Energy Audit Report

Bowen

709 2nd Ave NW, Calgary, AB

Prepared for **Norfolk Housing Association**

Prepared by **Sustainable Projects Group**

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Executive Summary

SPG conducted an energy audit for Norfolk Housing Association at Bowen to assess current energy performance and identify energy conservation measures (ECMs). The audit consisted of a site visit and data analysis based on observations made by the site auditor as well as information provided by Norfolk Housing Association.

The building's average annual consumption, cost, and greenhouse gas (GHG) emissions are summarized in the table below.

Table 1 Energy performance

Utility	Consumption	Energy (GJ/yr.)	Cost ($/yr.)	GHGs (t CO_2e/yr.)
Electricity	111,734 kWh/yr.	402	$19,797	60.3
Natural gas	2,055 GJ/yr.	2,055	$18,873	104.4
Water	3,420 m^3/yr.		$13,904	2.4
Total		**2,457**	**$52,575**	**167.0**

The report has been prepared to meet the energy and greenhouse gas (GHG) reduction targets of the Canada Greener Affordable Housing (CGAH) program. A total of 14 ECMs and one measure for additional consideration were identified. If all recommended ECMs, including onsite energy generation measures, are implemented (excluding additional consideration measures), the building's energy performance would improve by 73%, with an 81% reduction in GHG emissions, meeting the program's requirements.

The implementation of all recommended ECMs would cost $1,227,657, and save $36,418 per year, for an overall payback period of ~21 years. The implementation of all recommended ECMs would reduce the building's energy use intensity (EUI), greenhouse gas intensity (GHGI), energy cost intensity (ECI), and water use intensity (WUI). These results are outlined in the table below.

Table 2 Impact of ECMs on performance

Performance metric	Baseline performance	Benchmark	Performance after ECMs	Potential reduction
EUI (GJ/m^2)	0.99	0.82	0.43	56%*
GHGI (kg CO_2e/m^2)	67.06	91.10	13.01	81%
ECI ($/$m^2$)	$15.52		$10.42	33%
WUI (m^3/m^2)	1.37		0.94	32%

**Excluding on-site energy generation measures*

The identified ECMs, as well as the interactive effects ECMs have on one another when installed together, are outlined in the table below.

Table 3 ECM Summary

ECM		Annual Savings					Finance		
		Electricity (kWh/yr.)	Natural Gas (GJ/yr.)	Water (m^3/yr.)	GHGs (t CO_2e/yr.)	Utility Cost	Project Cost	Simple Payback (yrs.)	Net Present Value @5%
1	Pipe Insulation	0	195	0	9.9	$1,667	$741	<1	$19,004
2	Hydronic Heating Additive	0	87	0	4.4	$748	$2,625	2.8	$4,477
3	LED Upgrade - Fixture	613	0	0	0.3	$105	$1,204	9.6	$187
4	Low Flow Water Fixtures	0	173	1,082	9.5	$5,619	$82,759	11.1	$41,138
6	Energy Star Clothes Washer	1,359	0	8	0.7	$264	$4,777	14.0	-$1,273
7	Energy Star Dryer	4,514	0	0	2.4	$773	$15,919	15.5	-$5,677
8	BAS	0	308	0	15.7	$2,640	$76,414	16.7	-$31,319
11	Humidity Sensor Switch	0	11	0	0.5	$92	$4,537	25.5	-$2,208
12	Condensing Boiler	0	134	0	6.8	$1,146	$51,814	23.8	-$22,690
13	Heat pump (Boiler supplement)	0	960	0	48.7	$8,221	$429,592	26.6	-$289,183
14	High-efficiency MUA	0	37	0	1.9	$320	$62,183	>50	-$56,720
15	Window Upgrade	0	30	0	1.5	$256	$135,075	>50	-$128,564
Energy generation measures:									
5	Rooftop Solar	82,290	0	0	44.4	$14,098	$204,521	11.7	$81,322
10	Solar Carport	31,663	0	0	17.1	$5,425	$155,496	20.0	-$45,511
Net interactive effects		**0**	**-579**	**0**	**-29.4**	**-$4,957**	**$0**		
Total (accounting for interactions)		**120,439**	**1,356**	**1,090**	**134.6**	**$36,418**	**$1,227,657**	**21.2**	**-$529,496**
For additional consideration:									
9	Programmable Thermostats	0	103	0	5.2	$880	$29,534	18.8	-$14,502

1. Introduction

Norfolk Housing Association retained Sustainable Projects Group (SPG) to conduct an energy audit for Bowen. The purpose of this energy audit is to assess energy consumption and identify energy conservation measures (ECMs) with the intent to inform sound energy management decisions. The audit process involves the following stages:

- Creating an inventory of in-scope building components
- Developing an understanding of building systems, operation, and history
- Compiling utility data
- Determining utility baselines and benchmarking
- Calibrating an energy model including all in-scope end-uses
- Identifying and quantifying ECMs, including estimating potential savings and financial feasibility
- Providing insight and recommendations for energy management

This analysis draws on the following sources of information:

- Observations, notes, and pictures taken by SPG during the site assessment
- Communication, written and oral, with Norfolk Housing Association staff
- Documentation provided by Norfolk Housing Association, including:
    - Electricity data for the period of June 2023, to June 2024
    - Water data for the period of May 2023, to June 2024
    - Natural gas data for the period of January 2023, to May 2024
    - Mechanical drawings
    - Architectural drawings
    - Previous Building condition assessment
    - Other as applicable

This study is subject to following limitations:

- The information made available to SPG, as described above, was considered. Where/if key information was not available, attempts to find the information from published resources or best-guess assumptions guided by professional judgement and/or experience were made as needed.
- The accuracy of the information provided to SPG was not independently verified. All provided information was taken at face value.
- The information gathered by SPG during the site assessment was limited to the spaces that were accessible given the conditions at the time of visit. Information about inaccessible or concealed elements was inferred or estimated, when possible, but in some cases may not have been considered
- The site visit was limited to a visual, non-destructive survey. The survey is subject to practical limitations; all items may not have been individually confirmed. The viewing of items was prioritized based on their perceived importance to ensure a comprehensive yet efficient evaluation.
- Unless more contextual information was provided, the equipment operating conditions during the site visit were assumed to be representative of normal operation.

- The scope of the audit is limited to the following systems:
    - Building envelope
    - Heating, ventilation, and air conditioning (HVAC)
    - Domestic hot water (DHW)
    - Lighting
    - Water fixtures
    - Large appliances

Key contacts

We acknowledge and thank all parties who have supported and contributed to this work. For project inquiries, please contact the following persons:

Table 4 Key contacts

Name	Organization	Role	E-mail
Tegan Gallilee-Lang	SPG	Energy Team Manager	tegang@suspg.com
Lance Giesbrecht	SPG	Operations Manager	lanceg@suspg.com
Derek Enns	Norfolk Housing Association	Asset Maintenance Lead	derek.e@norfolkhousing.ca

2. Building and Systems

Bowen is a four-storey, 2,491 m^2 multi-unit residential building located at 709 2^{nd} Ave Northwest in Calgary, Alberta. Built in 1973, the property features 32 residential suites spread across levels 1-4. On average, the building accommodates approximately 35 residents daily.

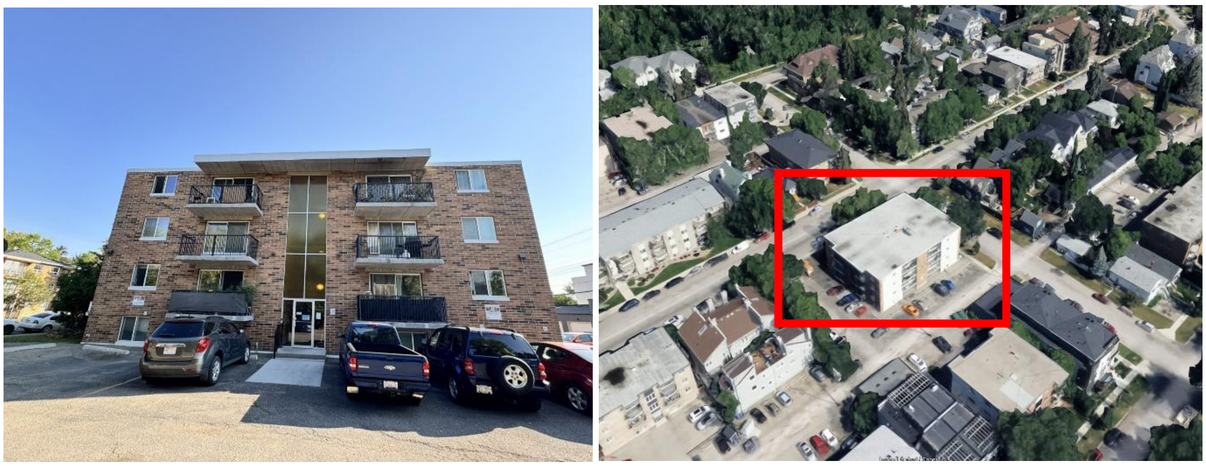

Figure 1 Bowen exterior (left), and simulated aerial view with red highlighting around in-scope building (right, Google Earth, 2024)

2.1. Building envelope

The building features a flat built-up roofing (BUR) system composed of roofing bitumen. The exterior walls are made up of clay brick masonry. Exterior doors consist of glazed aluminum swing doors. Residential suites are fitted with vinyl-framed double-pane windows, while stairwells are equipped with aluminum-framed double-pane windows.

Figure 2 Example envelope components; roof (top left), door (top right), and window (bottom)

A thermal camera was used to view the building envelope and identify areas of poor performance. Images were captured of such areas, if discovered, and of areas showing typical performance. Typically, a minimum temperature differential of 10°C between the building's interior and exterior environments is required for a useful assessment. Since the exterior ambient temperature was ~19°C at the time of the audit, this requirement was not met. The thermal images taken during the site visit have been included below for reference, but they do not support assessments regarding envelope performance. Scheduling thermal scans during the winter months and ideally at night is recommended for effective assessments.

The thermal images show some heat loss, represented in yellow and red colours. Some heightened heat loss is normal at points in the envelope with lower thermal resistance, like at windows and doors. No major areas of concern were noted when reviewing the thermal images.

Figure 3 Example thermal images

2.2. Heating, Cooling, and Ventilation

Space heating

The hydronic heating loop system, located in the Level 1 boiler room, includes two boilers and two circulator pumps. Boilers generally operate during the summer and are controlled via Tekmar controls. Additionally, a rooftop make-up air unit (MUA) serves the hallways and common areas. Heating equipment is catalogued in the table below.

Table 5 Space heating equipment

Equipment	Qty (#)	Location	Service area	Make	Model	Serial number	Year	Rating	Efficiency (%)
Boilers	2	L1 Boiler Room	Hydronic Heating Loop	Allied	AAE480-N-E-M	ABJG-0281	~2004	480,000 btu/h	~80%
MUA	1	Rooftop	Hallways & Common Areas	ICE	No Data	No Data	2015	100,000 btu/h	~80%
Circulator Pump	1	L1 Boiler Room	Hydronic Heating Loop	Grundfos	UMC 65-80 340	91584853	2017	0.74 kW	~80%
Circulator Pump	1	L1 Boiler Room	Hydronic Heating Loop	Grundfos	UMC	96406990	2006	0.74 kW	~80%

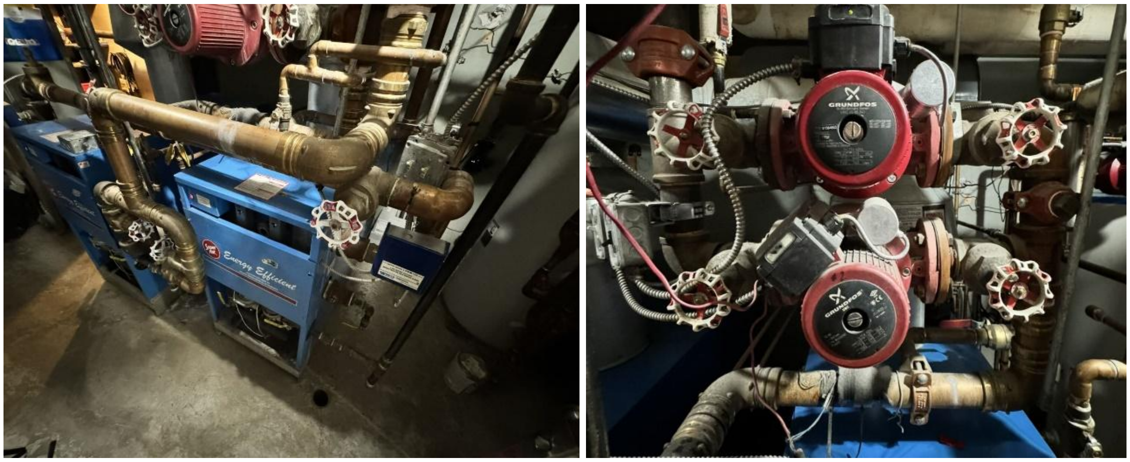

Figure 4 Boilers (left) and heating pumps (right)

Ventilation

A rooftop make-up air (MUA) unit provides ventilation for the hallways and common areas. Ventilation equipment is catalogued in the table below.

Table 6 Ventilation equipment

Equipment	Qty (#)	Location	Service area	Make	Model	Serial number	Year	Rating	Efficiency (%)	Estimated Airflow (CFM)
MUA	1	Rooftop	Hallways & Common Areas	ICE	No Data	No Data	2015	3 hp	~80%	No Data

Figure 5 MUA

2.3. Domestic Hot Water

The building's domestic hot water (DHW) system is powered by two boilers that indirectly heat the water through heat exchangers located within the DHW storage tanks. To maintain a consistent supply of hot water throughout the building, a circulation pump recirculates heated water back to the tank. DHW equipment is catalogued in the table below.

Table 7 DHW Equipment

Equipment	Qty (#)	Location	Service Equipment	Make	Model	Serial number	Year	Rating	Efficiency (%)
Boilers	2	L1 Boiler Room	DHW Loop	Allied	AAE480-N-E-M	ABJG-0281	2004	480,000 btu/h	~80%
HWT Supply Pump	1	L1 Boiler Room	DHW Tank	Grundfos	UPS 32-40	91580023	2013	0.12 kW	~90%
DHW Circulation Pump	1	L1 Boiler Room	DHW Loop	Grundfos	ALPHA2 15-55F/LC	No Data	2021	0.046 kW	~90%

Figure 6 HWT Tank and supply pump (left) and DHW circulation pump (right)

2.4. Lighting

The lighting technology in the building is a combination of incandescent, fluorescent, and LED fixtures for interior and exterior lighting. The most common fixture was a LED A19 sconce. Control types include switches, occupancy sensors, breakers, timers, and daylight sensors. A complete lighting schedule is included in Appendix A.

Figure 7 Example lighting fixtures

2.1. Water Fixtures

The water fixture inventory is presented in the table below.

Table 8 Water fixtures

Area	Type	Qty (#)	Flow/flush rate
L1 – Laundry Room	Faucet, kitchen, residential	1	2.2 gpm
L1 – Laundry Room	Clothes washer, commercial, top-loading	2	15.4 G/cycle
104 - Bachelor	Faucet, kitchen, residential	1	2.2 gpm
104 - Bachelor	Faucet, lavatory, public	1	1.5 gpm
104 - Bachelor	Toilet	1	1.6 gpf
104 - Bachelor	Showerhead, residential	1	2.5 gpm
403 – 1 Bedroom	Faucet, kitchen, residential	1	2.2 gpm
403 – 1 Bedroom	Faucet, lavatory, public	1	1.5 gpm
403 – 1 Bedroom	Toilet	1	1.6 gpf
403 – 1 Bedroom	Showerhead, residential	1	2.5 gpm
L1-4 Unaccessed Suites	Faucet, kitchen, residential	30	2.2 gpm
L1-4 Unaccessed Suites	Faucet, lavatory, public	30	1.5 gpm
L1-4 Unaccessed Suites	Toilet	30	1.6 gpf
L1-4 Unaccessed Suites	Showerhead, residential	30	2.5 gpm

Figure 8 Example water fixtures

2.2. Meters

The following utility meters were identified:

Table 9 Utility meter inventory

Meter Description	Utility type	Number	Location
Whole building	Electricity	682208	L1 Boiler Room
Whole building	Natural gas	No Data	Exterior
Whole building	Water	8012384202	L1 Boiler Room

2.3. Other

The laundry room houses two dryers and washers, supporting the building's laundry services. This equipment is catalogued in the table below.

Table 10 Other equipment

Equipment	Qty (#)	Location	Service area	Make	Model	Serial number	Year	Rating	Efficiency (%)
Dryers	2	Laundry Room	Laundry	Huebsch	HDGR09WF1102	0902020398	No Data	7.3 kW	~100%
Washers	2	Laundry Room	Laundry	Huebsch	HWTB21WM1102	101005284	No Data	~5 kW	~100%

Figure 9 dryers and washers

3. Performance

The building's energy and water performance were evaluated by analyzing utility data. The following table summarizes the source information:

Table 11 Utility data sources

Utility	Data type	Utility provider	Period	Notes
Electricity	Monthly utility bills from utility provider	Transalta	June 2023 to June 2024	All months within the data period have associated data.
Natural gas	Monthly utility bills from utility provider	Direct Energy	January 2023 to May 2024	All months within the data period have associated data.
Water	Monthly utility bills from utility provider	The City of Calgary	May 2023 to May 2024	All months within the data period have associated data.

3.1. Historical Data

Utility consumption trends are described below, alongside figures depicting monthly consumption. The tabulated monthly utility data is included in Appendix B.

Electricity

Due to only having twelve months of utility data, the identification of seasonal or other recurring trends is challenging. Notable peaks in consumption are observed in January and March 2024. The exact cause of these peaks is unknown. Baseload consumption is assumed to be attributed to loads that do not vary seasonally, such as ventilation and plug loads. The cause of the high consumption apparent in July 2023 is unknown but is assumed to be a billing anomaly or correction rather than being representative of actual consumption in July. Consumption data in September to October 2023 were omitted, as they were deemed anomalous compared to trending electricity consumption.

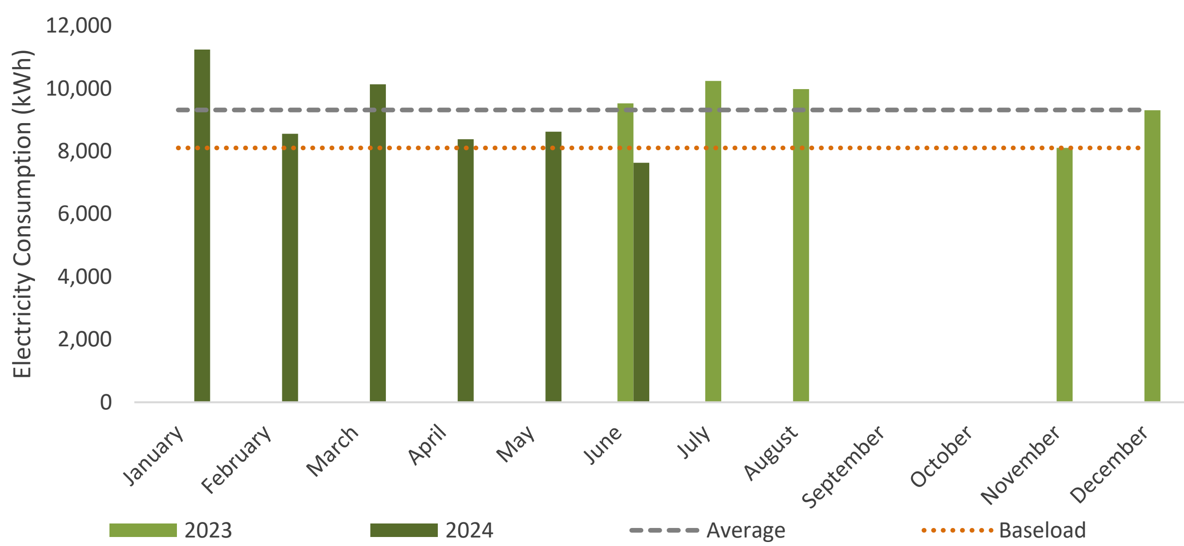

Figure 10 Electricity consumption over time

Natural gas

Natural gas consumption exhibits a non-homogeneous pattern characterized by a notable increase during the colder months. The observed trend of increased consumption from November to March can be attributed to the amplified demand for heating systems for the entire building. The baseload consumption is primarily associated with space heating. Consumption data in September to October 2023 were omitted, as they were deemed anomalous compared to trending natural gas consumption.

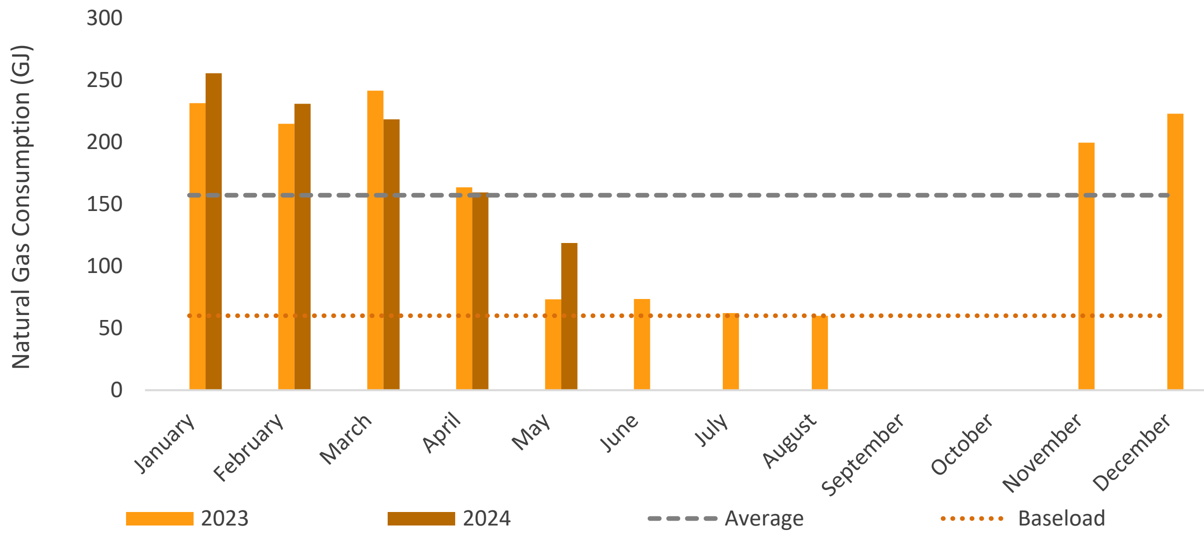

Figure 11 Natural gas consumption over time

Water

The water consumption appears to remain relatively consistent with an apparent increase from March to June 2024, though the cause is challenging to determine. Baseload consumption is attributed to the use of faucets, showerheads, and toilets.

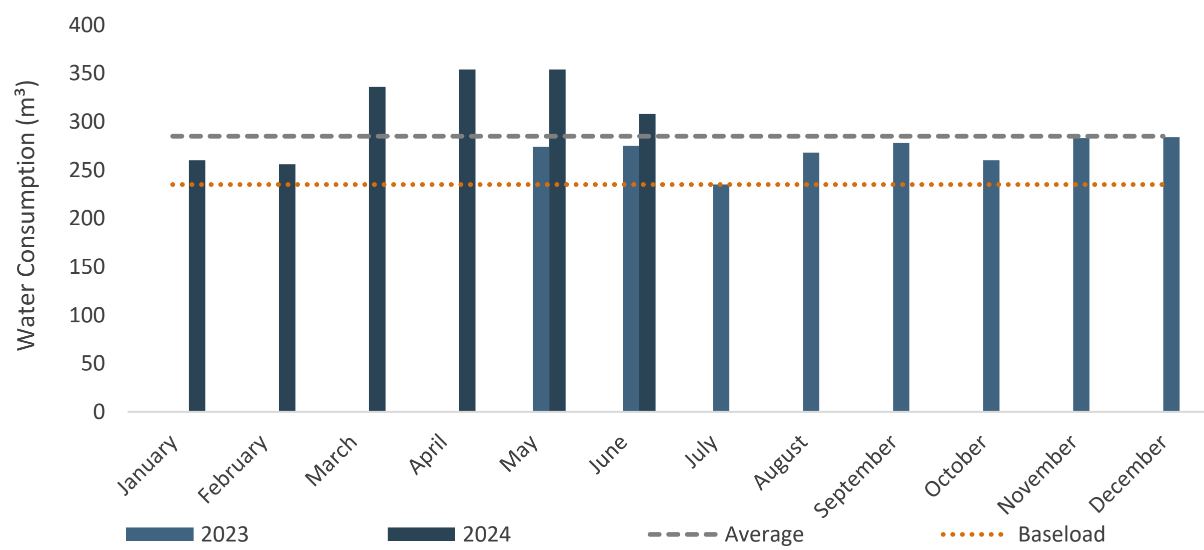

Figure 12 Water consumption over time

3.2. Baseline

The baseline annual consumption, cost and GHG emissions for each utility were calculated based on the average annual value for the entire period of available data. These results are presented in the table below.

Table 12 Baseline consumption, cost and GHGs

Utility	Consumption	Energy (GJ/yr.)	Cost ($/yr.)	GHGs (t CO_2e/yr.)
Electricity	111,734 kWh/yr.	402	$19,797	60.3
Natural gas	2,055 GJ/yr.	2,055	$18,873	104.4
Water	3,420 m^3/yr.		$13,904	2.4
Total		**2,457**	**$52,575**	**167.0**

Emission factors

The following table outlines the emission factors used to calculate GHGs for the baseline, and for the GHG reduction estimates in the ECM section.

Table 13 Emission factors

Utility	Emission factor	Source
Electricity	0.540 kg CO_2e/kWh	National Inventory Report: Greenhouse Gas Sources and Sinks in Canada (2023). Part 3, Annex 13
Natural Gas	50.784 kg CO_2e/GJ	National Inventory Report: Greenhouse Gas Sources and Sinks in Canada (2023). Part 2, Annex 6
Water	0.689 kg CO_2e/m^3	Maas, Carol. Greenhouse Gas and Energy Co-Benefits of Water Conservation. POLIS Project on Ecological Governance, University of Victoria. November 2008. Tables B-1 and D-3

Utility rates

An estimated marginal utility rate was used for each utility type to calculate cost savings from ECM implementation. The marginal utility rate is the rate representing only consumption-variable utility charges. This may include consumption charges, consumption-variable transmission/distribution/delivery charges, carbon taxes, municipal fees, and other federal and provincial taxes as applicable. This rate excludes all fixed charges such as monthly or daily service and delivery charges, and demand charges, which are typically not affected by ECM implementation.

The marginal utility rates were estimated using a linear regression analysis. The statistical relationship between cost and consumption was assessed in order to differentiate fixed and consumption-variable cost components. Consumption data in September to October 2023 were omitted from electricity and natural gas, as they were deemed anomalous compared to their trending utility consumption.

The marginal utility rates for the building are outlined in the table below.

Table 14 Utility rates

Utility	Marginal utility rate
Electricity	$0.17/kWh
Natural Gas	$8.57/GJ
Water	$3.83/m³

3.3. Benchmarking

Benchmarking is the evaluation of a building's performance by comparing it to other buildings with similar characteristics. Building performance is expressed per unit area, so that buildings of different sizes may be compared. Buildings are typically compared with others in the same country or region and the same general use category, since these will be expected to have similar energy sources and requirements.

Baseline values for energy use intensity (EUI), greenhouse gas emission intensity (GHGI), energy cost intensity (ECI), and water use intensity (WUI) are provided. The benchmark values for EUI are Canadian national median values by property type, and the benchmark values for GHGI are Canadian regional median values by property type from Energy Star Portfolio Manager (2023).

The table below outlines the baseline results for each metric, and the associated benchmarks, where they are available.

Table 15 Baseline performance and benchmarks

Metric	Baseline	Benchmark
EUI (GJ/m^2)	0.99	0.82
GHGI ($kgCO_2e/m^2$)	67.06	91.10
ECI ($\$/m^2$)	15.52	
WUI (m^3/m^2)	1.37	

3.4. End Uses

End uses were identified, and energy or water consumption was allocated to each end use. Quantifying how much of a utility a particular system consumes enables us to calculate utility savings from the implementation of ECMs.

Electricity

Electricity consumption was allocated to different end uses by considering a variety of factors, including equipment specifications, controls, schedules, typical runtimes, and utility baseload and variable consumption. The Plug Loads end use was estimated based on the difference between the consumption in other categories and the total estimated annual electricity consumption. The Plug Loads as included correspond to 5 W/m2, which is the estimated peak receptacle load value in the National Energy Code of Canada for Buildings 2017 (NECB) for the multi-unit residential building type.

The figure below shows the proportion of electricity consumed by the building's different end uses. Plug Loads system, which include dryers, washers, and other miscellaneous uses, consume the most electricity in the building.

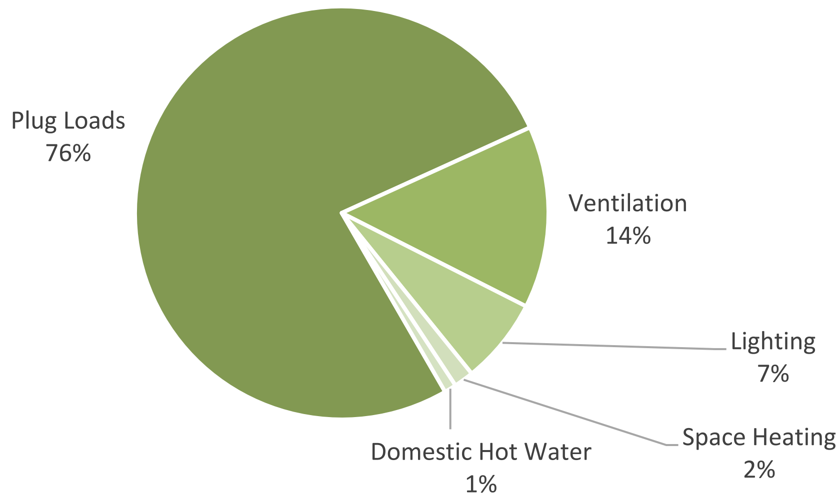

Figure 13 Electricity end uses

Natural gas

Natural gas consumption was allocated to different end uses by considering a variety of factors, including equipment specifications, controls, schedules, typical runtimes, and utility baseload and variable consumption. The figure below shows the proportion of natural gas consumed by the building's different end uses. The space heating system consumes the most natural gas in the building.

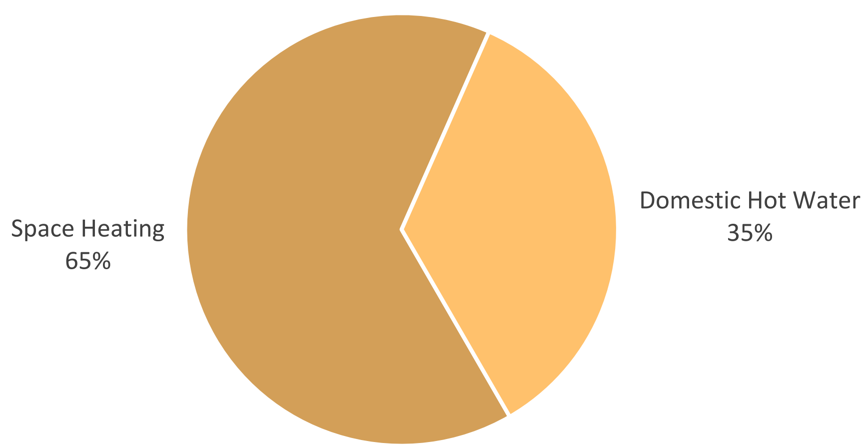

Figure 14 Natural gas end uses

Water

Water consumption was allocated to different end uses by multiplying the equipment flow rate by the estimated usage, while considering building occupancy and baseload and variable consumption. Values for use duration were taken from the LEED v4 indoor Water Use Reduction Calculator.

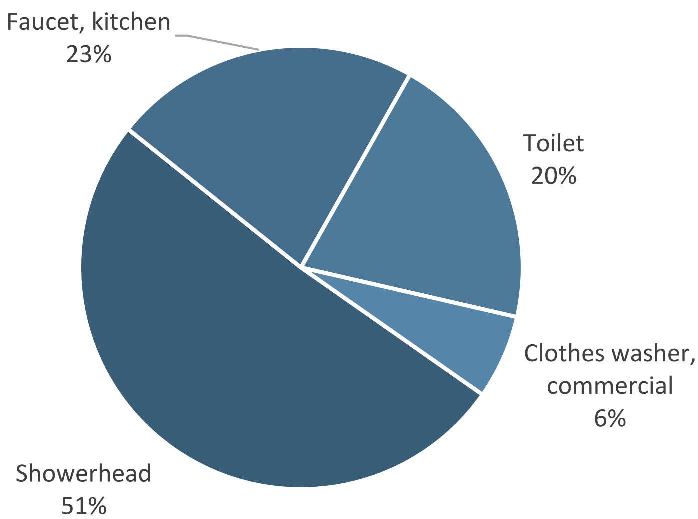

Figure 15 Water end uses

4. Energy Conservation Measures

An array of ECMs were identified which would improve energy and/or water performance. A wide variety of ECMs were considered, and only measures that could be implemented based on the building's unique characteristics were thoroughly investigated.

One measure for additional consideration is also outlined. These are measures which were investigated but are not recommended for implementation. This may be because there is no business case for the project, because our analysis is low confidence, because we have insufficient information to recommend the project, because the project directly conflicts with a recommended project, or as specified.

The metrics used to quantify each ECM and select details about the analysis methods are described below:

Cost

This metric describes the project's implementation cost, in Canadian dollars. The costs are class D, budgetary estimates (-20 to +30%). The actual project cost will be determined at the time of project initiation, to reflect current pricing, and in many cases following the completion of a detailed design. The cost estimates include the labour and materials for the project, but unless otherwise indicated, do not include engineering, design, travel, or other costs.

Utility Savings

This metric describes the reduction in annual energy or water consumption the project is estimated to achieve. Any negative savings, such as for electrification projects, represent an increase in utility consumption.

Interactive Effects

Each project has first been analyzed individually, with savings calculated as if no other projects are implemented. If multiple projects are implemented, the total savings may be reduced if multiple projects affect the same system. These interactions have been estimated using a generalized approach, described below.

The savings of each ECM are assigned as either a fixed-quantity reduction or a percentage reduction of the baseline consumption of a piece of equipment or group of equipment. This determination is made by an analyst based on the type of equipment and the type of measure being proposed. Where multiple ECMs impact the same equipment, the fixed reductions are summed together and then the percentage reductions are multiplied together, to determine the estimated interactive savings. Savings for groups of equipment are applied proportionally to all units within the group based on their baseline consumption.

Interactions between the system directly associated with an ECM and other systems, such as changes in internal heat gain due to a lighting upgrade, have typically not been considered. Measures for additional considerations were not accounted for when calculating interactive effects.

Results from project interactions are outlined in the 'net interactions' row of the ECM summary table, located at the end of this section. The 'total' row includes the sum of the ECMs and their interactions.

Cost Savings

This metric describes the estimated cost savings the project will achieve based on the utility consumption savings in the first year of the cashflow analysis. The cost savings ($/yr.) are calculated by multiplying the utility savings by the marginal utility rate. Note that the cost savings in subsequent years of the cashflow analysis change based on the modelled utility rate escalation, as described below.

Greenhouse Gas (GHG) Emission Savings

This metric describes the amount of GHG savings the project is estimated to achieve. It is measured in tonnes of carbon dioxide equivalent per year (tCO_2e). To calculate emissions savings, the fuel savings (kWh or GJ/yr.) are multiplied by the emission factor (tCO_2e/kWh or GJ). ECM lifetime GHG emissions savings are based on this annual savings value multiplied by the measure life, thus projected decreases in the electricity grid emission factor are not accounted for.

Simple Payback

This metric is the number of years it would take for the cost savings to be equal to the implementation cost. In other words, it is the length of time to earn back the project's cost. The lower the simple payback, the better. Note that the simple payback has been calculated considering utility rate escalation but without any discount rate applied to future cashflows.

Net Present Value (NPV)

Similar to simple payback, the NPV describes the financial feasibility of the project. In contrast to simple payback, it considers the opportunity cost, or the value that a certain amount of money today would have if it were to achieve a specified rate of return over time. The NPV encompasses the project cost and the annual cashflow analysis savings discounted at a rate of 5% per year, over the lifespan of the project. The higher the net present value, the better, and a value greater than zero is generally considered a worthwhile investment.

Utility Rate Escalation

The simple payback and the NPV account for utility cost escalation. Based on the GHG emission rate for each utility, that utility’s marginal rate identified for the first year of the cashflow analysis is broken into a carbon tax component and a non-carbon tax component. The carbon tax component is increased based on the federal and/or provincial legislated carbon tax escalations to 2030, as applicable. Projected changes to the provincial electricity GHG emission intensity are accounted for in how this carbon tax component changes for electricity. The non-carbon tax component is escalated at a constant rate of 3.5% per year.

Each identified ECM is described in detail below.

4.1. Pipe Insulation

Adding insulation to exposed hot piping reduces heat loss from the fluid to the environment as it travels through the piping. By reducing heat loss within the system, the return fluid will be at a higher temperature, reducing the load on heating equipment. Consequently, the energy consumption will be reduced. This ECM explores adding insulation to exposed piping in the boiler room for the space heating and domestic hot water system.

Table 17 Individual ECM Results

Labour Cost:	$440
Material Cost:	$301
Project Cost:	$741
Annual Natural Gas Savings:	195 GJ/yr.
Annual Utility Cost Savings:	$1,667
Simple Payback:	<1 yrs.
Measure Life:	10 yrs.
Annual GHGs:	9.9 t CO_2e
Lifetime GHG Reduction:	99 tonnes CO_2e
Net Present Value:	$19,004
Internal Rate of Return:	260%

Savings and Cost Assumptions

- The estimated natural gas savings are calculated based on the difference between the existing heat loss from the uninsulated piping and the theoretical heat loss after an insulating layer has been added to the hot bare piping. These calculations are based on several assumptions such as room and fluid temperatures, piping material, wind factor, piping diameter, and the total length of uninsulated piping. Actual savings will depend on the real value of those variables, as well as insulation thickness and material selection.
- The project cost was sourced from vendors and includes materials and labour for adding insulation to a total ~38 feet of piping.

	Bowen
Room temperature	28°C
Fluid temperature	70°C
Piping material	Aluminium
Piping diameter	Various

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 18: Pipe insulation - LCCA Key Outputs

Pipe Insulation - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$1,316
Operation NPV @ LCCA end year (Y0$; NPV)	$27,480
Total NPV @ LCCA end year (Y0$; NPV)	$26,163

Table 19: Pipe Insulation – Sensitivity Analysis

Pipe Insulation - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	$31,717	$26,163	$22,016
Energy Rate ($4/GJ, $8.11/GJ, $10/GJ)	$15,137		$31,234
Fuel Rate/Maintenance Inflation (1% 2%,4%)	$27,826		$23,491

*Most likely Scenario = real discount rate: 6%, energy rate: $8.11/GJ, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to further discuss this ECM
- Schedule a site visit by a qualified technician to assess piping layouts. SPG can assist with this.

4.2. Hydronic Heating Additive

Hydronic heating system use water/glycol as the medium for heat transfer. These fluids have high surface tensions that detract from their heat transfer efficiency. Heating fluid additives reduce the surface tension of working fluids to improve thermal contact between the fluid and the inner wall of the piping system. This increases the thermal transfer rate, improving the overall efficiency of the heating system. This ECM explores introducing heating additive to the hydronic loop at Bowen.

Table 20 Individual ECM Results

Labour Cost:	$300
Material Cost:	$2,325
Project Cost:	$2,625
Annual Natural Gas Savings:	87 GJ/yr.
Annual Utility Cost Savings	$748
Simple Payback:	2.8 yrs.
Measure Life:	8 yrs.
Annual GHGs	4.4 t CO_2e
Lifetime GHG Reduction:	35 tonnes CO_2e
Net Present Value:	$4,477
Internal Rate of Return:	35%

Savings and Cost Assumptions

- 5% savings were applied to natural gas consumption from the boilers. Case studies from Endotherm, a hydronic heating additive supplier, have shown that consumption savings range from 5-8% for residential buildings.
- The material cost is sourced from Endotherm, and includes 2 gallons of additive
- The labour cost includes one hour of work at 300$/hr.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 21: Hydronic Heating Additive - LCCA Key Outputs

Hydronic Heating Additive - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$5,495
Operation NPV @ LCCA end year (Y0$; NPV)	$12,325
Total NPV @ LCCA end year (Y0$; NPV)	$6,830

Table 22: Hydronic Heating Additive – Sensitivity Analysis

Hydronic Heating Additive - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	$8,654	$6,830	$5,477
Energy Rate ($4/GJ, $8.11/GJ, $10/GJ)	$1,885		$9,104
Fuel Rate/Maintenance Inflation (1% 2%,4%)	$7,576		$5,632

*Most likely Scenario = real discount rate: 6%, energy rate: $8.11/GJ, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to further discuss this ECM. Case studies can be provided upon request
- Schedule a free site assessment by a hydronic heating additive technician to finalize the volume of additive required and to determine if water treatment is required prior to installation

4.3. LED Lighting

Light emitting diode (LED) fixtures produce more light per unit power than any other type of light source. Therefore, upgrading to LED fixtures reduces electricity consumption. The existing lighting system uses a combination of incandescent, fluorescent, and LED fixtures for interior and exterior lighting. This ECM explores replacing the existing non-LED lights to LED fixtures.

Table 22 Individual ECM Results

Labour Cost:	$1,035
Material Cost:	$169
Project Cost:	$1,204
Annual Electricity Savings:	613 kWh/yr.
Annual Utility Cost Savings:	$105
Simple Payback:	9.6 yrs.
Measure Life:	15 yrs.
Annual GHG Reduction	0.3 t CO_2e
Lifetime GHG Reduction:	5 tonnes CO_2e
Net Present Value:	$187
Internal Rate of Return:	7%

Savings and Cost Assumptions

- The energy savings estimated for the LED lighting upgrades were calculated using the estimated annual hours of operation of each light fixture and the difference in wattage between the existing fixture and the proposed LED fixture.
- The presented cost is inclusive of all project expenses, such as materials, labour, travel, rentals, etc.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 23: LED Lighting - LCCA Key Outputs

LED Lighting - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$1,632
Operation NPV @ LCCA end year (Y0$; NPV)	$1,014
Total NPV @ LCCA end year (Y0$; NPV)	-$618

Table 24: LED Lighting – Sensitivity Analysis

LED Lighting - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	-$529	-$618	-$678
Energy Rate ($0.05/kWh, $0.12/kWh, $0.20/kWh	-$1,209		$58
Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$618		-$618

*Most likely Scenario = real discount rate: 6%, energy rate: $0.12/kWh, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to follow up with any project questions, concerns, or desired changes to the project scope

4.4. Low Flow Water Fixtures

Upgrading water fixtures to models with low flow/flush rates would reduce water consumption while still meeting water delivery needs. For fixtures that deliver hot water (faucets and showerheads), fuel consumption associated with the DHW system will also be reduced. This ECM explores replacing eligible water fixtures in the building with low flow models.

Table 25 Individual ECM Results

Labour Cost:	$30,282
Material Cost:	$52,477
Project Cost:	$82,759
Annual Natural Gas Savings:	173 GJ/yr.
Annual Water Savings:	1,082 m^3/yr.
Annual Utility Cost Savings	$5,619
Simple Payback:	11.1 yrs.
Measure Life:	25 yrs.
Annual GHGs	9.5 t CO_2e
Lifetime GHG Reduction:	238 tonnes CO_2e
Net Present Value:	$41,138
Internal Rate of Return:	9%

Savings and Cost Assumptions

- Water savings were calculated based on estimated fixture usage and the existing and proposed flow rates. The proposed rates are 1.28 GPF for toilets, and 1.5 GPM for showerheads and faucets.
- Natural gas savings were calculated based on typical cold water/hot water ratios and the efficiency of the existing DHW system.
- The project cost includes the materials and labour for installing 32 toilets, 32 showerheads, and 33 faucets. The costs were derived from RSMeans and fixture vendors.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 26: Low Flow Water Fixtures -LCCA Key Outputs

Low Flow Water Fixtures - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$83,530
Operation NPV @ LCCA end year (Y0$; NPV)	$76,593
Total NPV @ LCCA end year (Y0$; NPV)	-$6,937

Table 27: Low Flow Water Fixtures– Sensitivity Analysis

Low Flow Water Fixtures - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	$8,408	-$6,937	-$18,420
Energy Rate ($4/GJ, $8.11/GJ, $10/GJ)	-$16,733		-$2,432

Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$5,460		-$9,312

*Most likely Scenario = real discount rate: 6%, energy rate: $8.11/GJ, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to further discuss this ECM
- Finalize water fixture replacement schedule
- Obtain a formal quote from SPG or plumbing contractors

4.5. Rooftop Solar

A solar photovoltaic (PV) system provides the building with on-site renewable energy generation. The Bowen building is a good candidate for a solar PV system due to its large flat roof with southern exposure and minimal obstructions. This ECM explores adding a solar PV system to the building's roof.

Table 28 Individual ECM Results

Labour Cost:	$28,312
Material Cost:	$176,208
Project Cost:	$204,521
Annual Electricity Savings:	82,290 kWh/yr.
Annual Utility Cost Savings:	$14,098
Simple Payback:	11.7 yrs.
Measure Life:	25 yrs.
Annual GHG Reduction	44.4 t CO_2e
Lifetime GHG Reduction:	1,111 tonnes CO_2e
Net Present Value:	$81,322
Internal Rate of Return:	8%

Savings and Cost Assumptions

- The system was modelled using PVWatts software from NREL. A roof-mounted array with a tilt angle of 20° is represented and includes a 15% de-rate for snow cover and system losses. Considering the available roof space and the building's annual electricity consumption, a 77.6-kW DC system was chosen.
- The model calculates potential annual electricity production based on the array location, typical local weather data, and other system parameters. The theoretical maximum performance is modelled. Real electricity production may vary.
- The project cost is based on SPG's experience with similar projects and includes the materials and labour for installing the solar array.
- The condition and structure of the roof will need to be assessed prior to project implementation to determine if it can support the additional load.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM are presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 29: Rooftop Solar -LCCA Key Outputs

Rooftop Solar - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$206,427
Operation NPV @ LCCA end year (Y0$; NPV)	$136,108
Total NPV @ LCCA end year (Y0$; NPV)	-$70,319

Table 30: Rooftop Solar – Sensitivity Analysis

Rooftop Solar - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	-$43,450	-$70,319	-$90,429

Energy Rate ($0.05/kWh, $0.12/kWh, $0.20/kWh	-$149,715		$20,420
Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$70,319		-$70,319

*Most likely Scenario = real discount rate: 6%, energy rate: $0.12/kWh, fuel rate/maintenance inflation: 2%

Next Steps

- Confirm system compliance with relevant standards and requirements
- Finalize system size and parameters
- Obtain a formal quote from a solar contractor

4.6. Energy Star Clothes Washer

Energy Star certified residential clothes washers consume less energy and water than other models with equivalent capacity. Bowen has 2 washers that are not Energy Star certified. This ECM explores replacing those units with Energy Star models.

Table 31 Individual ECM Results

Labour Cost:	$402
Material Cost:	$4,376
Project Cost:	$4,777
Annual Electricity Savings:	1,359 kWh/yr.
Annual Water Savings:	8 m^3/yr.
Annual Utility Cost Savings	$264
Simple Payback:	14.0 yrs.
Measure Life:	15 yrs.
Annual GHGs	0.7 t CO_2e
Lifetime GHG Reduction:	11 tonnes CO_2e
Net Present Value:	-$1,273
Internal Rate of Return:	1%

Cost and Savings Assumptions

- The energy and water savings were calculated by determining the difference in consumption between the existing units and washers that have the minimum modified energy factor and maximum integrated water factor required for Energy Star eligibility.
- The project cost includes the materials and labour to install the washers.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 32: Energy Star Clothes Washer -LCCA Key Outputs

Energy Star Clothes Washer - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$6,474
Operation NPV @ LCCA end year (Y0$; NPV)	$2,643
Total NPV @ LCCA end year (Y0$; NPV)	-$3,831

Table 33: Energy Star Clothes Washer – Sensitivity Analysis

Energy Star Clothes Washer - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	-$3,764	-$3,831	-$3,858
Energy Rate ($0.05/kWh, $0.12/kWh, $0.20/kWh	-$5,142		-$2,331
Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$3,831		-$3,831

*Most likely Scenario = real discount rate: 6%, energy rate: $0.12/kWh, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to further discuss this ECM
- Engage a qualified contractor for an actionable quote

4.7. Energy Star Dryer

Energy Star certified residential clothes dryers consume less energy than other models with equivalent capacity. Bowen has 2 dryers that are not Energy Star certified. This ECM explores replacing those units with Energy Star models.

Table 34 Individual ECM Results

Labour Cost:	$1,893
Material Cost:	$14,026
Project Cost:	$15,919
Annual Electricity Savings:	4,514 kWh/yr.
Annual Utility Cost Savings	$773
Simple Payback:	15.5 yrs.
Measure Life:	15 yrs.
Annual GHGs	2.4 t CO_2e
Lifetime GHG Reduction:	37 tonnes CO_2e
Net Present Value:	-$5,677
Internal Rate of Return:	-1%

Savings and Cost Assumptions

- The energy savings were calculated by finding the difference in energy consumption between the existing units and dryers that have the minimum combined energy factor required for Energy Star eligibility.
- The project cost includes the materials and labour to install the dryers.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 35: Energy Star Dryer - LCCA Key Outputs

Energy Star Dryer - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$21,573
Operation NPV @ LCCA end year (Y0$; NPV)	$7,466
Total NPV @ LCCA end year (Y0$; NPV)	-$14,107

Table 36: Energy Star Dryer – Sensitivity Analysis

Energy Star Dryer - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	-$14,163	-$14,107	-$13,994
Energy Rate ($0.05/kWh, $0.12/kWh, $0.20/kWh)	-$18,462		-$9,130
Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$14,107		-$14,107

*Most likely Scenario = real discount rate: 6%, energy rate: $0.12/kWh, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to further discuss this ECM
- Engage a qualified contractor for an actionable quote

4.8. BAS

The building's HVAC system is currently controlled by manually adjusting simple thermostats and activating switches. A more advanced control system, such as a building automation system (BAS) might incorporate feedback from additional sensors, include additional on/off controls, and provide easy management of HVAC parameters through cloud-access software. Generally, a BAS facilitates centralized access to and control of equipment operation, a high level of coordination between different pieces of equipment, and automated adjustment of system parameters in response to external conditions. This ECM explores installing a BAS to promote more efficient use of HVAC equipment and ultimately save energy.

Table 40 Individual ECM Results

Project Cost:	$76,414
Annual Natural Gas Savings:	308 GJ/yr.
Annual Utility Cost Savings:	$2,640
Simple Payback:	16.7 yrs.
Measure Life:	15 yrs.
Annual GHGs	15.7 t CO_2e
Lifetime GHG Reduction:	235 tonnes CO_2e
Net Present Value:	-$31,319
Internal Rate of Return:	-1%

Savings and Cost Assumptions

- 10% savings were applied to the building's natural gas consumption from the boilers and MUA. This is a conservative estimate based on the building's HVAC configuration and age. Actual savings will depend on effective use of the installed system.
- The cost includes material and labour for the installation and commissioning of new controls, sensors, thermostats, and management software. Pricing was sourced from SensorSuite, a company specializing in automation systems for multi-unit residential buildings.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 41: BAS -LCCA Key Outputs

BAS - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$103,551
Operation NPV @ LCCA end year (Y0$; NPV)	$43,518
Total NPV @ LCCA end year (Y0$; NPV)	-$60,033

Table 42: BAS – Sensitivity Analysis

BAS - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	-$58,647	-$60,033	-$60,762
Energy Rate ($4/GJ, $8.11/GJ, $10/GJ)	-$77,495		-$52,003

Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$57,400		-$64,266

*Most likely Scenario = real discount rate: 6%, energy rate: $8.11/GJ, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to further discuss this ECM
- Obtain actionable quote from a qualified contractor

4.9. Solar Carport

A solar photovoltaic (PV) carport system provides the building with on-site renewable energy generation. The Bowen building is a good candidate for a solar PV carport system due to its large exterior parking area with southern exposure and minimal obstructions. This ECM explores adding such a solar PV carport system to the building's parking area.

Table 37 Individual ECM Results

Labour Cost:	$23,324
Material Cost:	$132,172
Project Cost:	$155,496
Annual Electricity Savings:	31,663 kWh/yr.
Annual Utility Cost Savings:	$5,425
Simple Payback:	20.0 yrs.
Measure Life:	25 yrs.
Annual GHG Reduction	17.1 t CO_2e
Lifetime GHG Reduction:	427 tonnes CO_2e
Net Present Value:	-$45,511
Internal Rate of Return:	2%

Savings and Cost Assumptions

- The system was modelled using PVWatts software from NREL. A carport array with a tilt angle of 7° is represented and includes a 15% de-rate for snow cover and system losses. Considering the available parking area and the building's annual electricity consumption, a 30.4-kW DC system was chosen.
- The model calculates potential annual electricity production based on the carport location, local weather data, and other system parameters. The theoretical maximum performance is modelled. Real electricity production may vary.
- The project cost is based on SPG's experience with similar projects and includes the materials and labour for installing the solar carport system.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM are presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 38: Solar Carport -LCCA Key Outputs

Solar Carport - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$156,945
Operation NPV @ LCCA end year (Y0$; NPV)	$52,371
Total NPV @ LCCA end year (Y0$; NPV)	-$104,575

Table 39: Solar Carport – Sensitivity Analysis

Solar Carport - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	-$94,673	-$104,575	-$112,045
Energy Rate ($0.05/kWh, $0.12/kWh, $0.20/kWh	-$135,124		-$69,661

Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$104,575		-$104,575

*Most likely Scenario = real discount rate: 6%, energy rate: $0.12/kWh, fuel rate/maintenance inflation: 2%

Next Steps

- Confirm system compliance with relevant standards and requirements
- Finalize system size and parameters
- Obtain a formal quote from a solar contractor

4.10. Humidity Sensor Switch

Washroom exhaust fans can be fitted with humidity sensor switches which automatically turn off the fans when the relative humidity is below for example 50%. This can save energy, since the outfitted fans will only run for the time necessary to remove excess moisture, instead of running continuously until they are manually switched off. In addition, if the fans run for a shorter amount of time, less air is being exhausted, so less fuel is consumed to heat the replacement outdoor air. This ECM explores installing humidity sensors on the washroom fans at Bowen.

Table 16 Individual ECM Results

Labour Cost:	$2,406
Material Cost:	$2,132
Project Cost:	$4,537
Annual Natural Gas Savings:	11 GJ/yr.
Annual Utility Cost Savings	$92
Simple Payback:	25.5 yrs.
Measure Life:	25 yrs.
Annual GHGs	0.5 t CO_2e
Lifetime GHG Reduction:	14 tonnes CO_2e
Net Present Value:	-$2,208
Internal Rate of Return:	0%

Savings and Cost Assumptions

- Electricity savings were calculated by assuming that the fans would run for 30 minutes without a humidity sensor, and 12 minutes with the humidity sensor. Actual savings will vary depending on the behaviour of occupants, including the duration of showers, and the current use of the fans.
- Natural gas savings were calculated based on the difference in the volume of air being replaced and subsequent energy required to heat the air in the existing and proposed scenarios. The average daily heating degree days at the building's location was used.
- The material cost was sourced from vendors, and the labour cost assumes that the electrician rate will be $97/hr, and that each retrofit will take a half hour to install.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 34: Humidity Sensor Switch – LCCA Key Outputs

Humidity Sensor Switch - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$4,580
Operation NPV @ LCCA end year (Y0$; NPV)	$1,511
Total NPV @ LCCA end year (Y0$; NPV)	**-$3,069**

Table 35: Humidity Sensor Switch – Sensitivity Analysis

Humidity Sensor Switch - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	-$2,781	**-$3,069**	-$3,287

Energy Rate ($4/GJ, $8.11/GJ, $10/GJ)	-$3,675		-$2,790
Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$2,977		-$3,215

*Most likely Scenario = real discount rate: 6%, energy rate: $8.11/GJ, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to further discuss this ECM
- Engage local contractors or maintenance staff to implement ECM

4.11. Condensing Boiler

Non-condensing boilers experience heat loss through water vapour that is produced as a by-product of burning fuel. Condensing boilers condense that waste water vapour to recover its energy and preheat the operating water. This heat recovery process enables condensing boilers to reach efficiencies of up to 96%.

This ECM explores upgrading the existing boilers, which have an 80% estimated thermal efficiency, to condensing models.

Table 17 Individual ECM Results

Labour Cost:	$11,458
Material Cost:	$40,355
Project Cost:	$51,814
Annual Natural Gas Savings:	134 GJ/yr.
Annual Utility Cost Savings:	$1,146
Simple Payback:	23.8 yrs.
Measure Life:	25 yrs.
Annual GHGs:	6.8 t CO_2e
Lifetime GHG Reduction:	170 tonnes CO_2e
Net Present Value:	-$22,690
Internal Rate of Return:	0%

Savings and Cost Assumptions

- Energy savings were modelled by applying a 92% efficiency to existing boiler energy consumption.
- The project cost was sourced from RSMeans and includes materials and labour for the installation, related pipe fitting, electrical work, and commissioning of the proposed unit(s).
- The condensing process will generate waste water that must be discharged into a nearby drain. Confirmation that the boilers are in proximity of a drain should be acquired prior to moving forward with the project.
- A 15% cost adjustment has been applied to account for additional equipment required in condensing boiler installations after they have been installed, this includes additional piping, pumps, and other components. This adjustment ensures improved flow rates and water quality while maintaining ease of use in the energy savings calculator. The increase addresses the potential underestimation of project costs, aligning with best practices for capturing accurate installation expenses.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 34: Condensing Boiler – LCCA Key Outputs

Condensing Boiler - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$52,297
Operation NPV @ LCCA end year (Y0$; NPV)	$18,891
Total NPV @ LCCA end year (Y0$; NPV)	***-$33,405***

Table 35: Condensing Boiler - Sensitivity Analysis

Condensing Boiler - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	-$29,778	***-$33,405***	-$36,156
Energy Rate ($4/GJ, $8.11/GJ, $10/GJ)	-$40,985		-$29,919
Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$32,262		-$35,243

*Most likely Scenario = real discount rate: 6%, energy rate: $8.11/GJ, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to further discuss this ECM
- Confirm boilers are in proximity of a drain
- Obtain a formal quote from a mechanical contractor

4.12. Heat pump (Boiler Supplement)

Heat pump technology uses the vapour-compression cycle to transfer heat from one medium to another. The heat pump would extract heat from the outdoor air and transfer it to the heating hydronic loop in this application. Heat pumps transfer heat energy opposed to generating it, which can yield efficiency ratings exceeding 300%.

This ECM explores installing a heat pump to complement the current heating system. The heat pump will provide heat to the building in temperatures as low as -18°C. For temperatures lower than that, the existing boiler will provide heating, and so it must remain integrated with the heating system as a backup heating source.

Table 33 Individual ECM Results

Labour Cost:	$70,518
Material Cost:	$359,074
Project Cost:	$429,592
Annual Natural Gas Savings:	960 GJ/yr.
Annual Utility Cost Savings:	$8,221
Simple Payback:	26.6 yrs.
Measure Life:	15 yrs.
Annual GHGs	48.7 t CO_2e
Lifetime GHG Reduction:	731 tonnes CO_2e
Net Present Value:	-$289,183
Internal Rate of Return:	-7%

Savings and Cost Assumptions

- Savings were estimated based on the existing boiler consumption, the existing boiler efficiency rating, and a proposed average efficiency rating of 93.08% for the heat pump.
- The project cost includes the materials and labour for the complete installation.
- Maintenance costs were included in the analysis. However, no sources were found for this specific case, so a 10-year maintenance cost assumption of 15% was made based on professional judgment and comparisons to similar systems.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 34: Heat Pump (Boiler Supplement) – LCCA Key Outputs

Heat Pump (Boiler Supplement)- LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$582,154
Operation NPV @ LCCA end year (Y0$; NPV)	$135,500
Total NPV @ LCCA end year (Y0$; NPV)	**-$446,654**

Table 35: Heat pump (Boiler Supplement) – Sensitivity Analysis

Heat Pump (Boiler Supplement) - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	-$461,524	**-$446,654**	-$433,815

Energy Rate ($4/GJ, $8.11/GJ, $10/GJ)	-$501,023		-$421,652
Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$438,456		-$459,833

*Most likely Scenario = real discount rate: 6%, energy rate: $8.11/GJ, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to further discuss this ECM
- Obtain formal quoting
- Ensure building electrical capacity can support the addition of 100-kW air to water heat pump. Mechanical specialists should be consulted to confirm proper heat pump sizing to avoid under sizing, or oversizing, the heat pump. An undersized heat pump will constantly operate due to insufficient heating capacity. An oversized heat pump will use more energy than is necessary to heat the space.

4.13. High-Efficiency MUA

This ECM explores replacing the existing MUA with a high-efficiency model to reduce natural gas consumption.

Table 46 Individual ECM Results

Labour Cost:	$419
Material Cost:	$61,764
Project Cost:	$62,183
Annual Natural Gas Savings:	37 GJ/yr.
Annual Utility Cost Savings:	$320
Simple Payback:	>50 yrs.
Measure Life:	15 yrs.
Annual GHGs	1.9 t CO_2e
Lifetime GHG Reduction:	28 tonnes CO_2e
Net Present Value:	-$56,720
Internal Rate of Return:	-18%

Savings and Cost Assumptions

- The estimated natural gas savings are based on the difference in the thermal efficiency between the existing and new models. The existing model has an estimated efficiency of 80%, while the proposed model is 91% efficient. Since the efficiency of the current model was estimated based on its age, we recommend determining the rated efficiency before moving forward with this project to confirm there is a potential for energy savings.
- The project cost was sourced from RSMeans and includes materials and labour for the installation of the new MUA.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 47: High efficiency MUA - LCCA Key Outputs

High efficiency MUA - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$84,266
Operation NPV @ LCCA end year (Y0$; NPV)	$5,272
Total NPV @ LCCA end year (Y0$; NPV)	-$78,994

Table 48: High efficiency MUA – Sensitivity Analysis

High efficiency MUA - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	-$84,124	-$78,994	-$74,910
Energy Rate ($4/GJ, $8.11/GJ, $10/GJ)	-$81,109		-$78,021
Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$78,675		$79,507

*Most likely Scenario = real discount rate: 6%, energy rate: $8.11/GJ, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to further discuss this ECM
- Confirm existing model efficiency

4.14. Window Upgrade

Upgrading windows to triple pane units with high R-values decreases heat loss through the windows. In turn, less heat is required to maintain the building's temperature setpoint, and less natural gas is consumed by the heating system. The buildings' windows are currently double-glazed units with vinyl frames. This ECM explores replacing current units with triple pane, vinyl framed units.

Table 18 Individual ECM Results

Labour Cost:	$28,311
Material Cost:	$106,765
Project Cost:	$135,075
Annual Natural Gas Savings:	30 GJ/yr.
Annual Utility Cost Savings:	$256
Simple Payback:	>50 yrs.
Measure Life:	25 yrs.
Annual GHGs	1.5 t CO_2e
Lifetime GHG Reduction:	38 tonnes CO_2e
Net Present Value:	-$128,564
Internal Rate of Return:	-13%

Savings and Cost Assumptions

- Windows were catalogued during the site audit. Note that not each individual window was inspected, but that windows that appeared visually alike were categorized as the same type. The energy and cost savings are based on replacing 69 windows which account for ~710 ft^2 of the vertical façade. The existing windows have 1.98 to 2.00 (ft^2*°F*h/btu) nominal R-Values, while the proposed windows have an R-Value of 2.8 (ft^2*°F*h/btu).
- Costs were sourced from RSMeans and include materials and labour for the removal of current windows and installation of new windows, adjusted for location. Travel costs are not included.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 34: Window Upgrade – LCCA Key Outputs

Window Upgrade - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$136,334
Operation NPV @ LCCA end year (Y0$; NPV)	$4,223
Total NPV @ LCCA end year (Y0$; NPV)	**-$132,111**

Table 35: Window Upgrade – Sensitivity Analysis

Window Upgrade - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	-$132,002	**-$132,111**	-$132,296
Energy Rate ($4/GJ, $8.11/GJ, $10/GJ)	-$136,334		-$131,331
Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$131,885		-$132,522

*Most likely Scenario = real discount rate: 6%, energy rate: $8.11/GJ, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to further discuss this ECM
- Obtain formal quote

4.15. Programmable Thermostats (Additional Consideration)

Programmable thermostats facilitate automation of building temperature setpoints. By using scheduling functions, for example, the setpoint could be automatically lowered during the hours when the building is unoccupied. During low setpoint periods, the heating system operates less frequently, realizing natural gas savings.

This ECM explores replacing the non-programmable thermostats in the building with programmable models, offering a cost-effective alternative to the recommended 'BAS' ECM.

Table 43 Individual ECM Results

Labour Cost:	$26,788
Material Cost:	$2,745
Project Cost:	$29,534
Annual Natural Gas Savings:	103 GJ/yr.
Annual Utility Cost Savings	$880
Simple Payback:	18.8 yrs.
Measure Life:	15 yrs.
Annual GHGs	5.2 t CO_2e
Lifetime GHG Reduction:	78 tonnes CO_2e
Net Present Value:	-$14,502
Internal Rate of Return:	-3%

Savings and Cost Assumptions

- A 5% reduction to the heating system's energy consumption was applied to model energy savings. Actual savings will depend on effective use of programming capabilities.
- The project cost was sourced from RSMeans and includes the material and labour to install ~34 thermostats. This cost may vary should the building in reality have more or fewer thermostats than estimated.

LCCA & Sensitivity Analysis

The LCCA and sensitivity analysis for this ECM is presented below. The parameters evaluated for the sensitivity analysis are discount rate, energy rate and cost escalation.

Table 44: Programmable Thermostats -LCCA Key Outputs

Programmable Thermostats - LCCA Key Outputs	
Capital NPV @ LCCA end year (Y0$; NPV)	-$40,022
Operation NPV @ LCCA end year (Y0$; NPV)	$14,506
Total NPV @ LCCA end year (Y0$; NPV)	-$25,516

Table 45: Programmable Thermostats – Sensitivity Analysis

Programmable Thermostats - Sensitivity analysis for total NPV @ LCCA end year (Y0$; NPV)			
Parameter	**Low**	**Most likely***	**High**
Real Discount Rate (4%,6%,8%)	-$25,461	-$25,516	-$25,439
Energy Rate ($4/GJ, $8.11/GJ, $10/GJ)	-$31,337		-$22,840

Fuel Rate/Maintenance Inflation (1% 2%,4%)	-$24,639		-$26,927

*Most likely Scenario = real discount rate: 6%, energy rate: $8.11/GJ, fuel rate/maintenance inflation: 2%

Next Steps

- Engage SPG to further discuss this ECM
- Obtain a formal quote from a mechanical contractor

4.16. Summary

14 ECMs and one measure for additional consideration were identified. The implementation of every recommended ECM would cost $1,227,657, save $36,418 per year, for an overall payback period of ~21 years. The following table summarizes the selected ECMs.

Table 49 ECM Summary

ECM		Annual Savings					Finance		
		Electricity (kWh/yr.)	Natural Gas (GJ/yr.)	Water (m^3/yr.)	GHGs (t CO_2e/yr.)	Utility Cost	Project Cost	Simple Payback (yrs.)	Net Present Value @5%
1	Pipe Insulation	0	195	0	9.9	$1,667	$741	<1	$19,004
2	Hydronic Heating Additive	0	87	0	4.4	$748	$2,625	2.8	$4,477
3	LED Upgrade - Fixture	613	0	0	0.3	$105	$1,204	9.6	$187
4	Low Flow Water Fixtures	0	173	1,082	9.5	$5,619	$82,759	11.1	$41,138
6	Energy Star Clothes Washer	1,359	0	8	0.7	$264	$4,777	14.0	-$1,273
7	Energy Star Dryer	4,514	0	0	2.4	$773	$15,919	15.5	-$5,677
8	BAS	0	308	0	15.7	$2,640	$76,414	16.7	-$31,319
11	Humidity Sensor Switch	0	11	0	0.5	$92	$4,537	25.5	-$2,208
12	Condensing Boiler	0	134	0	6.8	$1,146	$51,814	23.8	-$22,690
13	Heat pump (Boiler supplement)	0	960	0	48.7	$8,221	$429,592	26.6	-$289,183
14	High-efficiency MUA	0	37	0	1.9	$320	$62,183	>50	-$56,720
15	Window Upgrade	0	30	0	1.5	$256	$135,075	>50	-$128,564
Energy generation measures:									
5	Rooftop Solar	82,290	0	0	44.4	$14,098	$204,521	11.7	$81,322
10	Solar Carport	31,663	0	0	17.1	$5,425	$155,496	20.0	-$45,511
Net interactive effects		**0**	**-579**	**0**	**-29.4**	**-$4,957**	**$0**		
Total (accounting for interactions)		**120,439**	**1,356**	**1,090**	**134.6**	**$36,418**	**$1,227,657**	**21.2**	**-$529,496**
For additional consideration:									
9	Programmable Thermostats	0	103	0	5.2	$880	$29,534	18.8	-$14,502

The implementation of every recommended ECM would reduce the building's EUI, GHGI, ECI, and WUI. These results are outlined in the table below.

Table 50 Impact of ECMs on performance

Performance metric	Baseline performance	Benchmark	Performance after ECMs	Potential reduction
EUI (GJ/m^2)	0.99	0.82	0.43	56%*
GHGI ($kgCO_2e/m^2$)	67.06	91.10	13.01	81%
ECI ($\$/m^2$)	$15.52		$10.42	33%
WUI (m^3/m^2)	1.37		0.94	32%

**Excluding on-site energy generation measures*

5. About Us

SPG – Sustainable Projects Group

Sustainable Projects Group (SPG) is a leading design-build energy efficiency company dedicated to driving actionable sustainability in the built environment. We specialize in providing comprehensive solutions tailored to our diverse clientele:

- ASHRAE Energy Audits
- Building Condition Assessments (BCAs)
- Energy Modeling
- Energy Retrofits & Clean Technology Installations
- Funding Support
- Engineering Design
- Construction Management
- Energy Management Software (JOBI)

Rooted in our mission to eliminate GHG emissions from the built environment, SPG embodies values of sustainability, innovation, integrity, and excellence in every project we take on.

Next Steps

Knowledge is power. An energy audit is the first step to realizing sustainable building operations. Here are some recommendations to turn your data into action:

- Carry out an **LED lighting upgrade**. Our lighting analysis is fully actionable, meaning you can quickly execute on recommendations without the need for further analysis or engineering.
- Conduct a **building condition assessment**. Combining a building assessment with an energy audit allows us to align ECMs with equipment replacement times, creating an optimized implementation plan that aligns with your capital deployment strategy.
- Engage in **detailed engineering** of selected measures. As Prime Consultants, SPG will cover everything from applying for available **funding** opportunities to engineering **design**, **construction management**, and **measurement & verification.**
- Integrate your data with **JOBI,** SPG's revolutionary energy management software. JOBI uses a dynamic framework that facilitates capital alignment and optimization to achieve portfolio-wide decarbonization and millions of dollars in energy cost savings.

Connect with SPG today to learn more or request a demo!

6. Appendices

6.1. Appendix A - Lighting inventory

Table 51 Lighting inventory

Section	Room	Fixture	Qty (#)
L1	Boiler Room	1L-X-A19-LED-9W-Keyless-E26-Ceil Sfc	3
L1	Laundry Room	1L-CFL-28W-Keyless-E26-Ceil Sfc	2
L1	103 - Bachelor	1L-4ft-LED-20W-Strip-Wall Sfc-Wrap-Van	1
L1	103 - Bachelor	1L-LED-15W-Sconce-Wall Sfc	2
L4	403 - 1 Bedroom	2L-A19-LED-9W-Sconce-E26-Wall Sfc	3
L4	403 - 1 Bedroom	1L-4ft-LED-20W-Strip-Wall Sfc-Wrap-Van	1
L4	403 - 1 Bedroom	1L-A19-LED-9W-Pot Light-E26-Rcs	1
L1-4	Patio	1L-A19-Inc-65W-Sconce-E26-Wall Sfc	24
L4	Hallway	1L-LED-15W-Sconce-Wall Sfc	4
L3	Hallway	1L-LED-15W-Sconce-Wall Sfc	4
L2	Hallway	1L-LED-15W-Sconce-Wall Sfc	4
L1	Hallway	1L-LED-15W-Sconce-Wall Sfc	4
Stairwell	West Stairwell	1L-LED-15W-Sconce-Wall Sfc	4
Stairwell	West Stairwell	3L-A19-LED-9W-Sconce-E26-Ceil Sfc	1
Stairwell	East Stairwell	1L-LED-15W-Sconce-Wall Sfc	4
Stairwell	East Stairwell	3L-BR30-LED-12W-Low Bay-E26-Pend-Arch	1
L1	East Stairwell	1L-CFL-28W-Keyless-E26-Ceil Sfc	1
Exterior	Main Entrance	1L-A19-LED-9W-Sconce-E26-Wall Sfc	2
Exterior	Parking Lot Entrance	1L-Large-LED-80W-Wall Pack-Wall Sfc	2
L1-4	Unaccessed Bachelor Suites	1L-4ft-LED-20W-Strip-Wall Sfc-Wrap-Van	3
L1-4	Unaccessed Bachelor Suites	1L-LED-15W-Sconce-Wall Sfc	6
L1-4	Unaccessed 1 Bedroom Suites	2L-A19-LED-9W-Sconce-E26-Wall Sfc	81
L1-4	Unaccessed 1 Bedroom Suites	1L-4ft-LED-20W-Strip-Wall Sfc-Wrap-Van	27
L1-4	Unaccessed 1 Bedroom Suites	1L-A19-LED-9W-Pot Light-E26-Rcs	27

6.2. Appendix B - Utility data

Electricity

Table 52 Electricity utility data

	2023		2024	
	Cost	**Consumption (kWh)**	**Cost**	**Consumption (kWh)**
January			$2,038	11,234
February			$1,513	8,554
March			$1,610	10,131
April			$1,429	8,379
May			$1,417	8,620
June	$1,791	9,522	$1,361	7,631
July	$1,717	10,238		
August	$1,984	9,977		
September	$642	10,285		
October	$2,695	8,653		
November	$1,579	8,102		
December	$1,635	9,300		
Total	**$8,705**	**47,140**	**$9,369**	**54,549**

Natural gas

Table 53 Natural gas utility data

	2023		2024	
	Cost	Consumption (GJ)	Cost	Consumption (GJ)
January	$2,159	231	$2,387	255
February	$1,984	215	$1,959	231
March	$2,127	241	$1,846	218
April	$1,427	164	$1,749	159
May	$737	73	$1,187	119
June	$692	73		
July	$595	62		
August	$589	60		
September	$706	209		
October	$1,406	379		
November	$1,697	199		
December	$2,077	223		
Total	**$14,083**	**1,542**	**$9,128**	**983**

Water

Table 54 Water utility data

	2023		2024	
	Cost	Consumption (m^3)	Cost	Consumption (m^3)
January			$1,078	260
February			$1,059	256
March			$1,365	336
April			$1,418	354
May	$1,113	274	$1,418	354
June	$1,125	275	$1,250	308
July	$960	235		
August	$1,091	268		
September	$1,131	278		
October	$1,054	260		
November	$1,140	283		
December	$1,154	284		
Total	**$8,768**	**2,157**	**$7,589**	**1,868**

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