall upgrade to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	48,991	3,581	6.8
	Natural gas use	[m3/yr]	19,536	17,589	1,947	10.0
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	48,991	3,581	6.8
	Natural gas energy	[kWh/yr]	206,237	185,680	20,557	10.0
	Total energy	[kWh/yr]	258,809	234,671	24,138	9.3
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.6	1.5	0.11	6.8
	Natural gas GHGs	[tCO2e/yr]	37.8	34.0	3.8	10.0
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	39.3	35.5	3.9	9.8
Utility cost	Electricity utility cost	[\$/yr]	5,215	4,860	355	6.8
	Natural gas utility cost	[\$/yr]	5,079	4,573	506	10.0
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,699	188	10.0
	Total utility cost	[\$/yr]	12,182	11,132	1,050	8.6
Financial	Assumed life	[yrs]	15	75	—	—
	Project cost	[\$]	0	2,556,900	—	—
	Incentive amount	[\$]	0	511,380	—	—
	Incremental project cost	[\$]	0	2,045,520	—	—
	Life cycle cost	[\$]	290,048	933,662	—	—
	Net present value	[\$]	0	-643,614	—	—
	Project cost per GHG reduction	[\$yr/tCO2e]	—	528,418	—	—
	Simple payback period	[yr]	—	>20	—	—

5.17 Windows and doors to high performance

Measure description

Existing condition

Most windows appear to be double-pane aluminum windows. The facility has hollow metal doors 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. This will improve the thermal performance of the windows from about R2 or R3 to at least R7 or R8.

Doors

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

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

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

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

Project cost estimate

Table 47: Project cost estimate (Windows and doors to high performance)

Category	Line item	Unit	Value
Construction	Window and door replacement	[\$]	204,000
	General requirements (25%)	[\$]	51,000
Contingency	Subtotal after Construction	[\$]	255,000
	Design Contingency (25%)	[\$]	63,800
	Construction Contingency (10%)	[\$]	25,500
Design, Contractors, PM	Subtotal after Contingency	[\$]	344,300
	Engineering Design and Field Review (10%)	[\$]	34,400
	Contractor Fee (7%)	[\$]	24,100
Total	Total	[\$]	402,800

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 0.8137 BTU/hr.ft².F.
- **Proposed.** The average U-value of all windows and doors was assumed to be 0.125 BTU/hr.ft².F (R8). Infiltration flow was assumed to be reduced by 10% in total relative to the Baseline for affected spaces.

Utility analysis results

Table 48: Windows and doors to high performance analysis results summary

Category	Description	Unit	Baseline	Proposed	Reduction	Reduction [%]
Utility use	Electricity use	[kWh/yr]	52,573	51,438	1,135	2.2
	Natural gas use	[m3/yr]	19,536	15,963	3,573	18.3
	Carbon offset use	[tCO2e/yr]	0	0	0	—
Equivalent energy use	Electricity energy	[kWh/yr]	52,573	51,438	1,135	2.2
	Natural gas energy	[kWh/yr]	206,237	168,518	37,718	18.3
	Total energy	[kWh/yr]	258,809	219,956	38,853	15.0
GHG emissions	Electricity GHGs	[tCO2e/yr]	1.6	1.6	0.03	2.2
	Natural gas GHGs	[tCO2e/yr]	37.8	30.8	6.9	18.3
	Carbon offsets GHGs	[tCO2e/yr]	0	0	0	—
	Total GHGs	[tCO2e/yr]	39.3	32.4	6.9	17.6
Utility cost	Electricity utility cost	[\$/yr]	5,215	5,103	113	2.2
	Natural gas utility cost	[\$/yr]	5,079	4,150	929	18.3
	Carbon offsets utility cost	[\$/yr]	0	0	0	—
	Federal carbon charge	[\$/yr]	1,888	1,542	345	18.3
	Total utility cost	[\$/yr]	12,182	10,795	1,387	11.4
Financial	Assumed life	[yrs]	15	40	—	—
	Project cost	[\$]	0	402,800	—	—
	Incentive amount	[\$]	0	80,560	—	—
	Incremental project cost	[\$]	0	322,240	—	—
	Life cycle cost	[\$]	290,048	465,460	—	—
	Net present value	[\$]	0	-175,412	—	—
	Project cost per GHG reduction	[\$/tCO2e]	—	46,443	—	—
	Simple payback period	[yr]	—	>20	—	—

5.18 Measure risk analysis

Utility use sensitivity

Figure 123 indicates how sensitive cumulative electricity and natural gas use are to variations in each risk parameter.

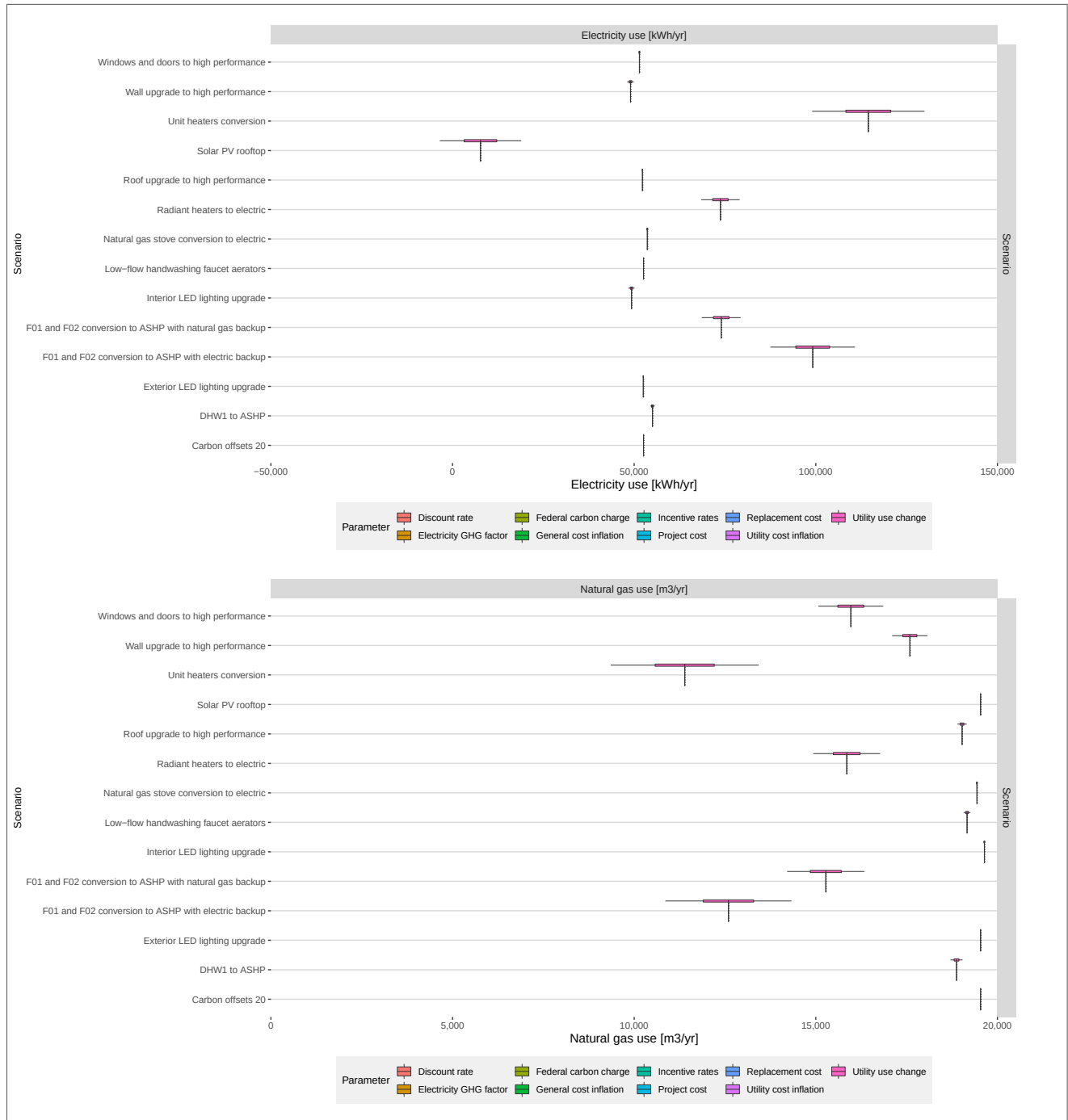


Figure 123: Utility cumulative use sensitivity analysis

GHG emissions and life cycle cost sensitivity

Figure 124 indicates how sensitive cumulative GHG emissions and life cycle costs are to variations in each risk parameter.

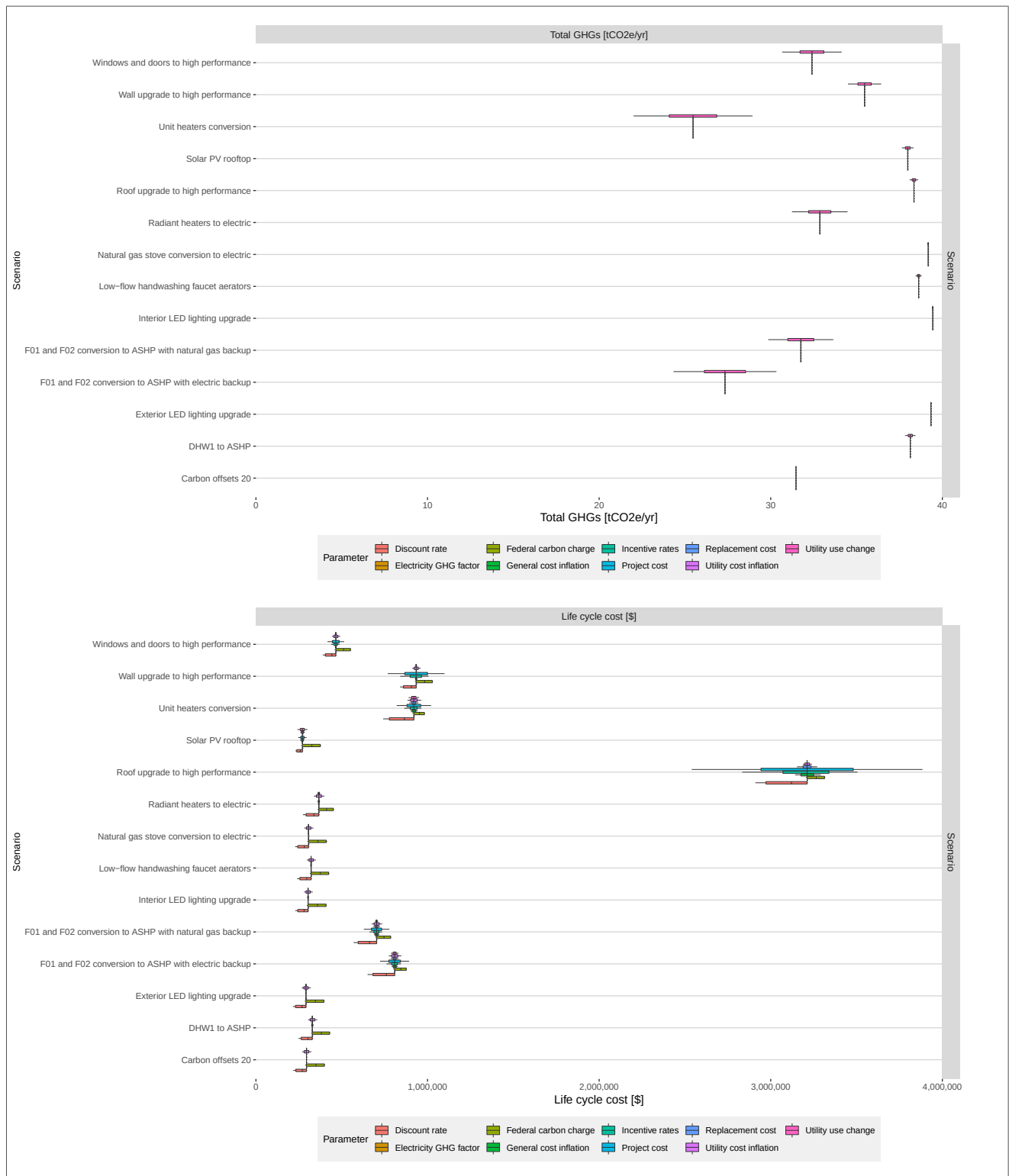


Figure 124: GHG cumulative emissions and life cycle cost sensitivity analysis

5.19 Measure analysis summary

For each analyzed measure, the analysis results are summarized in Table 49.

Table 49: Measure analysis summary

Measure ID	Utility use				Equivalent energy use		GHG emissions		Utility cost		Financial							
Measure name	Electricity use reduction	Electricity use reduction	Natural gas use reduction	Natural gas use reduction	Total energy reduction	Total energy reduction	Total GHG reduction	Total GHG reduction	Utility cost reduction	Utility cost reduction	Assumed life	Project cost	Incentive amount	Incremental project cost	Life cycle cost	Net present value	Project cost per GHG reduction	Simple payback period
-	[kWh/yr]	[%]	[m3/yr]	[%]	[kWh/yr]	[%]	[tCO2e/yr]	[%]	[\$/yr]	[%]	[yrs]	[\$]	[\$]	[\$]	[\$]	[\$]	[\$/yr/tCO2e]	[yr]
Baseline	52,573	100.0	19,536	100.0	258,809	100.0	39	100.0	12,182	100.0	15	0	0	0	290,048	0	-	-
Carbon offsets 20	0	0.0	0	0.0	0	0.0	8	20.0	-236	-1.9	20	-	0	-	294,352	-4,304	-	-
DHW1 to ASHP	-2,455	-4.7	663	3.4	4,539	1.8	1	3.1	-7	-0.1	15	30,000	166	29,834	328,509	-38,461	24,737	-4,126
Exterior LED lighting upgrade	65	0.1	0	0.0	65	0.0	0	0.0	6	0.1	20	1,500	0	1,500	291,437	-1,389	759,109	231
F01 and F02 conversion to ASHP with electric backup	-46,571	-88.6	6,941	35.5	26,705	10.3	12	30.5	-2,145	-17.6	15	436,200	87,240	348,960	808,228	-518,181	29,064	-163
F01 and F02 conversion to ASHP with natural gas backup	-21,386	-40.7	4,261	21.8	23,595	9.1	8	19.3	-602	-4.9	15	382,900	76,580	306,320	702,990	-412,942	40,371	-509
Interior LED lighting upgrade	3,308	6.3	-105	-0.5	2,204	0.9	-0	-0.3	291	2.4	20	21,000	0	21,000	303,764	-13,717	-205,295	72
Low-flow handwashing faucet aerators	0	0.0	373	1.9	3,933	1.5	1	1.8	133	1.1	7	18,000	93	17,907	321,324	-31,276	24,876	135
Natural gas stove conversion to electric	-1,043	-2.0	101	0.5	21	0.0	0	0.4	-68	-0.6	15	12,000	0	12,000	306,449	-16,402	73,512	-178
Radiant heaters to electric	-21,175	-40.3	3,684	18.9	17,719	6.8	6	16.5	-787	-6.5	15	39,500	7,900	31,600	366,368	-76,320	4,877	-40
Roof upgrade to high performance	297	0.6	510	2.6	5,682	2.2	1	2.5	211	1.7	20	3,461,000	692,200	2,768,800	3,211,864	-2,921,816	2,783,307	13,100
Solar PV rooftop	44,883	85.4	0	0.0	44,883	17.3	1	3.4	4,452	36.5	30	150,800	30,160	120,640	270,792	19,256	89,002	27
Unit heaters conversion	-61,877	-117.7	8,144	41.7	24,096	9.3	14	35.3	-3,234	-26.5	15	515,200	103,040	412,160	920,237	-630,189	29,720	-127
Wall upgrade to high performance	3,581	6.8	1,947	10.0	24,138	9.3	4	9.8	1,050	8.6	75	2,556,900	511,380	2,045,520	933,662	-643,614	528,418	1,949
Windows and doors to high performance	1,135	2.2	3,573	18.3	38,853	15.0	7	17.6	1,387	11.4	40	402,800	80,560	322,240	465,460	-175,412	46,443	232
Total project cost	-	-	-	-	-	-	-	-	-	-	-	8,027,800	-	-	-	-	-	-
DHW1 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	4,000	0	4,000	294,772	-4,724	-	-
Exterior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	300	0	300	290,360	-312	-	-
Exterior walls renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	75	9,000	0	9,000	292,962	-2,914	-	-
F01 and F02 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	19,000	0	19,000	312,488	-22,440	-	-
Interior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	22,000	0	22,000	312,915	-22,868	-	-
Natural gas stove renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	5,000	0	5,000	295,953	-5,905	-	-
Roof renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	454,000	0	454,000	761,951	-471,903	-	-
Sinks renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10	18,000	0	18,000	316,525	-26,477	-	-
Unit heaters renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	9,000	0	9,000	299,800	-9,752	-	-
Windows and doors renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	123,000	0	123,000	364,726	-74,679	-	-
BAU measure totals	-	-	-	-	-	-	-	-	-	-	-	663,300	-	-	-	-	-	-

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 50.
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 50.

Table 50: 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 125 and Table 51 present the results of this exercise, indicating which measures were assigned to which scenario.

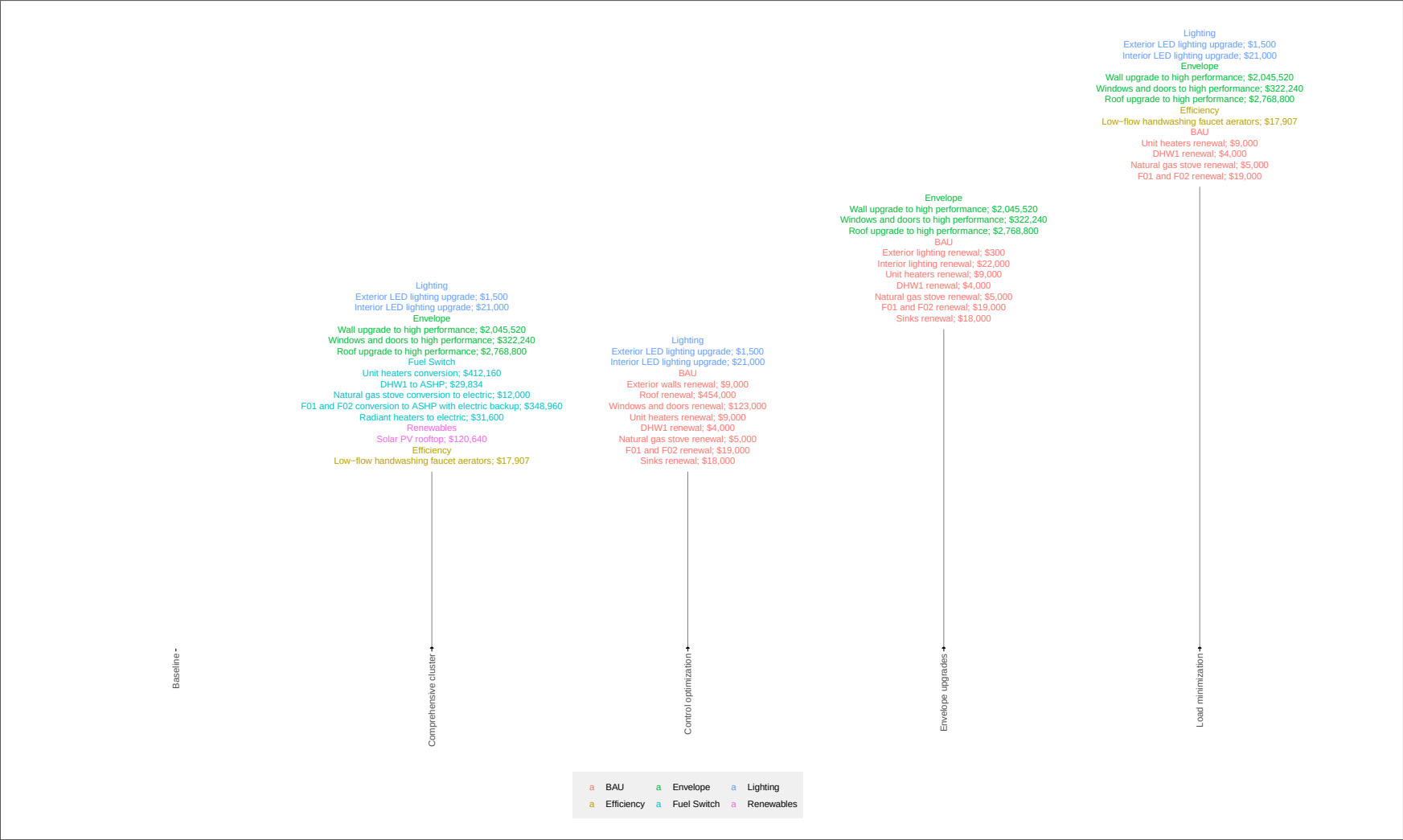


Figure 125: Scenario composition

Table 51: Cluster composition

Measure	Control optimization	Envelope upgrades	Load minimization	Comprehensive cluster
Carbon offsets 20	✗	✗	✗	✗
DHW1 to ASHP	✗	✗	✗	✓
Exterior LED lighting upgrade	✓	✗	✓	✓
F01 and F02 conversion to ASHP with electric backup	✗	✗	✗	✓
F01 and F02 conversion to ASHP with natural gas backup	✗	✗	✗	✗
Interior LED lighting upgrade	✓	✗	✓	✓
Low-flow handwashing faucet aerators	✗	✗	✓	✓
Natural gas stove conversion to electric	✗	✗	✗	✓
Radiant heaters to electric	✗	✗	✗	✓
Roof upgrade to high performance	✗	✓	✓	✓
Solar PV rooftop	✗	✗	✗	✓
Unit heaters conversion	✗	✗	✗	✓
Wall upgrade to high performance	✗	✓	✓	✓
Windows and doors to high performance	✗	✓	✓	✓
DHW1 renewal	✓	✓	✓	✗
Exterior lighting renewal	✗	✓	✗	✗
Exterior walls renewal	✓	✗	✗	✗
F01 and F02 renewal	✓	✓	✓	✗
Interior lighting renewal	✗	✓	✗	✗
Natural gas stove renewal	✓	✓	✓	✗
Roof renewal	✓	✗	✗	✗
Sinks renewal	✓	✓	✗	✗
Unit heaters renewal	✓	✓	✓	✗
Windows and doors renewal	✓	✗	✗	✗

6.4 Cluster scenario performance analysis

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

Cluster scenario performance analysis summary

Results of the scenario analysis are summarized in Table 52, 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 52: Scenario analysis summary

Measure ID		Utility use				Equivalent energy use		GHG emissions		Utility cost		Financial							
Scenario	Measure name	Electricity use reduction	Electricity use reduction	Natural gas use reduction	Natural gas use reduction	Total energy reduction	Total energy reduction	Total GHG reduction	Total GHG reduction	Utility cost reduction	Utility cost reduction	Assumed life	Project cost	Incentive amount	Incremental project cost	Life cycle cost	Net present value	Project cost per GHG reduction	Simple payback period
-	-	[kWh/yr]	[%]	[m3/yr]	[%]	[kWh/yr]	[%]	[tCO2e/yr]	[%]	[\$/yr]	[%]	[yrs]	[\$]	[\$]	[\$]	[\$]	[\$]	[\$/tCO2e]	[yr]
Comprehensive cluster	Combined	-37,195	-70.7	19,536	100.0	169,042	65.3	37	93.1	3,277	26.9	-	7,644,900	1,512,739	6,132,161	5,010,065	-4,720,017	167,420	1.871
Comprehensive cluster	Exterior LED lighting upgrade	65	0.1	0	0.0	65	0.0	0	0.0	6	0.1	20	1,500	0	1,500	291,437	-1,389	759,109	231
Comprehensive cluster	Interior LED lighting upgrade	3,308	6.3	-105	-0.5	2,204	0.9	-0	-0.3	291	2.4	20	21,000	0	21,000	303,764	-13,717	-205,295	72
Comprehensive cluster	Wall upgrade to high performance	3,581	6.8	1,947	10.0	24,138	9.3	4	9.8	1,050	8.6	75	2,556,900	511,380	2,045,520	933,662	-643,614	528,418	1,949
Comprehensive cluster	Windows and doors to high performance	1,135	2.2	3,573	18.3	38,853	15.0	7	17.6	1,387	11.4	40	402,800	80,560	322,240	465,460	-175,412	46,443	232
Comprehensive cluster	Roof upgrade to high performance	297	0.6	510	2.6	5,682	2.2	1	2.5	211	1.7	20	3,461,000	692,200	2,768,800	3,211,864	-2,921,816	2,783,307	13,100
Comprehensive cluster	Unit heaters conversion	-61,877	-117.7	8,144	41.7	24,096	9.3	14	35.3	-3,234	-26.5	15	515,200	103,040	412,160	920,237	-630,189	29,720	-127
Comprehensive cluster	DHW1 to ASHP	-2,455	-4.7	663	3.4	4,539	1.8	1	3.1	-7	-0.1	15	30,000	166	29,834	328,509	-38,461	24,737	-4,126
Comprehensive cluster	Solar PV rooftop	44,883	85.4	0	0.0	44,883	17.3	1	3.4	4,452	36.5	30	150,800	30,160	120,640	270,792	19,256	89,002	27
Comprehensive cluster	Natural gas stove conversion to electric	-1,043	-2.0	101	0.5	21	0.0	0	0.4	-68	-0.6	15	12,000	0	12,000	306,449	-16,402	73,512	-178
Comprehensive cluster	Comprehensive cluster	-46,571	-88.6	6,941	35.5	26,705	10.3	12	30.5	-2,145	-17.6	15	436,200	87,240	348,960	808,228	-518,181	29,064	-163
Comprehensive cluster	Low-flow handwashing faucet aerators	0	0.0	373	1.9	3,933	1.5	1	1.8	133	1.1	7	18,000	93	17,907	321,524	-31,276	24,876	135
Comprehensive cluster	Radiant heaters to electric	-21,175	-40.3	3,684	18.9	17,719	6.8	6	16.5	-787	-6.5	15	39,500	7,900	31,600	366,368	-76,320	4,877	-40
Control optimization	Combined	3,374	6.4	-105	-0.5	2,269	0.9	-0	-0.3	297	2.4	-	663,500	0	663,500	895,561	-605,513	-6,614,099	2,231
Control optimization	Exterior LED lighting upgrade	65	0.1	0	0.0	65	0.0	0	0.0	6	0.1	20	1,500	0	1,500	291,437	-1,389	759,109	231
Control optimization	Interior LED lighting upgrade	3,308	6.3	-105	-0.5	2,204	0.9	-0	-0.3	291	2.4	20	21,000	0	21,000	303,764	-13,717	-205,295	72
Control optimization	Exterior walls renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	75	9,000	0	9,000	292,962	-2,914	-	-
Control optimization	Roof renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	454,000	0	454,000	761,951	-471,903	-	-
Control optimization	Windows and doors renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	40	123,000	0	123,000	364,726	-74,679	-	-
Control optimization	Unit heaters renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	9,000	0	9,000	299,800	-9,752	-	-
Control optimization	DHW1 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	4,000	0	4,000	294,772	-4,724	-	-
Control optimization	Natural gas stove renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	5,000	0	5,000	295,953	-5,905	-	-
Control optimization	F01 and F02 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	19,000	0	19,000	312,488	-22,440	-	-
Control optimization	Sinks renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10	18,000	0	18,000	316,525	-26,477	-	-
Envelope upgrades	Combined	3,951	7.5	5,787	29.6	65,040	25.1	11	28.7	2,456	20.2	-	6,498,000	1,284,140	5,213,860	3,938,156	-3,648,109	461,345	2,123
Envelope upgrades	Wall upgrade to high performance	3,581	6.8	1,947	10.0	24,138	9.3	4	9.8	1,050	8.6	75	2,556,900	511,380	2,045,520	933,662	-643,614	528,418	1,949
Envelope upgrades	Windows and doors to high performance	1,135	2.2	3,573	18.3	38,853	15.0	7	17.6	1,387	11.4	40	402,800	80,560	322,240	465,460	-175,412	46,443	232
Envelope upgrades	Roof upgrade to high performance	297	0.6	510	2.6	5,682	2.2	1	2.5	211	1.7	20	3,461,000	692,200	2,768,800	3,211,864	-2,921,816	2,783,307	13,100
Envelope upgrades	Exterior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	900	0	900	290,360	312	-	-
Envelope upgrades	Interior lighting renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	22,000	0	22,000	312,915	-22,868	-	-
Envelope upgrades	Unit heaters renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	9,000	0	9,000	299,800	-9,752	-	-
Envelope upgrades	DHW1 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	4,000	0	4,000	294,772	-4,724	-	-
Envelope upgrades	Natural gas stove renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	5,000	0	5,000	295,953	-5,905	-	-
Envelope upgrades	F01 and F02 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	19,000	0	19,000	312,488	-22,440	-	-
Envelope upgrades	Sinks renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10	18,000	0	18,000	316,525	-26,477	-	-
Load minimization	Combined	3,447	6.6	6,604	33.8	73,166	28.3	13	32.7	2,697	22.1	-	6,498,000	1,284,233	5,213,967	3,942,090	-3,652,042	405,254	1,933
Load minimization	Exterior LED lighting upgrade	65	0.1	0	0.0	65	0.0	0	0.0	6	0.1	20	1,500	0	1,500	291,437	-1,389	759,109	231
Load minimization	Interior LED lighting upgrade	3,308	6.3	-105	-0.5	2,204	0.9	-0	-0.3	291	2.4	20	21,000	0	21,000	303,764	-13,717	-205,295	72
Load minimization	Wall upgrade to high performance	3,581	6.8	1,947	10.0	24,138	9.3	4	9.8	1,050	8.6	75	2,556,900	511,380	2,045,520	933,662	-643,614	528,418	1,949
Load minimization	Windows and doors to high performance	1,135	2.2	3,573	18.3	38,853	15.0	7	17.6	1,387	11.4	40	402,800	80,560	322,240	465,460	-175,412	46,443	232
Load minimization	Roof upgrade to high performance	297	0.6	510	2.6	5,682	2.2	1	2.5	211	1.7	20	3,461,000	692,200	2,768,800	3,211,864	-2,921,816	2,783,307	13,100
Load minimization	Low-flow handwashing faucet aerators	0	0.0	373	1.9	3,933	1.5	1	1.8	133	1.1	7	18,000	93	17,907	321,524	-31,276	24,876	135
Load minimization	Unit heaters renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	9,000	0	9,000	299,800	-9,752	-	-
Load minimization	DHW1 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	4,000	0	4,000	294,772	-4,724	-	-
Load minimization	Natural gas stove renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	5,000	0	5,000	295,953	-5,905	-	-
Load minimization	F01 and F02 renewal	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	19,000	0	19,000	312,488	-22,440	-	-

Utility use comparison

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

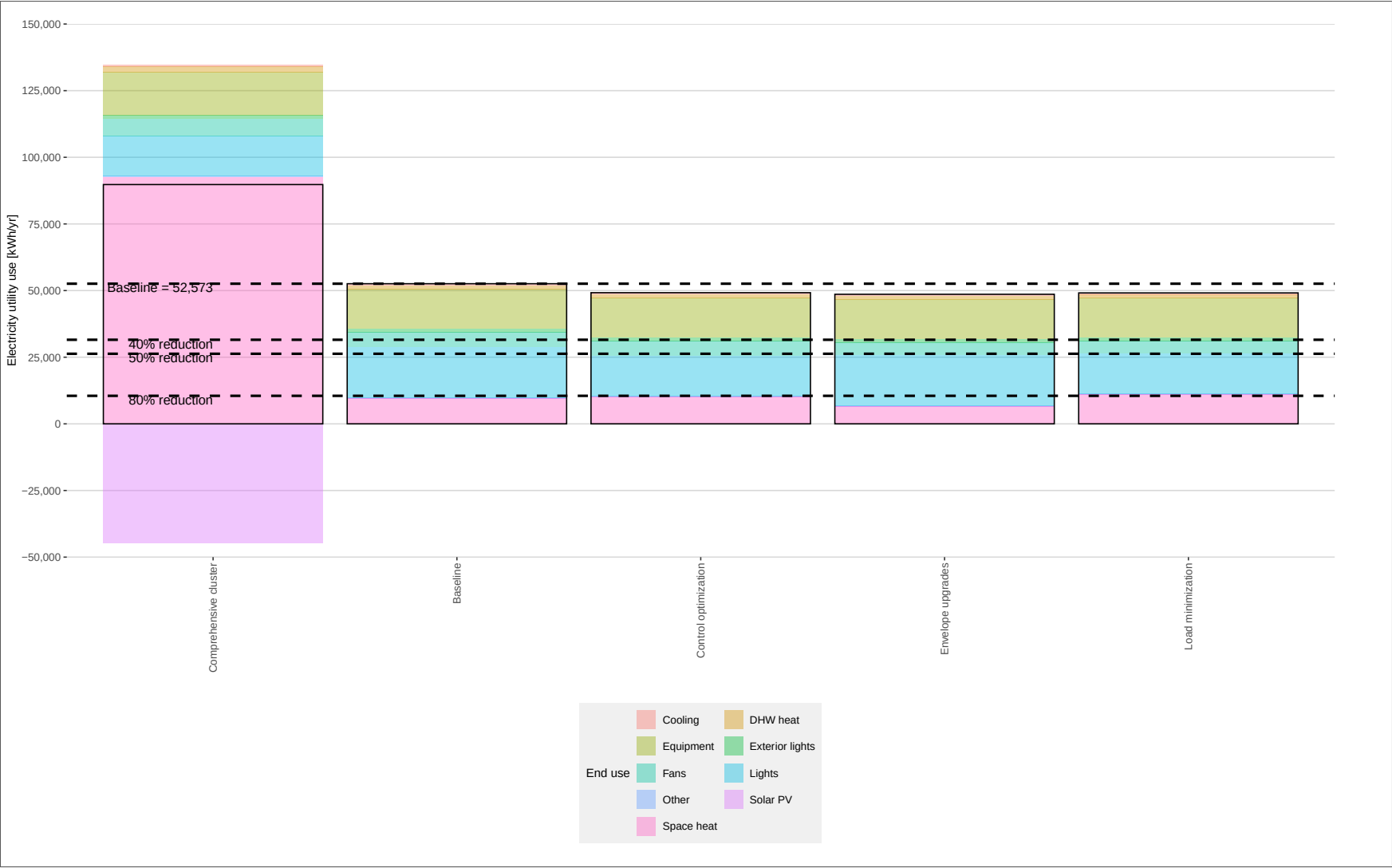


Figure 126: Electricity utility use expected yearly for each scenario by end use

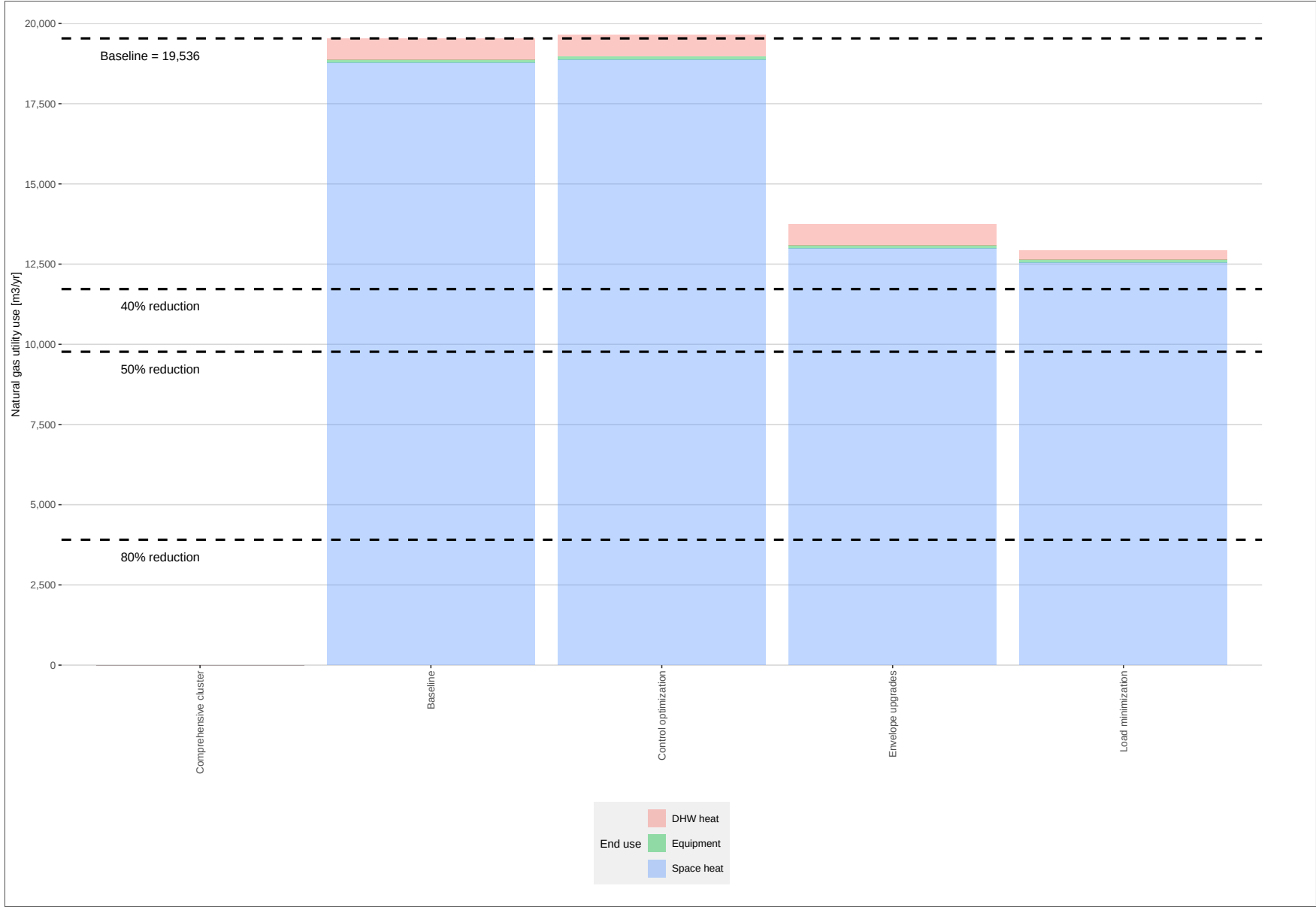


Figure 127: Natural gas utility use expected yearly for each scenario by end use

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.

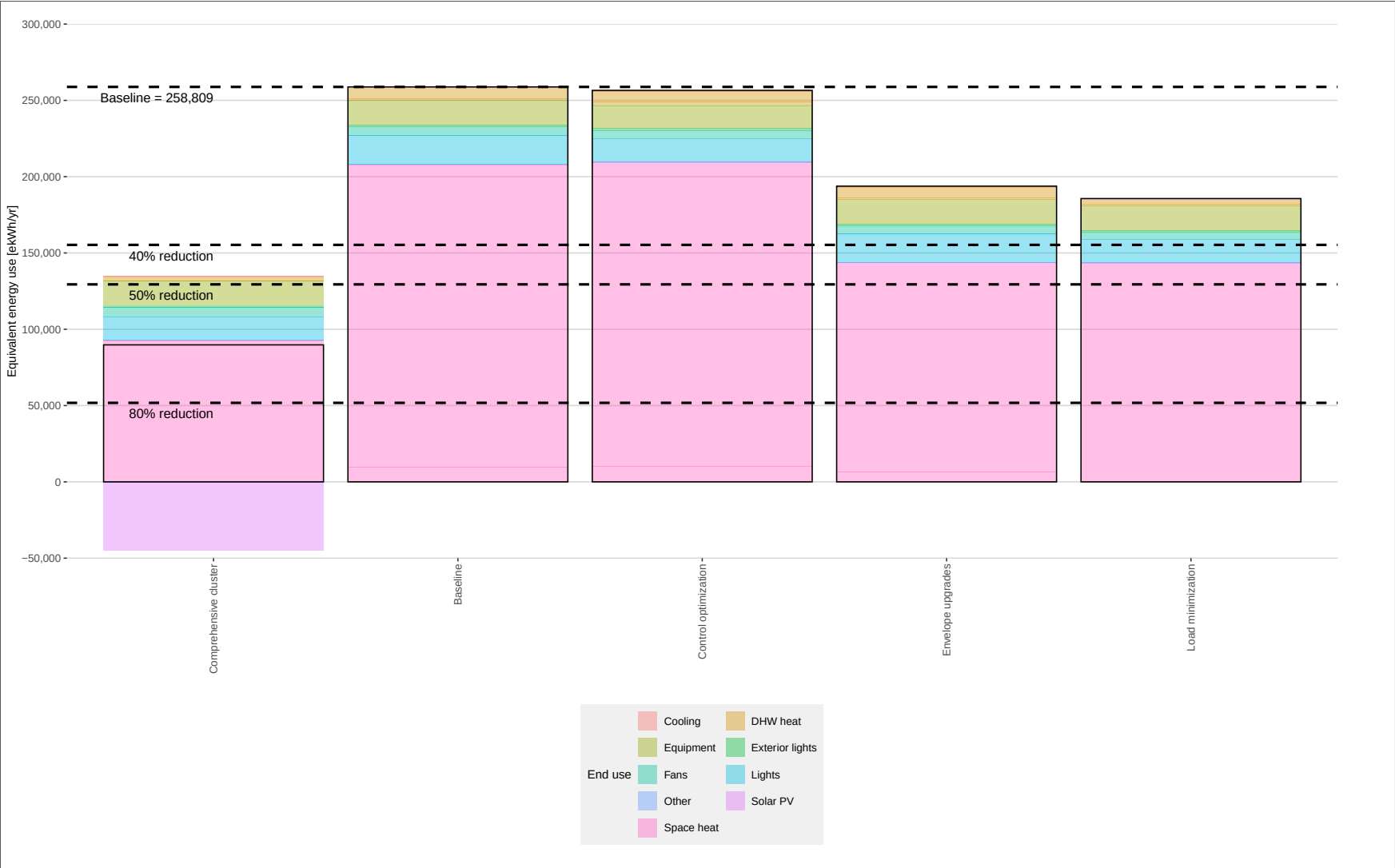


Figure 128: Equivalent energy use expected yearly for each scenario by end use



Figure 129: GHG emissions expected yearly for each scenario by end use

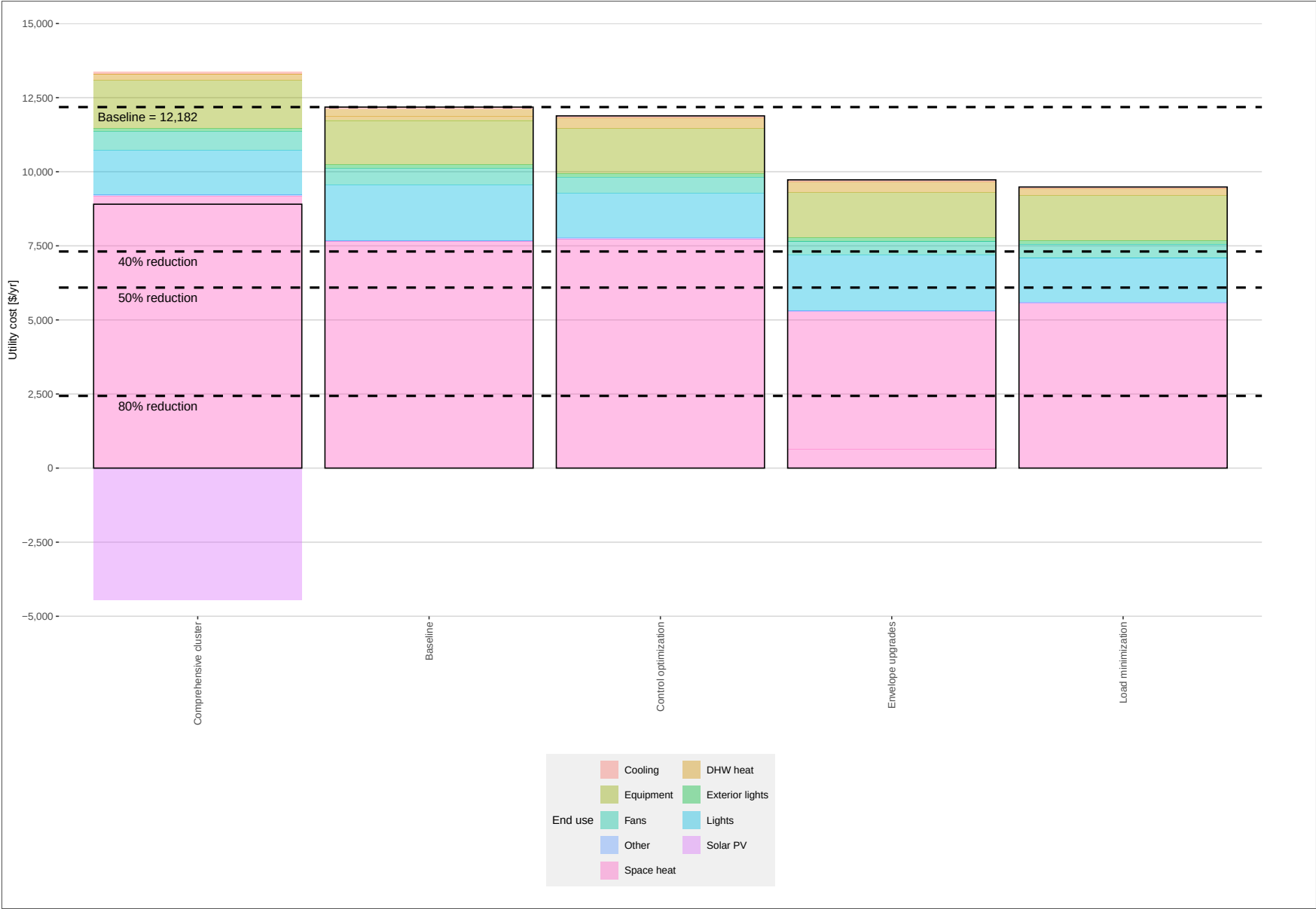


Figure 130: Utility costs expected yearly for each scenario by end use

Financial performance comparison

The following figures compare the financial performance between each scenario.

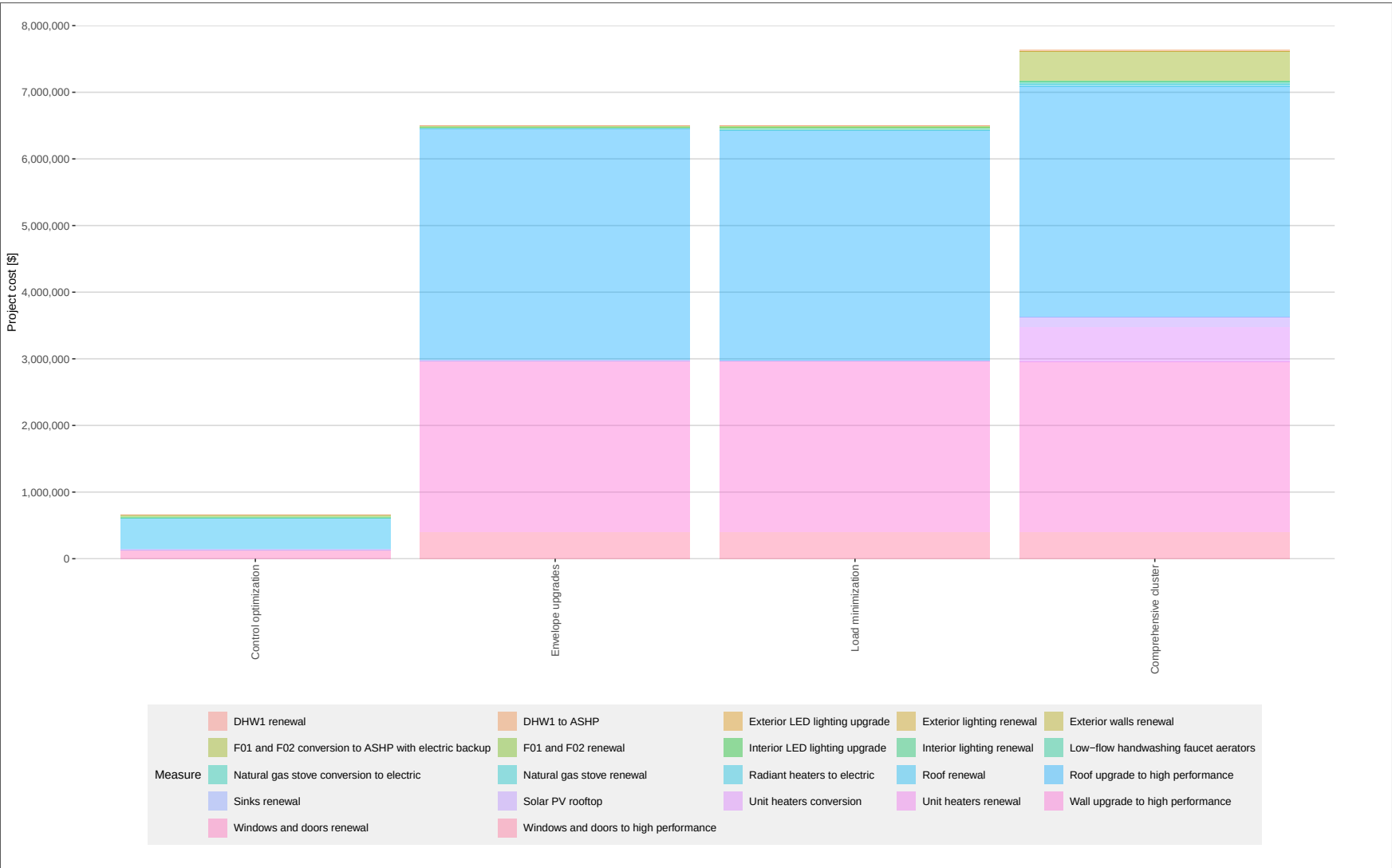


Figure 131: Project cost expected for each scenario by measure

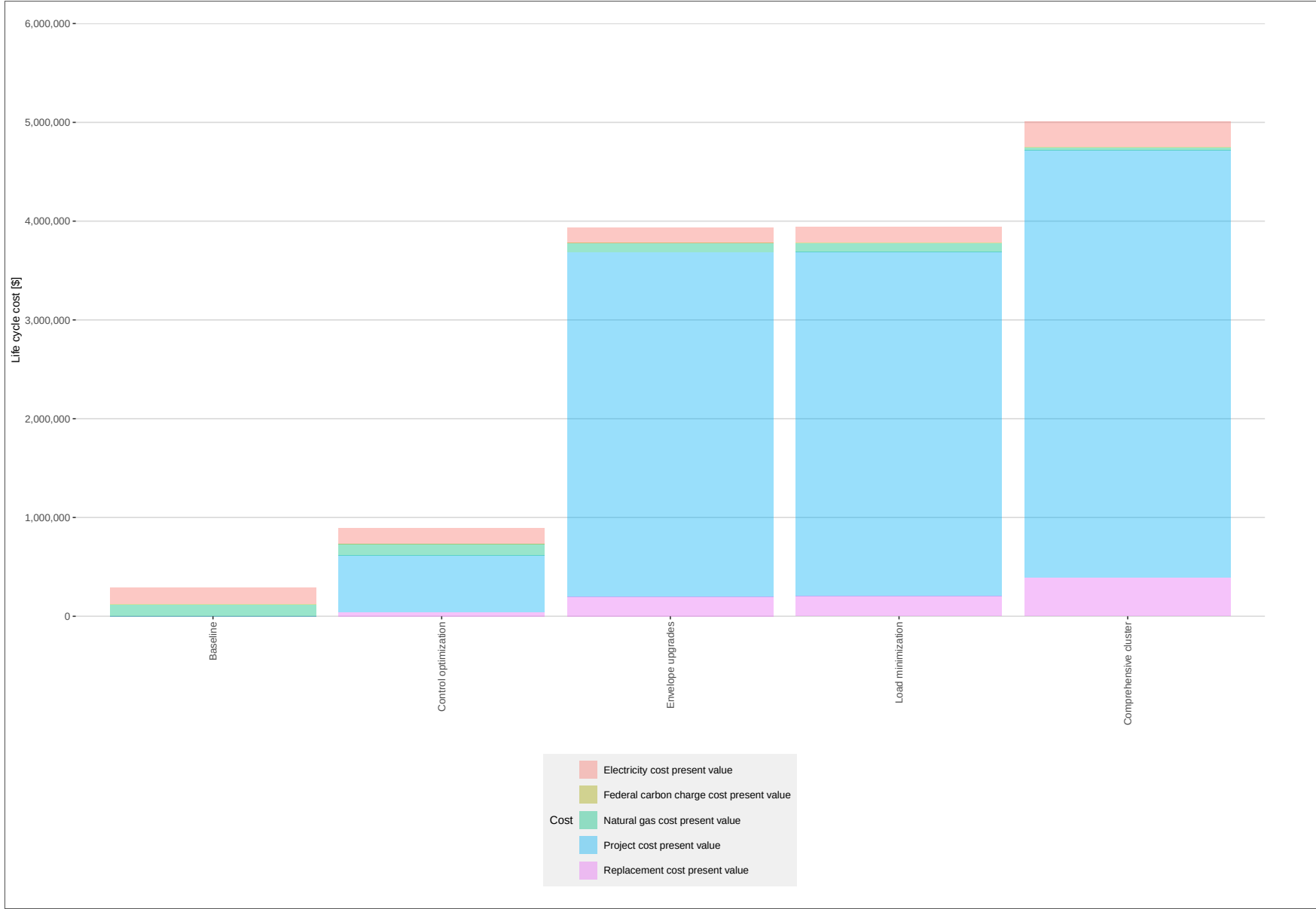


Figure 132: Life cycle cost expected for each scenario by cost item

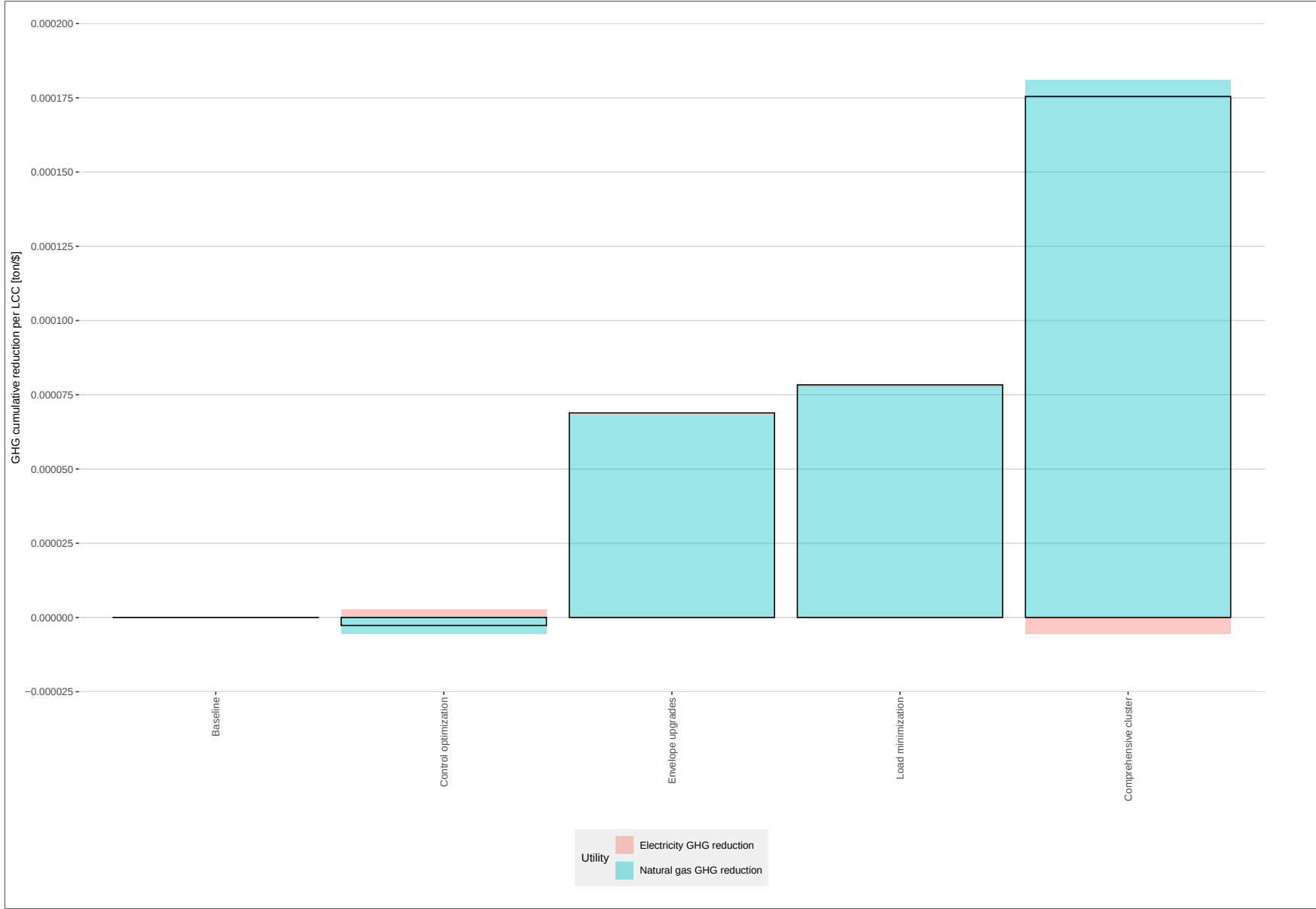


Figure 133: GHG cumulative reduction per life cycle cost (LCC) dollar expected for each scenario by utility

6.5 Plan scenario development

Plan scenario identification and objectives

The plan scenarios that were analyzed and their objectives are summarized in Table 53.

Table 53: 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 53. Results of the plan scenario composition are presented in Figure 134, 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 54 to 59.

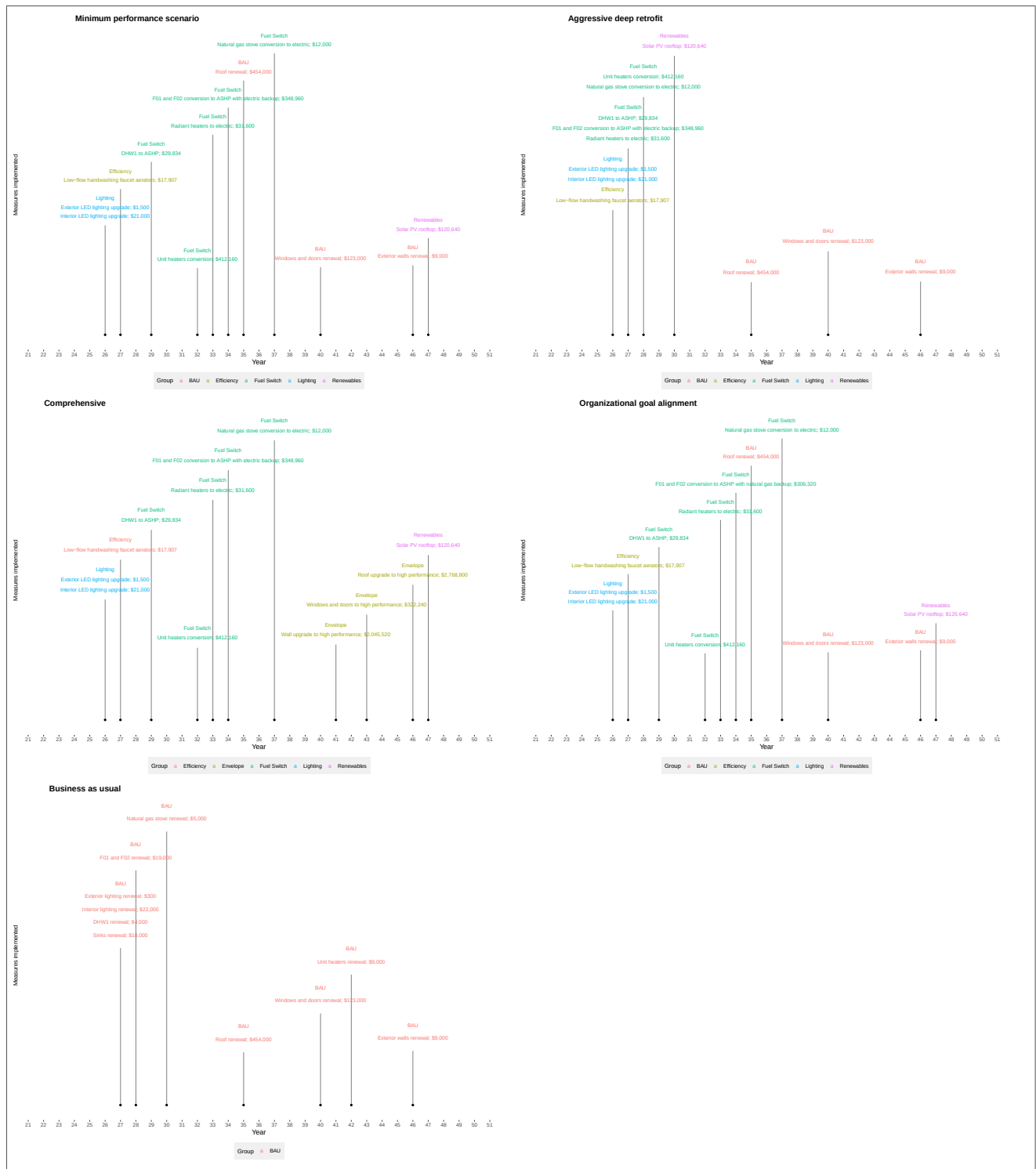


Figure 134: Plan scenario composition, indicating which measures are implemented when and at what cost in each plan scenario

Table 54: Scenario composition summary

Measure	Minimum performance scenario	Aggressive deep retrofit	Comprehensive	Organizational goal alignment
Carbon offsets 20	✗	✗	✗	✗
DHW1 to ASHP	✓	✓	✓	✓
Exterior LED lighting upgrade	✓	✓	✓	✓
F01 and F02 conversion to ASHP with electric backup	✓	✓	✓	✗
F01 and F02 conversion to ASHP with natural gas backup	✗	✗	✗	✓
Interior LED lighting upgrade	✓	✓	✓	✓
Low-flow handwashing faucet aerators	✓	✓	✓	✓
Natural gas stove conversion to electric	✓	✓	✓	✓
Radiant heaters to electric	✓	✓	✓	✓
Roof upgrade to high performance	✗	✗	✓	✗
Solar PV rooftop	✓	✓	✓	✓
Unit heaters conversion	✓	✓	✓	✓
Wall upgrade to high performance	✗	✗	✓	✗
Windows and doors to high performance	✗	✗	✓	✗
DHW1 renewal	✗	✗	✗	✗
Exterior lighting renewal	✗	✗	✗	✗
Exterior walls renewal	✓	✓	✗	✓
F01 and F02 renewal	✗	✗	✗	✗
Interior lighting renewal	✗	✗	✗	✗
Natural gas stove renewal	✗	✗	✗	✗
Roof renewal	✓	✓	✗	✓
Sinks renewal	✗	✗	✗	✗
Unit heaters renewal	✗	✗	✗	✗
Windows and doors renewal	✓	✓	✗	✓

Table 55: Minimum performance scenario measure implementation timeline

Measure	Year
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Low-flow handwashing faucet aerators	2027
DHW1 to ASHP	2029
Unit heaters conversion	2032
Radiant heaters to electric	2033
F01 and F02 conversion to ASHP with electric backup	2034
Roof renewal	2035
Natural gas stove conversion to electric	2037
Windows and doors renewal	2040
Exterior walls renewal	2046
Solar PV rooftop	2047

Table 56: Aggressive deep retrofit measure implementation timeline

Measure	Year
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Low-flow handwashing faucet aerators	2026
DHW1 to ASHP	2027
F01 and F02 conversion to ASHP with electric backup	2027
Radiant heaters to electric	2027
Natural gas stove conversion to electric	2028
Unit heaters conversion	2028
Solar PV rooftop	2030
Roof renewal	2035
Windows and doors renewal	2040
Exterior walls renewal	2046

Table 57: Comprehensive measure implementation timeline

Measure	Year
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Low-flow handwashing faucet aerators	2027
DHW1 to ASHP	2029
Unit heaters conversion	2032
Radiant heaters to electric	2033
F01 and F02 conversion to ASHP with electric backup	2034
Natural gas stove conversion to electric	2037
Wall upgrade to high performance	2041
Windows and doors to high performance	2043
Roof upgrade to high performance	2046
Solar PV rooftop	2047

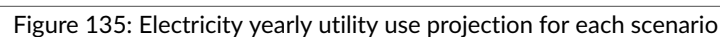
Table 58: Organizational goal alignment measure implementation timeline

Measure	Year
Exterior LED lighting upgrade	2026
Interior LED lighting upgrade	2026
Low-flow handwashing faucet aerators	2027
DHW1 to ASHP	2029
Unit heaters conversion	2032
Radiant heaters to electric	2033
F01 and F02 conversion to ASHP with natural gas backup	2034
Roof renewal	2035
Natural gas stove conversion to electric	2037
Windows and doors renewal	2040
Exterior walls renewal	2046
Solar PV rooftop	2047

Table 59: Business as usual measure implementation timeline

Measure	Year
DHW1 renewal	2027
Exterior lighting renewal	2027
Interior lighting renewal	2027
Sinks renewal	2027
F01 and F02 renewal	2028
Natural gas stove renewal	2030
Roof renewal	2035
Windows and doors renewal	2040
Unit heaters renewal	2042
Exterior walls renewal	2046

Figures 135 through 138 present the projected yearly electricity use, natural gas use, GHG emissions and life cycle costs associated with each plan scenario.



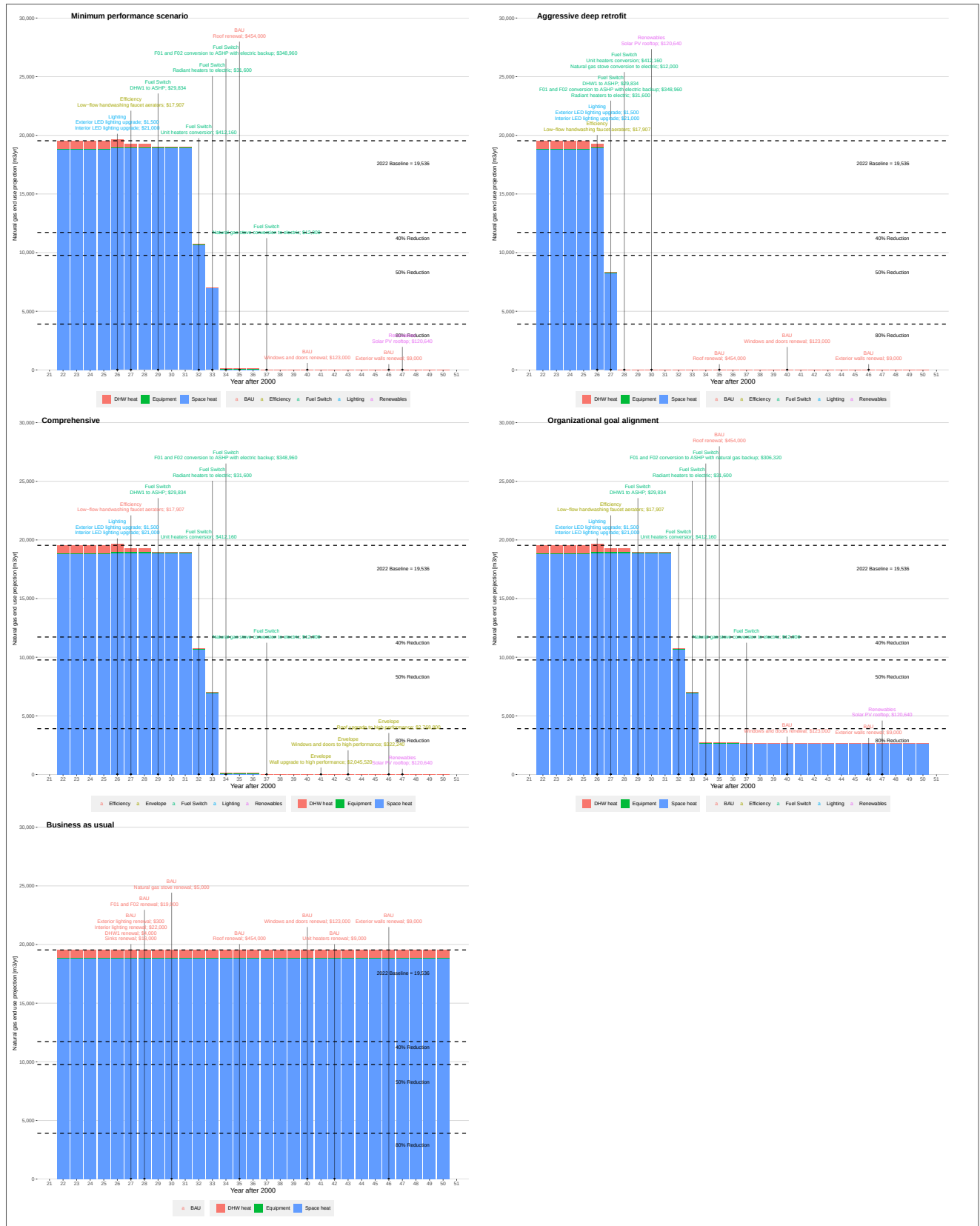


Figure 136: Natural gas yearly utility use projection for each scenario



Figure 137: GHG yearly emissions projection for each scenario

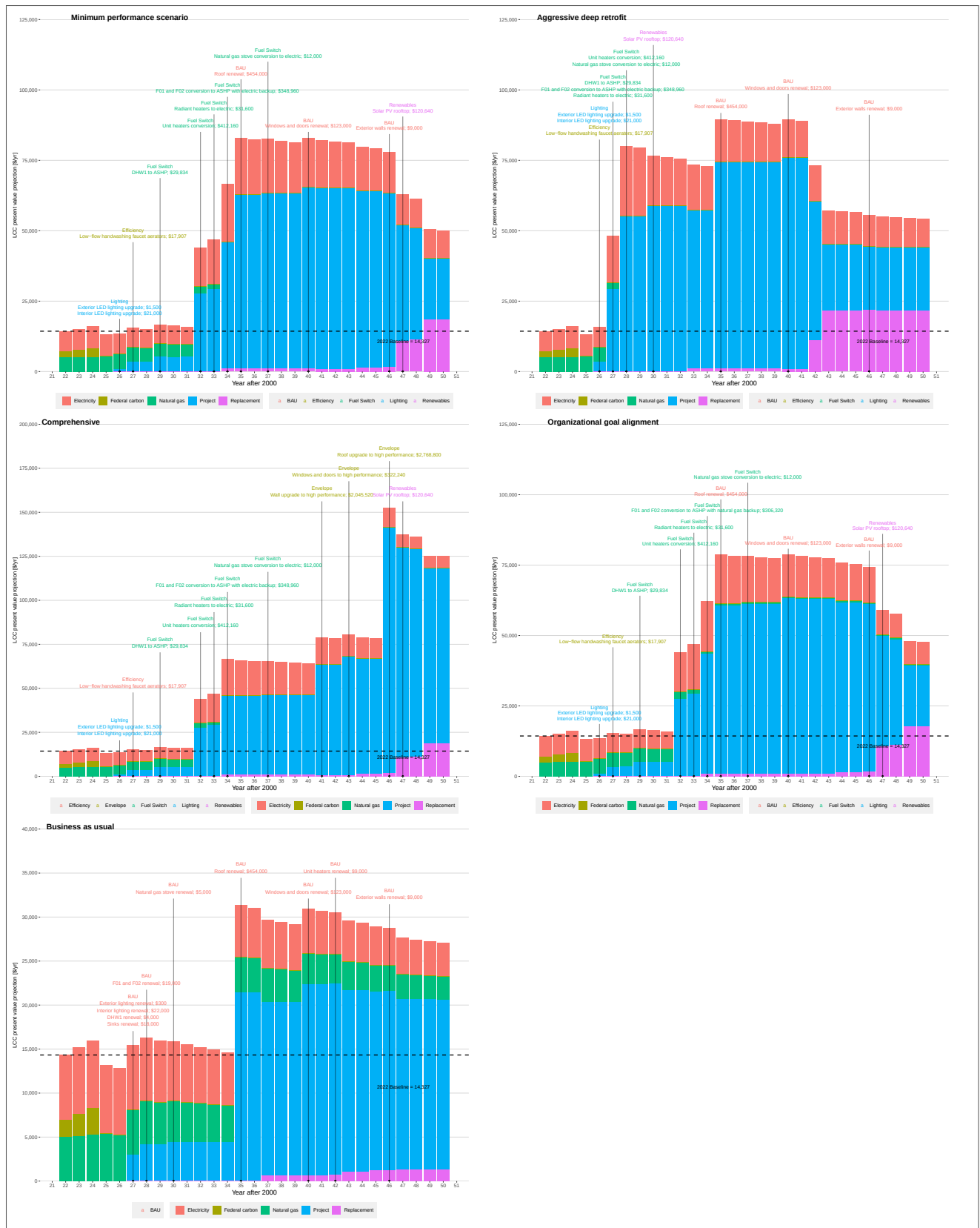


Figure 138: Life cycle yearly cost (after discounting to present value) projection for each scenario

6.7 Plan performance summary

Plan performance summary

Table 60 summarizes the performance of each plan scenario with respect to utility use, GHG emissions, utility cost, and financial metrics. The first half of Table 60 represents the estimated performance in the final year (2050) of the evaluation period. The second half of Table 60 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 60 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 138).

Table 60: 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]	137,188	137,188	89,767	112,410	52,573
	Electricity monthly peak (av)	[kW]	39.7	39.7	29.5	30.4	14.1
	Electricity yearly peak (max)	[kW]	85.8	85.8	65.0	57.1	15.7
	Natural gas use	[m3/yr]	0	0	0	2,637	19,536
GHG emissions final	Electricity GHGs	[tCO2e/yr]	1.3	1.3	0.9	1.1	0.5
	Natural gas GHGs	[tCO2e/yr]	0.0	0.0	0.0	5.1	37.8
	Carbon offsets GHGs	[tCO2e/yr]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e/yr]	1.3	1.3	0.9	6.2	38.3
Utility cost final	Electricity utility cost	[\$/yr]	33,446	33,446	21,885	27,405	12,817
	Natural gas utility cost	[\$/yr]	0	0	0	1,194	8,842
	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]	33,446	33,446	21,885	28,599	21,659
Utility use cumulative	Electricity use	[kWh]	3,669,745	3,622,992	3,265,436	3,248,517	1,524,610
	Natural gas use	[m3]	211,336	105,749	211,336	256,168	566,546
GHG emissions cumulative	Electricity GHGs	[tCO2e]	115	127	109	105	56
	Natural gas GHGs	[tCO2e]	408	204	408	495	1,095
	Carbon offsets GHGs	[tCO2e]	0.00	0.00	0.00	0.00	0.00
	Total GHGs	[tCO2e]	524	332	517	600	1,150
Utility cost cumulative	Electricity utility cost	[\$]	724,841	694,486	633,464	636,775	285,596
	Natural gas utility cost	[\$]	60,755	28,750	60,755	78,155	197,011
	Carbon offsets utility cost	[\$]	0.00	0.00	0.00	0.00	0.00
	Federal carbon charge	[\$]	7,361	7,361	7,361	7,361	7,361
	Total utility cost	[\$]	792,958	730,597	701,581	722,291	489,969
Financial cumulative	Project cost	[\$]	2,214,492	2,026,011	10,812,980	2,150,793	816,982
	Replacement cost	[\$]	856,395	784,160	856,395	813,530	62,649
	Life cycle cost	[\$]	1,510,282	1,795,824	1,769,925	1,444,663	664,109

6.8 Scenario analysis discussion

Baseline

- This scenario reflects existing conditions.

Minimum performance scenario

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

Aggressive deep retrofit

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

Organizational goal alignment

- To achieve the organizational goal alignment of 80% reduction in GHG emissions without carbon offsets, the heating systems must be electrified, although natural gas can be used as a backup heating source.

Comprehensive

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

7 END