Solar Technology Feasibility Study

Similkameen Recreation Centre

311 9th St., Keremeos, BC

Prepared for Regional District of Okanagan-Similkameen

Prepared by Sustainable Projects Group

3122 114 Ave SE, Calgary, AB | www.suspg.com | 1-855-888-8355

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Executive Summary

SPG conducted a feasibility study for the Regional District of Okanagan-Similkameen (RDOS) at the Similkameen Recreation Centre (SRC) to assess current energy performance and identify the potential performance and economic viability of three solar-based energy technologies. This study consisted of a site visit and data analysis based on observations made by the site auditor as well as information provided by RDOS staff.

The building is currently performing 17% better than the average for buildings of this type in Canada based on the building's baseline energy usage intensity (EUI) compared to the national benchmark. 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	161,871 kWh/yr.	583	$18,676	1.9
Natural Gas	462 GJ/yr.	462	$7,102	23.5
Total		**1,044**	**$25,778**	**25.4**

The three solar technologies investigated were solar photovoltaics, solar air heating, and solar water heating. Several sizes of each technology were investigated, as was the financial performance sensitivity to several levels of incentive funding support. The system sizes recommended in this report are based on regulatory limits (solar PV) or technology-specific general sizing guidance (solar water and air heaters). Based on implementing all three technologies, the building's energy performance (EUI) will improve (decrease) 5% and greenhouse gas intensity (GHGI) will improve (decrease) by 13%. The overall implementation would cost $151,117, and save $5,499 per year, for an overall payback period of 19 years.

Table 2 Impact of ECMs on performance

Performance metric	Baseline performance	Benchmark	Performance after ECMs	Potential reduction
EUI (GJ/m²)	0.91	1.10	0.87	5%
GHGI (kg CO_2e/m²)	22.17	39.60	19.35	13%
ECI ($/m²)	$22.54		$21.96	3%

The cost and energy performance of all investigated systems and sizes are outlined in the table below.

Table 3 ECM Summary

	ECM	Annual Savings				Finance				Lifetime Savings	
		Electricity (kWh/yr.)	Natural Gas (GJ/yr.)	GHGs (t CO_2e/yr.)	Utility Cost	Project Cost	Simple Payback (yrs.)	Net Present Value @5%	Internal Rate of Return	Lifetime GHG Reduction (tonnes CO_2e)	Lifetime GHG Abatement Rate (/t CO_2e)
5	Solar water heater (collector = 5.1 m²)	-57	9	0.4	$112	$22,838	>50	-$20,595	-13%	9	$2,583
9	Solar air heater (collector = 20 m²)	-267	43	2.2	$548	$22,744	23.4	-$9,712	1%	54	$421
	Energy generation measures:										
2	Solar photovoltaic (50 kW DC)	54,193	0	0.6	$4,839	$105,534	16.0	-$4,765	5%	16	$6,774
	Total	**53,869**	**51**	**3.2**	**$5,499**	**$151,117**	**18.8**	**-$34,651**	**3%**	**81**	**$1,874**
	For additional consideration:										
1	Solar photovoltaic (60 kW DC)	65,031	0	0.7	$5,807	$126,641	16.0	-$5,718	5%	19	$6,774
3	Solar water heater (collector = 1.8 m²)	-25	4	0.2	$48	$15,853	>50	-$14,900	-15%	4	$4,216
4	Solar water heater (collector = 3.4 m²)	-42	7	0.3	$84	$19,240	>50	-$17,564	-13%	7	$2,913
6	Solar water heater (collector = 6.9 m²)	-68	10	0.5	$134	$26,648	>50	-$23,967	-12%	11	$2,521
7	Solar water heater (collector = 10.2 m²)	-76	12	0.6	$148	$33,632	>50	-$30,669	-13%	12	$2,878
8	Solar air heater (collector = 10 m²)	-134	26	1.3	$342	$11,372	19.8	-$3,249	2%	33	$340
10	Solar air heater (collector = 40 m²)	-534	62	3.1	$785	$45,489	29.9	-$26,777	-2%	79	$579
11	Solar air heater (collector = 70 m²)	-935	78	3.9	$961	$79,605	38.5	-$56,609	-4%	99	$808
12	Solar photovoltaic (50 kW DC) (25% funded)	54,193	0	0.6	$4,839	$79,151	12.8	$21,619	7%	16	$5,080
13	Solar photovoltaic (50 kW DC) (50% funded)	54,193	0	0.6	$4,839	$52,767	9.2	$48,002	12%	16	$3,387
14	Solar water heater (collector = 5.1 m²) (25% funded)	-57	9	0.4	$112	$17,128	>50	-$14,886	-11%	9	$1,937
15	Solar water heater (collector = 5.1 m²) (50% funded)	-57	9	0.4	$112	$11,419	44.6	-$9,176	-8%	9	$1,292
16	Solar air heater (collector = 20 m²) (25% funded)	-267	43	2.2	$548	$17,058	18.7	-$4,026	3%	54	$316
17	Solar air heater (collector = 20 m²) (50% funded)	-267	43	2.2	$548	$11,372	13.6	$1,661	6%	54	$211

1. Introduction

The Regional District of Okanagan-Similkameen (RDOS) retained Sustainable Projects Group (SPG) to conduct a feasibility study of three solar energy technologies at the Similkameen Recreation Centre (SRC). The purpose of this study is to assess existing energy consumption in the relevant systems and size and estimate performance of the technologies with the intent to inform sound energy management decisions. The study 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 or otherwise estimating existing energy use in the relevant systems
- Sizing and quantifying the three technologies, 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 RDOS staff
- Documentation provided by RDOS, including:
  - Utility data for the period of January 2022 to December 2023
  - Architectural drawings
  - Equipment schedules

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.

1.1. 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
Suraj Baral	RDOS	Community Energy Specialist	sbaral@rdos.bc.ca

2. Existing Systems and Performance Investigation

2.1. Building Systems and Components

Building Overview

The Similkameen Recreation Centre (SRC) is a predominantly single storey recreation and community facility located at 311 9th St, Keremeos, British Columbia. The building is believed to have been constructed around 1987. The interior consists of several physical activity-related spaces such as a fitness area and racquet courts, changing rooms, washrooms, and a bowling alley. The building is believed to be operated by approximately 6 full time staff and receives an estimated 80 visitors daily. The building operating hours are 5 am to 11 pm daily.

Figure 1 SRC exterior from south (top), and aerial view of building and site (bottom, Google Earth, 2024)

General Electrical Infrastructure

The building's existing electrical system was reviewed during the site visit. Single line diagrams of the system have been prepared. Photos of the diagrams are attached in Section 4.2 Appendix B, with additional copies submitted separately.

Heating and Ventilation

The building is served by four standard-efficiency roof top units (RTUs), which are the primary sources of both heating and ventilation. These RTUs are listed in the table below:

Table 5: RTU schedule

Service zone	Make	Model	Year	Heating rating	Cooling rating	Supply air rate
A	Daikin	DSG0601403BXXXAA	[unknown]	138,000 Btu/h	5 ton	1800 CFM
B	Carrier	48HJE005---551--	2007	115,000 Btu/h	4 ton	1450 CFM
C	Carrier	48EZ-048130501--	2008	130,000 Btu/h	4 ton	1600 CFM
D	[unknown]	48EZ-04/130501--	2007	130,000 Btu/h	4 ton	1600 CFM

The following figure shows the ventilation zones for each of the four RTUs.

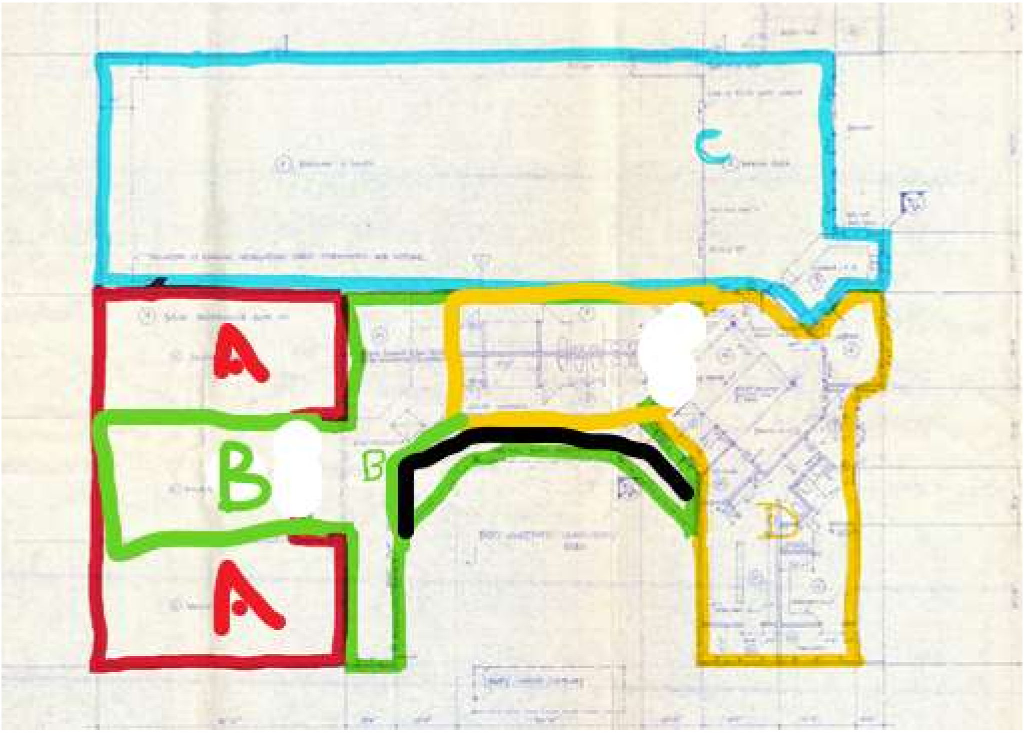

Figure 2: Approximate RTU service zones

Domestic Hot Water

The building has several hot water heaters. Two standard-efficiency Rheem water heaters are believed to serve the seasonal ice rink facilities. One standard-efficiency John Wood water heater is believed to serve the general domestic hot water needs of the building, expected to be primarily faucets and showerheads. These water heaters are listed in the table below:

Table 6: DHW equipment

Equipment	Qty (#)	Location	Service area	Make	Model	Year	Rating	Capacity	Efficiency (%)
Rheem DHW heater	2	Zamboni room	Seasonal ice facilities	Rheem	PROG75S-75NCN53	2015/2016	75,100 Btu/h	284 L	80% (est.)
John Wood DHW heater	1	[unknown]	Whole bldg. – standard water fixture DHW	John Wood	JW850S40N-AV 400	[unknown]	40,000 Btu/h	189 L	80% (est.)

2.2. Historic Utility Analysis

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

Table 7 Utility data sources

Utility	Data type	Utility provider	Period	Notes
Electricity	Monthly utility bills from utility provider, and tabulated monthly cost and consumption	FortisBC	2021-12-28 to 2023-12-28	Monthly bills from provider only supplied for most recent 12 months of bills. Tabulated data provided for full 24 months of historic data.
Natural gas	Monthly utility bills from utility provider, and tabulated monthly cost and consumption	FortisBC	2021-12-18 to 2023-12-18	[none]
Water	[none available]	[unknown]	N/A	Water supplied to site is believed to not be metered.

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

Electricity

Electricity consumption shows a clear seasonal profile, with much greater consumption during the winter months. It is suspected that this seasonal energy consumption is driven by the operation of the ice rink. The electricity consumption in the remaining months in relatively steady, and is anticipated to be composed of baseloads such as ventilation fans, lights, and non-seasonal plug loads.

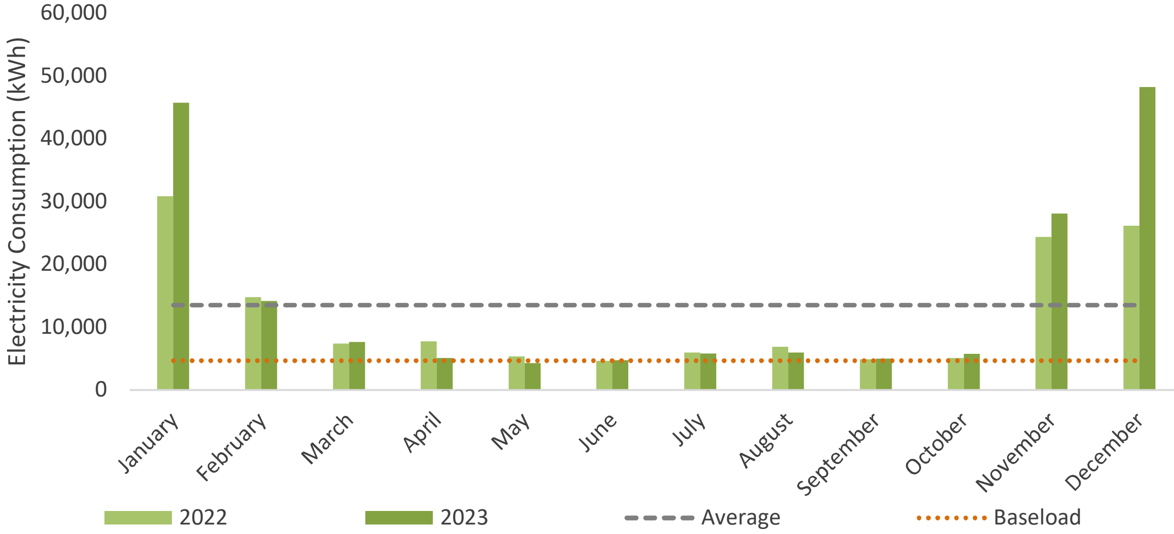

Figure 3 Electricity consumption over time

Natural gas

Natural gas consumption shows a clear seasonal trend with greater consumption occurring in the winter months. This is expected due to the use of natural gas as the primary fuel for building heating. The summertime baseload is anticipated to be driven by the use of gas for DHW.

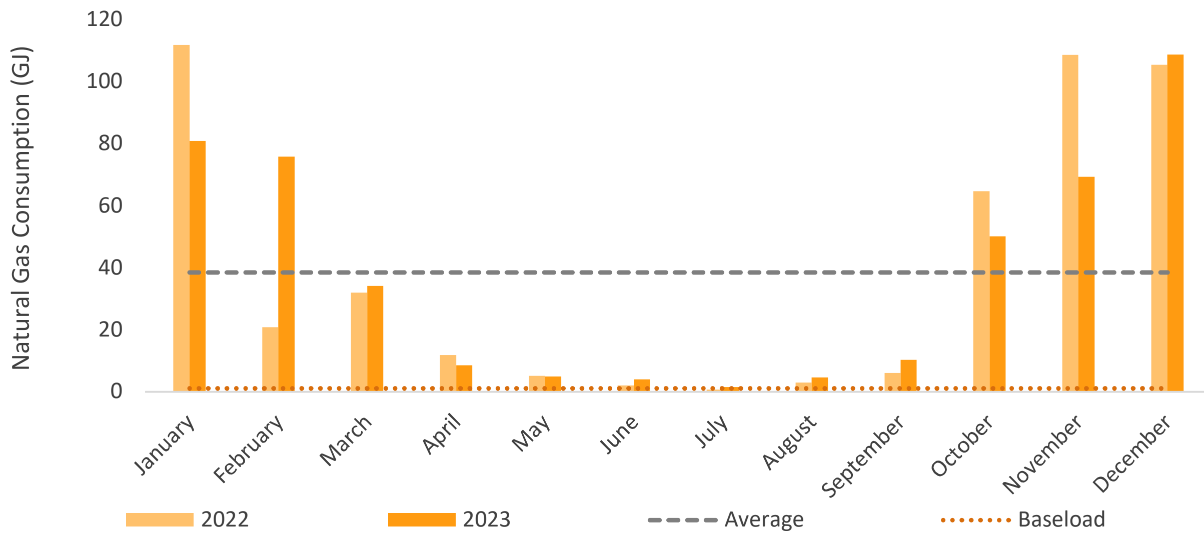

Figure 4 Natural gas consumption over time

Annual Consumption Indicators

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 8 Baseline consumption, cost and GHGs

Utility	Consumption	Energy (GJ/yr.)	Cost ($/yr.)	GHGs (t CO_2e/yr.)
Electricity	161,871 kWh/yr.	583	$18,676	1.9
Natural Gas	462 GJ/yr.	462	$7,102	23.5
Total		**1,044**	**$25,778**	**25.4**

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 9 Emission factors

Utility	Emission factor	Source
Electricity	0.012 kg CO_2e/kWh	BC Electricity emission intensity factors for grid-connected entities
Natural Gas	50.887 kg CO_2e/GJ	National Inventory Report: Greenhouse Gas Sources and Sinks in Canada (2023). Part 2, Annex 6

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. The most recent 12 months of utility data are typically included in this calculation so that the marginal rate is reflective of current pricing.

As the electricity rate structure is composed of both consumption-variable ($/kWh) and demand-variable ($/kW) components, a multivariate regression was performed to disaggregate these components. The electricity cost breakdown excluded the billing period from 2023-01-28 to 2023-02-28 due to the BC Cost of Living Rebate credit being applied in this month, making it an outlier with respect to the underlying rate structure.

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

Table 10 Utility rates

Utility	Fixed utility rate	Marginal utility consumption rate	Marginal utility demand rate
Electricity	$63.25/month	$0.082/kWh	$12.23/kW
Natural Gas	$45.01/month	$13.44/GJ	[none]

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), and energy cost intensity (ECI) 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. SRC's performance over the billing period is better than the benchmark EUI and better than the benchmark GHGI for fitness centre/health club/gym-type buildings.

Table 11 Baseline performance and benchmarks

Metric	Baseline	Benchmark
EUI (GJ/m²)	0.91	1.10
GHGI (kg CO_2e/m²)	22.17	39.60
ECI ($/m²)	22.54	

3. Solar Technology Investigation

This study has investigated several solar technologies and their applicability for use at the SRC. These technologies are:

- Solar photovoltaics to generate electricity
- Solar air heating to provide supplementary preheating for fresh air used in ventilation
- Solar water heating to supplement the domestic hot water system

Each of these technologies are discussed in their respective sections below, including a general introduction to the technology, the application and potential for contributing energy/energy services for SRC, and details on the proposed solution.

Numerical results are provided for each application including the metrics 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.

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).

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.

3.1. Solar Photovoltaics

Technology Introduction

General Technology Description

Solar photovoltaic (PV) is a common technology that produces electricity from sunlight. The technology has existed at a commercial level for decades and is a common form of distributed renewable energy generation.

Proposed Application

A solar PV system may be a suitable way to generate renewable electricity for the SRC facility. Installing the system on the rooftop is a standard approach, and given the relatively unobstructed southern view and large flat roof, is considered a likely suitable approach. No alternative applications (e.g., ground-mounted PV panels, exterior cladding-integrated PV system, etc.) were considered in this study.

Preliminary System Design

Basis of Design

Based on data collected during the site visit and satellite imagery, the roof layout was recreated in the *Helioscope* software and an initial PV panel layout was created based on a minimum 3ft setback from the roof perimeter and a minimum 2 ft setback from roof obstructions (RTUs, vents, etc.). This layout strived to balance maximizing the available roof space with the realistic construction limitations that would be encountered, for example, not utilizing remote roof areas that would only have space for one or two panels.

Another consideration for system size is the limit on system size for the net metering program offered by FortisBC, which allows a generating capacity of 50 kW maximum. Though the amount of energy generated is limited to what is required to offset expected annual energy consumption, this building's electricity consumption is such that the net metering program limiting factor is kW capacity.

Proposed System

The system design that maximizes usage of roof space for PV consists of 120 panels at 500W DC each, for a total DC system size of 60 kW. The panels are proposed to be mounted in racks at an angle of 10°. A total of three 15 kW 3-phase inverters have been proposed to effectively create a 45.8 kW AC system, with the inverters assumed to be located on the roof. The inverters are proposed to be integrated to the 120/208V 400A splitter that is fed from the 75 kVA transformer.

Several figures related to the proposed system are included in section 4.3 Appendix C, including a screenshot from the simulation program, a diagram of the proposed PV panel layout, and an indicative single line diagram showing the location of PV system integration with the existing electrical infrastructure.

A system with a total capacity of 50 kW has also been investigated, though without the detailed design considerations described above.

Implementation Cost Estimate

The project cost was estimated based on SPG's experience with similar projects and includes the materials and labour for installing the 60 kW or 50 kW DC solar array. The constituent material and labour costs are shown in Table 13. Detailed structural or wind-load studies have not been factored into the proposed implementation cost. Commentary on the existing structure is provided in a later report section.

Technology Performance

Energy Benefits

The energy benefits of a solar PV system consist of generating electricity. Generated electricity will preferentially be consumed on-site and therefore reduce purchased electricity. During periods where instantaneous and/or monthly generation exceed consumption, the excess electricity is exported to the grid and a credit will later be attributed to the utility account.

The monthly electricity generation for the 60 kW system was estimated using *Helioscope* and is provided in the table below. Please be aware that this is a modelled potential generation based on the array typical local weather data, and other system parameters, and amounts to an estimate of the theoretical maximum performance. Real electricity production may vary based on any of the above or other factors. The electricity production for the 50 kW system was estimated as a 50/60th fraction of the simulated results for the 60 kW system.

Table 12: Modelled monthly electricity production and several annual production indicators by system size

Month	60 kW system generation (kWh)	50 kW system generation (kWh)	Average existing consumption (kWh)
January	1,449	1,208	38,259
February	3,001	2,501	14,439
March	5,516	4,597	7,471
April	7,324	6,103	6,393
May	8,495	7,079	4,772
June	8,334	6,945	4,650
July	9,501	7,918	5,846
August	8,356	6,963	6,386
September	6,534	5,445	4,891
October	3,901	3,251	5,389
November	1,406	1,172	26,199
December	1,214	1,012	37,178
Annual total:	65,031	54,193	161,871
Energy offset (%):	40.2%	33.5%	

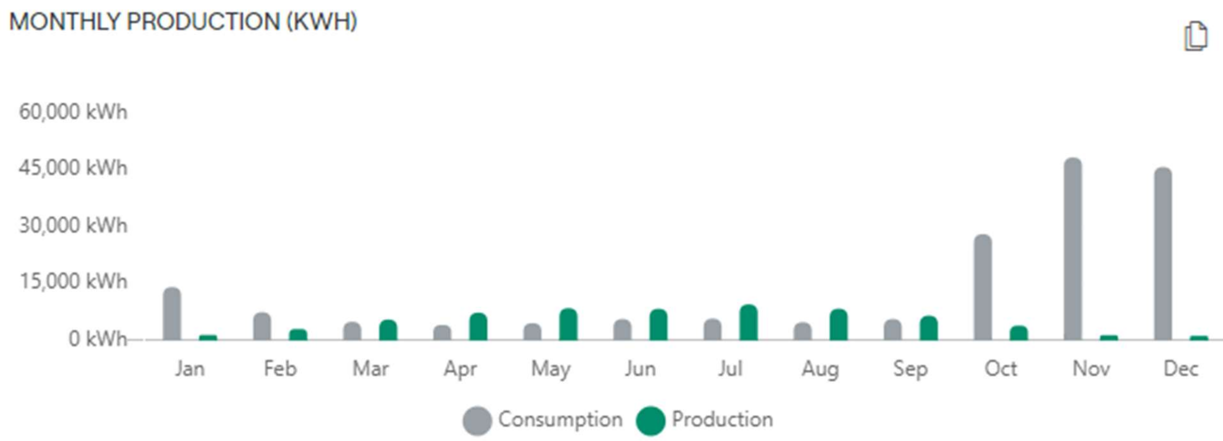

Figure 5: Modelled monthly production for the 60 kW system and average monthly consumption profiles

Economic Performance

Financial and GHG-savings indicators are provided in the table below.

Table 13: Solar PV financial and energy performance indicators

	60 kW system	50 kW system
Labour Cost:	$13,931	$11,609
Material Cost:	$112,711	$93,926
Project Cost:	$126,641	$105,534
Annual Electricity Savings:	65,031 kWh/yr.	54,193 kWh/yr.
Annual Utility Cost Savings:	$5,807	$4,839
Simple Payback:	16.0 yrs.	16.0 yrs.
Measure Life:	25 yrs.	25 yrs.
Annual GHGs:	0.7 t CO_2e/yr.	0.6 t CO_2e/yr.
Lifetime GHG Reduction:	19 tonnes CO_2e	16 tonnes CO_2e
Net Present Value @5%:	-$5,718	-$4,765
Internal Rate of Return:	5%	5%

Conclusion and Recommendations

The net present value indicator for both investigated systems is negative, indicating that under the explored conditions the project may not be a worthwhile financial investment. The greenhouse gas mitigation of the project is not otherwise considered in the cashflow analysis however, and may represent a reason to proceed with the project. Should the effective discount rate of the organization be lower or if implementation funding is available to support the capital costs, then the project’s cashflow representation may have a positive NPV.

The next steps in project implementation are likely reaching out to local electrical/solar contractors and requesting actionable project quotes.

The cashflow analysis is based on the observed effective cost of importing electricity to the site, which has been assumed to be the same as the value of electricity exported from the site, which is consistent with net metering. The actual financial performance of the 60 kW system will be based on the value of electricity in the electricity market, which has not been considered but will very likely be worse than in the net metering case. Thus, if a solar PV project proceeds, it is recommended to proceed with no larger than a 50 kW system.

3.2. Solar Air Heating

Technology Introduction

General Technology Description

Solar air heaters use solar energy to preheat ventilation fresh air during the heating season. The typical technology assembly consists of absorption plates and a plenum. The exterior-facing plates absorb solar radiation. Then, air is drawn through perforations in the plates to the plenum, absorbing heat from the plates as it passes through. The heated air is circulated through the ventilation system by the existing fan motors. Since the outdoor air is now partially heated by solar, less fuel is required to heat it to the supply setpoint temperature.

Proposed Application

Solar air heating was investigated as a source of preheating fresh air being supplied by the RTUs on the west of the building. The solar collector would be on the two-storey southern face near the RTUs, with preheated air ducted to the RTUs.

Figure 6: Proposed solar air heating application: collector mounted on red indicated wall face, preheats air from green indicated RTUs

Preliminary System Design

Basis of Design

The energy load served by the solar air heaters is based on heating the fresh air streams already being provided by the building ventilation system. Due to the anti-synergy between the need for building space heating and the availability of sunlight, solar thermal technologies for space heating are particularly sensitive to diminishing returns with respect to collector size or system output capacity. Several sizes of collectors were investigated with energy performance and financial performance to illustrate this trade-off.

Based on SPG's understanding of the building's ventilation zones (see Figure 2: Approximate RTU service zones), RTU A and RTU B are thought to likely have the highest ventilation loads due to the underlying physical activity space being served. The ventilation loads were estimated based on 18 hours per day of operation, with no occupancy-related ventilation controls, and the occupied floor area devoted to physical activity (estimated as 80 m²) for both of RTU A and RTU B. The resulting outdoor air rate is approximately 535 CFM for each.

Proposed System

The solar air heater collectors investigated were transpired-plate type collectors. The system was modelled as two collectors, each serving one of the nearby RTUs. Collector sizes ranged in size from 5 m² to 35 m², where two 35 m² collectors was deemed the most collector area that could be fit on the proposed wall face. Note that elsewhere in this report, the system size is described based on the combined area, e.g., "10 m² collector size" representing 2x 5m² collectors.

The pre-heating air passing through the collector would be transferred by duct to the RTUs. The solar air collector would be able to be bypassed when heating is not required.

Implementation Cost Estimate

The cost was sourced from RETScreen cost database, and is based on a cost per area formulation to represent the full labour and material costs, adjusted for provincial/federal tax and inflation.

Technology Performance

Energy Benefits

The energy savings from the solar air heaters were estimated using RETScreen expert and account for reduced heating required for ventilation air, heat loss reduction through the wall under which the solar air heater collectors are mounted, and a ventilation fan energy use increase. The operation of the heater was limited to September through April, with only 50% utilization deemed in April and September and 100% utilization deemed in the intermedial winter months. Fuel savings based on displacing heating that otherwise would have been provided by the standard efficiency (i.e., 80%) gas-fired RTUs was calculated on an annual basis. The annual fuel savings for each investigated size of collector is provided in the table below.

Table 14: Fuel savings and fraction of system heat provision by solar air heater collector size

Solar Collector Size:	10 m²	20 m²	40 m²	70 m²
Annual Natural Gas Savings:	26 GJ/yr.	43 GJ/yr.	62 GJ/yr.	78 GJ/yr.
Base System Natural Gas Use:	246 GJ/yr.	246 GJ/yr.	246 GJ/yr.	246 GJ/yr.
Fraction of Base Heat Requirement Provided:	11%	17%	25%	32%

Economic Performance

Financial and energy/GHG-savings indicators are provided in the table below.

Table 15: Solar air heater financial and energy performance indicators by collector size

Solar Collector Size:	10 m²	20 m²	40 m²	70 m²
Material Cost:	$11,372	$22,744	$45,489	$79,605
Annual Electricity Savings:	-134 kWh/yr.	-267 kWh/yr.	-534 kWh/yr.	-935 kWh/yr.
Annual Natural Gas Savings:	26 GJ/yr.	43 GJ/yr.	62 GJ/yr.	78 GJ/yr.
Total Energy Savings:	26 GJ	42 GJ	60 GJ	74 GJ
Annual Utility Cost Savings:	$342	$548	$785	$961
Simple Payback:	19.8 yrs.	23.4 yrs.	29.9 yrs.	38.5 yrs.
Measure Life:	25 yrs.	25 yrs.	25 yrs.	25 yrs.
Annual GHGs:	1.3 t CO_2e/yr.	2.2 t CO_2e/yr.	3.1 t CO_2e/yr.	3.9 t CO_2e/yr.
Lifetime GHG Reduction:	33 tonnes CO_2e	54 tonnes CO_2e	79 tonnes CO_2e	99 tonnes CO_2e
Net Present Value @5%:	-$3,249	-$9,712	-$26,777	-$56,609
Internal Rate of Return:	2%	1%	-2%	-4%

Conclusion and Recommendations

The energy and GHG savings of larger-collector systems were higher, but the diminishing returns of increased solar collector size are apparent in the progressively worse payback/rate of return of the projects with larger collectors. The largest solar collector size investigated (70 m², which would use essentially the entire available wall face) would only offset ~1/3 of the heating fuel use in the underlying ventilation heating systems.

The net present value of all sizes of solar collectors are negative, and the internal rates of return for the projects are also low (<2%) or negative. Under the investigated conditions, it is not clear if a solar air heater is a suitable investment.

The next steps in project implementation are likely reaching out to specialized solar air heater providers and requesting a preliminary assessment.

The method used in this analysis is based on modelling the energy performance of the system with a limited number of factors and is based on an annual approach, with the potential to overestimate the annual provision of heat. Estimates regarding the season of use were made to attempt to counteract this, but further modelling or assessment may be required. The system did not go through a detailed design phase, which may require specific collector sizing in order to meet the detailed design requirements. The cost estimates are intended to be conservatively high, but do not account for the non-linear costs of system design, which may counteract the diminishing returns vis-à-vis financial performance the investigated sizing otherwise exhibits.

3.3. Solar Water Heating

Technology Introduction

General Technology Description

A solar water heater utilizes solar energy to heat or pre-heat domestic hot water. In cold weather climates, closed-loop systems are common where a secondary fluid such as glycol would be passed through the exterior solar collector and back to the interior DHW system. Solar water heater collectors come in several varieties, ranging from glazed plates where liquid passes through, to evacuated glass tubes containing dark-surface absorber plates connected to a passive refrigerant heat pipe. As DHW is typically a non-seasonal load, the solar water heater should operate all year. Due to the seasonal and intermittent nature of available solar energy, a backup DHW system will always be required.

Proposed Application

A solar water heater is proposed to provide a year-round supplement for the domestic hot water system for standard fixture usage (showers, washroom faucets, etc.). The existing DHW heater for this system is the 40,000 Btu/h John Wood storage-style water heater.

Preliminary System Design

Basis of Design

The existing DHW consumption has been estimated by two approaches. The first involves reviewing the historic utility account and identifying the monthly baseload observed in the summer, when gas heating is expected to be negligible. The month with minimum natural gas consumption in the two years of available data is July, with monthly consumption of 0.68 GJ in 2022 and 1.46 GJ in 2023, leading to an average baseload consumption of 1.07 GJ/month or 12.84 GJ/year.

The second approach for estimating existing DHW consumption is based on estimated facility occupancy (6 FTE staff and 80 daily visitors), typical water fixture flow rates (1.5 GPM for faucets and 2.5 GPM for showers), typical hot water usage ratios, and the average DHW system efficiency (80%), and an assumed 55°C water temperature rise. The daily uses per occupant type were taken from the LEED v4 Indoor Water Use Reduction Calculator. The results of this analysis lead to an estimate DHW fuel consumption of 12.58 GJ/year.

The two estimates are in close agreement. The baseline annual fuel consumption of the system was taken to be 12.58 GJ/year, which is equivalent to using 120 L/day for 365 days per year.

Similar to solar air heating though to a lesser extent, solar water heating is subject to diminishing returns with respect to sizing. If the system is sized to fully meet the DHW load in the summer, only a small fraction of the load will be met in the winter. Increasing size beyond this will see lower utilization in the summer, and lower marginal fuel savings per size increase.

Proposed System

This is a relatively minor DHW load, meaning the system would likely be a solar DHW kit style installation rather than a large custom-engineered system. The most common style of solar DHW collector for kits is evacuated glass tubes. Due to the load being anticipated as irregular (i.e., varying throughout the day), additional hot water storage was included in the proposed system. Several sizes of collectors were investigated, ranging from 1.8 m² to 10.2 m². The collectors are proposed to be placed on the roof in steel racks at a 45° angle. Based on the DHW load, the system size suggested by the modelling program RETScreen Expert is 5.1 m² of collector area, which corresponds to about 2 large collector manifolds.

Implementation Cost Estimate

The cost to implement the systems were based on a hybrid cost estimate approach, based partially on the RETScreen cost database entries for full-installed cost rates by size for various types of solar water heaters, and partially on observed solar DHW kit (materials only) costs for several sizes of kits available online through Canadian distributors.

The costs for the various kit sizes were associated with the total collector area for the given kits to develop a cost-per-collector-area relationship on top of a fixed cost portion (i.e., a portion of the cost is fixed regardless of total collector area). This relationship was taken to be indicative of the overall fixed-vs-area-variable cost relationship. The cost relationship used was based on the typical scale of the RETScreen cost database entries, adjusted to exhibit the fixed-vs-variable cost behaviour described above. The final presented costs include all kit materials, installation labour, and soft costs.

Technology Performance

Energy Benefits

The fuel energy savings from the solar water heaters were estimated using RETScreen Expert and account for reduced DHW heater fuel use and increased electricity consumption associated with the solar DHW circulation pump. The system was simulated as operating year-round. The energy savings are provided for each investigated collector size in the table below.

Table 16: Fuel savings and fraction of system heat provision by solar air heater collector size

Solar Collector Size:	1.8 m²	3.4 m²	5.1 m²	6.9 m²	10.2 m²
Annual Natural Gas Savings:	4 GJ/yr.	7 GJ/yr.	9 GJ/yr.	10 GJ/yr.	12 GJ/yr.
Base System Natural Gas Use:	12.58 GJ/yr.	12.58 GJ/yr.	12.58 GJ/yr.	12.58 GJ/yr.	12.58 GJ/yr.
Fraction of Base Heat Requirement Provided:	32%	56%	72%	79%	95%

Economic Performance

Financial and energy/GHG-savings indicators are provided in the table below.

Table 17: Solar water heater financial and energy performance indicators by collector size

Solar Collector Size:	1.8 m^2	3.4 m^2	5.1 m^2	6.9 m^2	10.2 m^2
Material Cost:	$15,853	$19,240	$22,838	$26,648	$33,632
Annual Electricity Savings:	-25 kWh/yr.	-42 kWh/yr.	-57 kWh/yr.	-68 kWh/yr.	-76 kWh/yr.
Annual Natural Gas Savings:	4 GJ/yr.	7 GJ/yr.	9 GJ/yr.	10 GJ/yr.	12 GJ/yr.
Total Energy Savings:	4 GJ	6 GJ	8 GJ	10 GJ	11 GJ
Annual Utility Cost Savings:	$48	$84	$112	$134	$148
Simple Payback:	>50 yrs.	>50 yrs.	>50 yrs.	>50 yrs.	>50 yrs.
Measure Life:	20 yrs.	20 yrs.	20 yrs.	20 yrs.	20 yrs.
Annual GHGs:	0.2 t CO_2e/yr.	0.3 t CO_2e/yr.	0.4 t CO_2e/yr.	0.5 t CO_2e/yr.	0.6 t CO_2e/yr.
Lifetime GHG Reduction:	4 tonnes CO_2e	7 tonnes CO_2e	9 tonnes CO_2e	11 tonnes CO_2e	12 tonnes CO_2e
Net Present Value @5%:	-$14,900	-$17,564	-$20,595	-$23,967	-$30,669
Internal Rate of Return:	-15%	-13%	-13%	-12%	-13%

Conclusion and Recommendations

The systems investigated offset between a third and nearly all the existing DHW fuel consumption. The energy and GHG savings of larger collector systems were higher but showed diminishing returns with respect to fuel saved. Due to the cost modelling method accounting for the expected relatively minor cost changes by increased collector size, the ROI of the investigated systems does improve with larger collector sizes. The net present value of all systems is negative however, and is larger in absolute value (i.e., more negative) with larger collector size systems. Under the investigated conditions, it is not clear if a solar water heater is a suitable investment. While the cost estimation method is intended to be conservative, the maximum utility cost savings that can be achieved by a solar DHW system are very low due to low DHW use in the building.

The next steps in project implementation are likely reaching out to a contractor familiar with installing solar water heater kits and requesting a preliminary assessment.

3.4. Available Funding Sources

Several sources of potential funding for the recommended projects have been investigated. Details of the incentive programs are below.

FortisBC – Custom Efficiency Program

The Fortis BC Custom Efficiency Program can provide incentives for studies associated with energy-saving projects as well as implementation funding. The eligibility criteria posted online suggest that natural gas savings projects would need to exceed 1,000 GJ/year of savings annually to qualify, which these projects fall notably short of. The requirement for electricity projects is only 50,000 kWh/year, which both sizes of PV systems would meet.

Green Municipal Fund – Capital project: GHG impact retrofit

This funding source can provide grant and loan support to community building retrofit project bundles that achieve 30% or greater GHG emission reduction compared to baseline emissions. The three recommended sizes of the investigated technologies will result in a total emission reduction of 13%, which falls notably short of the 30% cutoff. If bundled with other energy-saving projects, ideally natural gas projects, the savings threshold may be achievable.

3.5. Financial Performance Sensitivity Analysis

As the financial performance of the measures should not be understood irrespective of funding support but where this report cannot assess the degree to which funding is available should these projects go forward, a sensitivity analysis has been performed to showcase the overall financial performance of the technologies based on partial funding levels of 25% and 50%, compared to the previous analyses which assumed no funding support. The results of this analysis are shown in the following three tables, each showing results for the recommended size of that technology.

Table 18: Payback sensitivity analysis by funding level for the solar PV project with capacity = 50 kW

Funding Support:	0%	25%	50%
Project Net Cost:	$105,534	$79,151	$52,767
Annual Electricity Savings:	54,193 kWh/yr.	54,193 kWh/yr.	54,193 kWh/yr.
Annual Utility Cost Savings:	$4,839	$4,839	$4,839
Simple Payback:	16.0 yrs.	12.8 yrs.	9.2 yrs.
Measure Life:	25 yrs.	25 yrs.	25 yrs.
Annual GHGs:	0.6 t CO_2e/yr.	0.6 t CO_2e/yr.	0.6 t CO_2e/yr.
Lifetime GHG Reduction:	16 tonnes CO_2e	16 tonnes CO_2e	16 tonnes CO_2e
Net Present Value @5%:	-$4,765	$21,619	$48,002
Internal Rate of Return:	5%	7%	12%

Table 19: Payback sensitivity analysis by funding level for the solar air heater project with collector = 20 m²

Funding Support:	0%	25%	50%
Project Net Cost:	$22,744	$17,058	$11,372
Annual Electricity Savings:	-267 kWh/yr.	-267 kWh/yr.	-267 kWh/yr.
Annual Natural Gas Savings:	43 GJ/yr.	43 GJ/yr.	43 GJ/yr.
Total Energy Savings:	42 GJ	42 GJ	42 GJ
Annual Utility Cost Savings:	$548	$548	$548
Simple Payback:	23.4 yrs.	18.7 yrs.	13.6 yrs.
Measure Life:	25 yrs.	25 yrs.	25 yrs.
Annual GHGs:	2.2 t CO_2e/yr.	2.2 t CO_2e/yr.	2.2 t CO_2e/yr.
Lifetime GHG Reduction:	54 tonnes CO_2e	54 tonnes CO_2e	54 tonnes CO_2e
Net Present Value @5%:	-$9,712	-$4,026	$1,661
Internal Rate of Return:	1%	3%	6%

Table 20: Payback sensitivity analysis by funding level for the solar water heater project with collector = 5.1 m²

Funding Support:	0%	25%	50%
Project Net Cost:	$22,838	$17,128	$11,419
Annual Electricity Savings:	-57 kWh/yr.	-57 kWh/yr.	-57 kWh/yr.
Annual Natural Gas Savings:	9 GJ/yr.	9 GJ/yr.	9 GJ/yr.
Total Energy Savings:	8 GJ	8 GJ	8 GJ
Annual Utility Cost Savings:	$112	$112	$112
Simple Payback:	>50 yrs.	>50 yrs.	44.6 yrs.
Measure Life:	20 yrs.	20 yrs.	20 yrs.
Annual GHGs:	0.4 t CO_2e/yr.	0.4 t CO_2e/yr.	0.4 t CO_2e/yr.
Lifetime GHG Reduction:	9 tonnes CO_2e	9 tonnes CO_2e	9 tonnes CO_2e
Net Present Value @5%:	-$20,595	-$14,886	-$9,176
Internal Rate of Return:	-13%	-11%	-8%

3.6. Structural Review

The placement of the solar PV and solar water heating systems on the SRC roof warrants consideration of the existing structure's capacity for this additional load.

The proposed system sizes are 50 kW for solar PV and 5.1 m² of collector area for solar water heating, which correspond to approximately 3,480 kg and 144 kg, respectively.

This additional load likely exceeds what can be safely assumed to be suitable for an existing structure. A limited set of schematics were available at the time of writing, and were insufficient to allow a detailed structural analysis.

Ideally a full set of structural drawings can be located and a detailed document analysis can be conducted. Alternatively, a structural upgrade to reinforce the existing joists can likely be undertaken to ensure structural suitability for the added load, though this could be expensive. Without detailed structural drawings, it cannot be confirmed whether such an upgrade is even necessary, though in the absence of drawings, it may be a suitable path forward.

3.7. Summary

The following table summarizes the performance of each technology and system size investigated, including results with partial incentive funding available. The total project savings are based on solar air heater and solar water heater system sizes shown near the top of the table, i.e., ECM #'s 5, 9, and 2.

Table 21 ECM Summary

ECM		Annual Savings				Finance				Lifetime Savings	
		Electricity (kWh/yr.)	Natural Gas (GJ/yr.)	GHGs (t CO_2e/yr.)	Utility Cost	Project Cost	Simple Payback (yrs.)	Net Present Value @5%	Internal Rate of Return	Lifetime GHG Reduction (tonnes CO_2e)	Lifetime GHG Abatement Rate (/t CO_2e)
5	Solar water heater (collector = 5.1 m²)	-57	9	0.4	$112	$22,838	>50	-$20,595	-13%	9	$2,583
9	Solar air heater (collector = 20 m²)	-267	43	2.2	$548	$22,744	23.4	-$9,712	1%	54	$421
	Energy generation measures:										
2	Solar photovoltaic (50 kW DC)	54,193	0	0.6	$4,839	$105,534	16.0	-$4,765	5%	16	$6,774
	Total	**53,869**	**51**	**3.2**	**$5,499**	**$151,117**	**18.8**	**-$34,651**	**3%**	**81**	**$1,874**
	For additional consideration:										
1	Solar photovoltaic (60 kW DC)	65,031	0	0.7	$5,807	$126,641	16.0	-$5,718	5%	19	$6,774
3	Solar water heater (collector = 1.8 m²)	-25	4	0.2	$48	$15,853	>50	-$14,900	-15%	4	$4,216
4	Solar water heater (collector = 3.4 m²)	-42	7	0.3	$84	$19,240	>50	-$17,564	-13%	7	$2,913
6	Solar water heater (collector = 6.9 m²)	-68	10	0.5	$134	$26,648	>50	-$23,967	-12%	11	$2,521
7	Solar water heater (collector = 10.2 m²)	-76	12	0.6	$148	$33,632	>50	-$30,669	-13%	12	$2,878
8	Solar air heater (collector = 10 m²)	-134	26	1.3	$342	$11,372	19.8	-$3,249	2%	33	$340
10	Solar air heater (collector = 40 m²)	-534	62	3.1	$785	$45,489	29.9	-$26,777	-2%	79	$579
11	Solar air heater (collector = 70 m²)	-935	78	3.9	$961	$79,605	38.5	-$56,609	-4%	99	$808
12	Solar photovoltaic (50 kW DC) (25% funded)	54,193	0	0.6	$4,839	$79,151	12.8	$21,619	7%	16	$5,080
13	Solar photovoltaic (50 kW DC) (50% funded)	54,193	0	0.6	$4,839	$52,767	9.2	$48,002	12%	16	$3,387
14	Solar water heater (collector = 5.1 m²) (25% funded)	-57	9	0.4	$112	$17,128	>50	-$14,886	-11%	9	$1,937
15	Solar water heater (collector = 5.1 m²) (50% funded)	-57	9	0.4	$112	$11,419	44.6	-$9,176	-8%	9	$1,292
16	Solar air heater (collector = 20 m²) (25% funded)	-267	43	2.2	$548	$17,058	18.7	-$4,026	3%	54	$316
17	Solar air heater (collector = 20 m²) (50% funded)	-267	43	2.2	$548	$11,372	13.6	$1,661	6%	54	$211

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

Table 22 Impact of ECMs on performance

Performance metric	Baseline performance	Benchmark	Performance after ECMs	Potential reduction
EUI (GJ/m²)	0.91	1.10	0.87	5%
GHGI (kg CO_2e/m²)	22.17	39.60	19.35	13%
ECI ($/m²)	$22.54		$21.96	3%

4. Appendices

4.1. Appendix A - Utility data

Electricity

Table 23 Electricity utility data

	2022		2023	
	Cost	**Consumption (kWh)**	**Cost**	**Consumption (kWh)**
January	$3,102	30,819	$4,446	45,698
February	$1,804	14,739	$956	14,138
March	$977	7,352	$1,033	7,589
April	$1,006	7,712	$825	5,074
May	$816	5,314	$756	4,230
June	$759	4,591	$796	4,709
July	$863	5,906	$885	5,786
August	$939	6,865	$894	5,907
September	$778	4,829	$816	4,952
October	$797	5,040	$1,078	5,738
November	$2,611	24,339	$3,022	28,059
December	$2,733	26,138	$4,661	48,218
Total	**$17,186**	**143,644**	**$20,167**	**180,098**

Natural gas

Table 24 Natural gas utility data

	2022		2023	
	Cost	**Consumption (GJ)**	**Cost**	**Consumption (GJ)**
January	$1,618	112	$1,271	81
February	$320	21	$1,198	76
March	$493	32	$546	34
April	$201	12	$159	8
May	$106	5	$105	5
June	$66	2	$89	4
July	$45	1	$54	1
August	$82	3	$98	5
September	$128	6	$165	10
October	$1,068	65	$660	50
November	$1,772	109	$902	69
December	$1,687	105	$1,370	109
Total	**$7,585**	**471**	**$6,618**	**452**

4.2. Appendix B – Single Line Diagrams of Existing Electrical Infrastructure

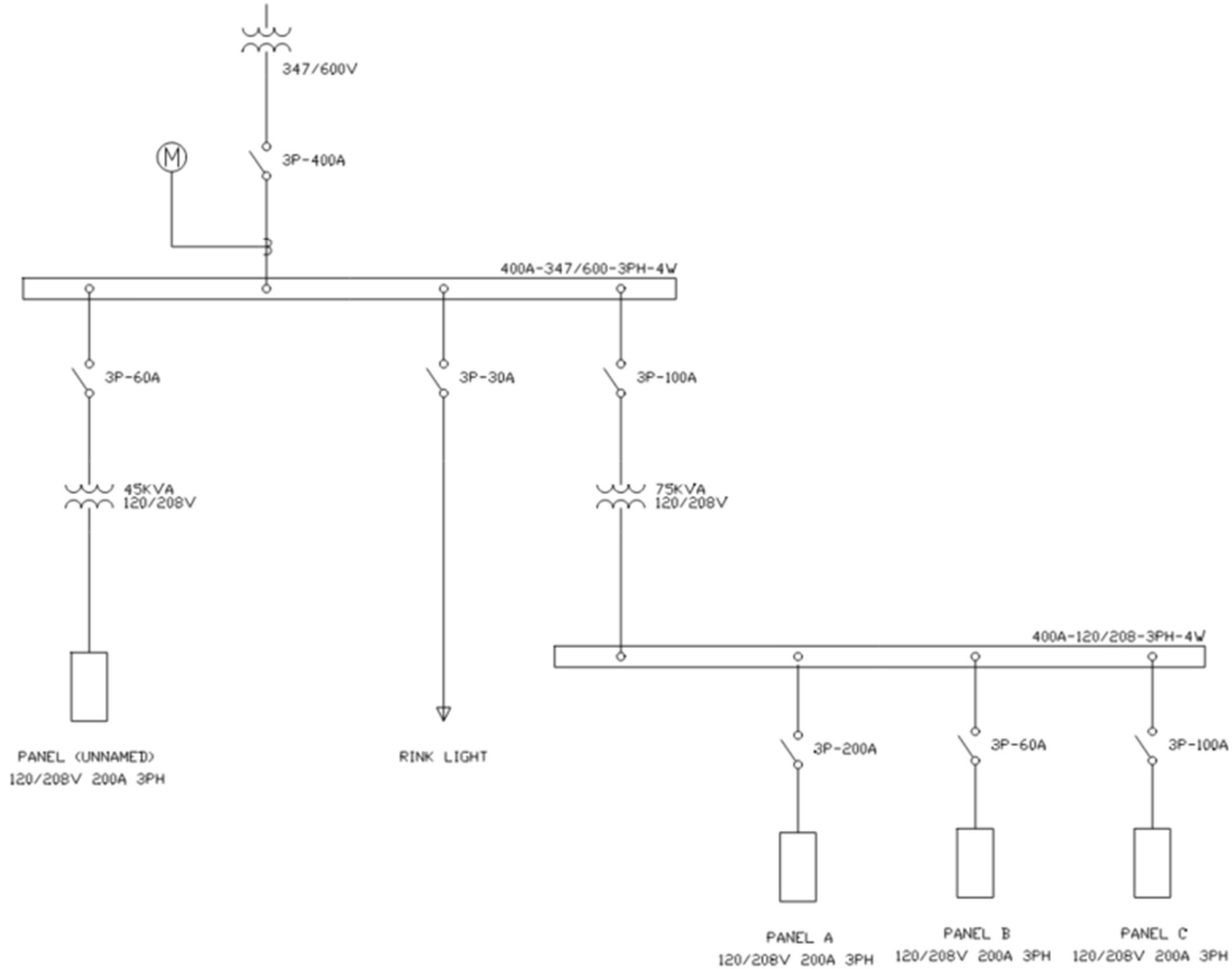

Figure 7: Single Line Diagram (SLD) of existing electrical infrastructure

4.3. Appendix C – Supplementary Figures of Proposed 60 kW Solar PV System

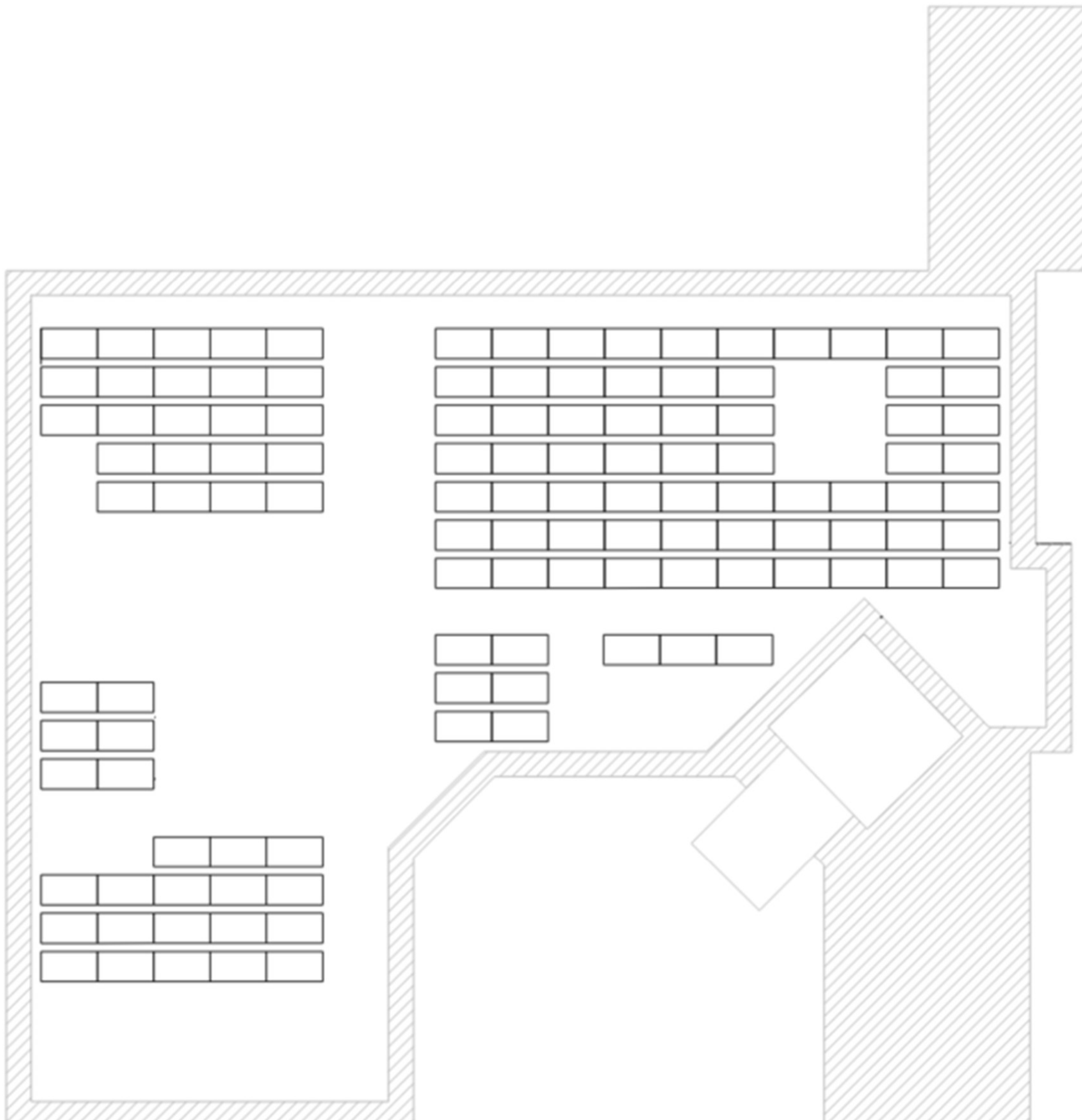

Figure 8: Overhead view of proposed panel layout

Figure 9: Rendered image of modelling software representation of 60 kW PV system

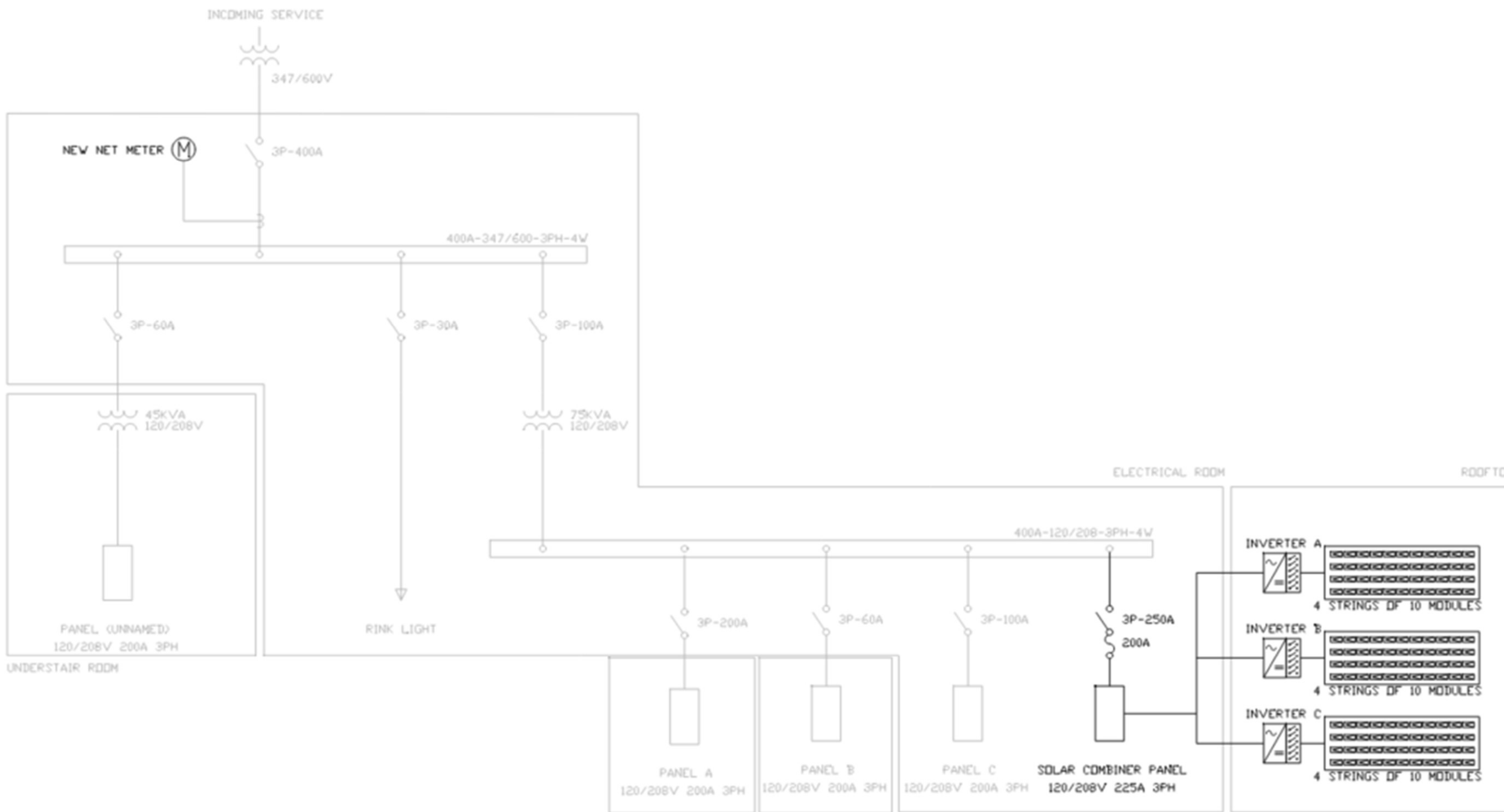

Figure 10: Single line diagram representation of likely location of integration for 60 kW PV system

4.4. Appendix D – Combined Proposed Systems Roof Schematic

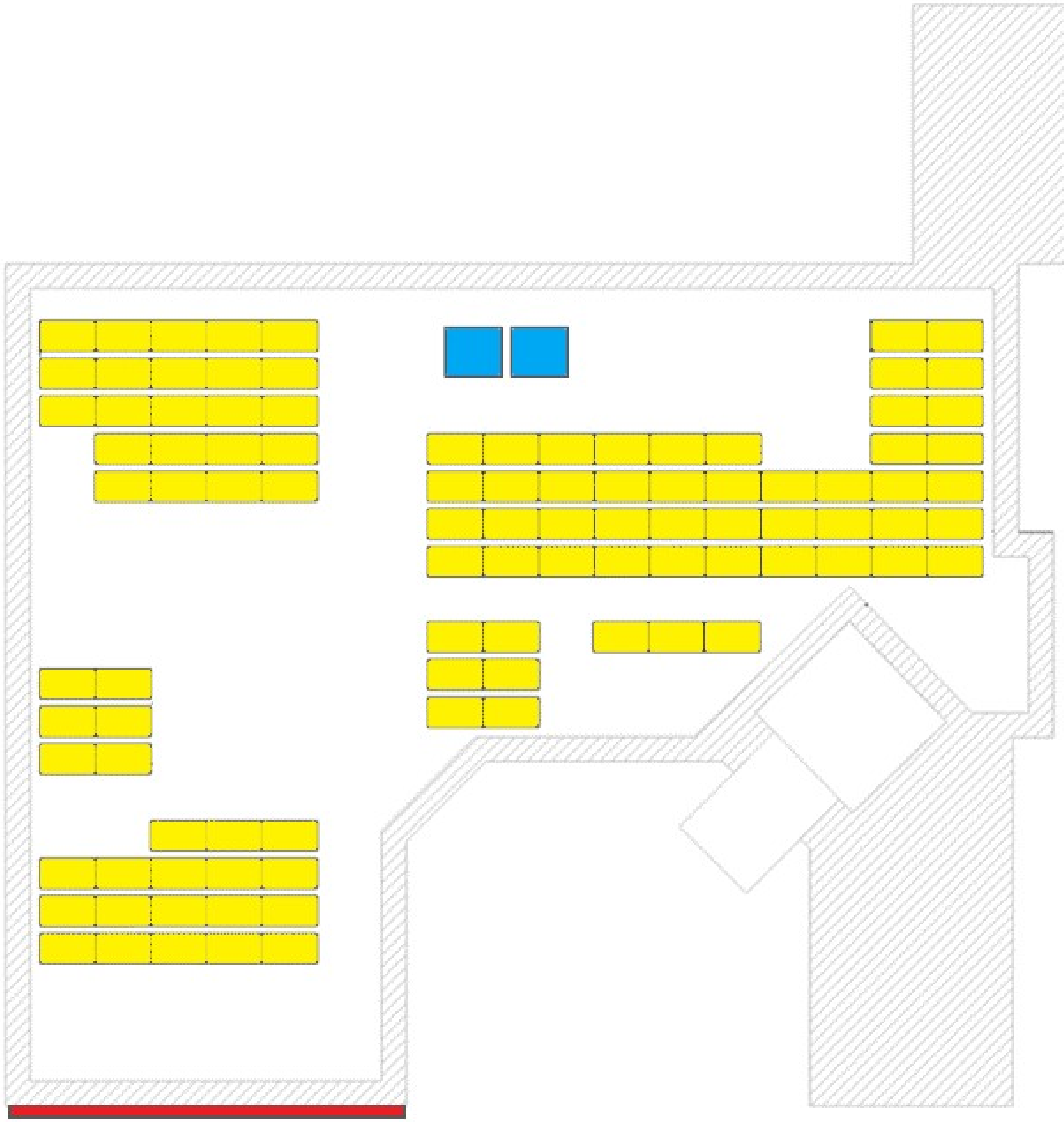

Figure 11: Proposed system indicative roof equipment layout, with solar panels in yellow, solar water heater collectors in blue, and the solar air heater collector in red (oriented vertically along wall face)

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