Regina Public Schools Energy Audit Summary

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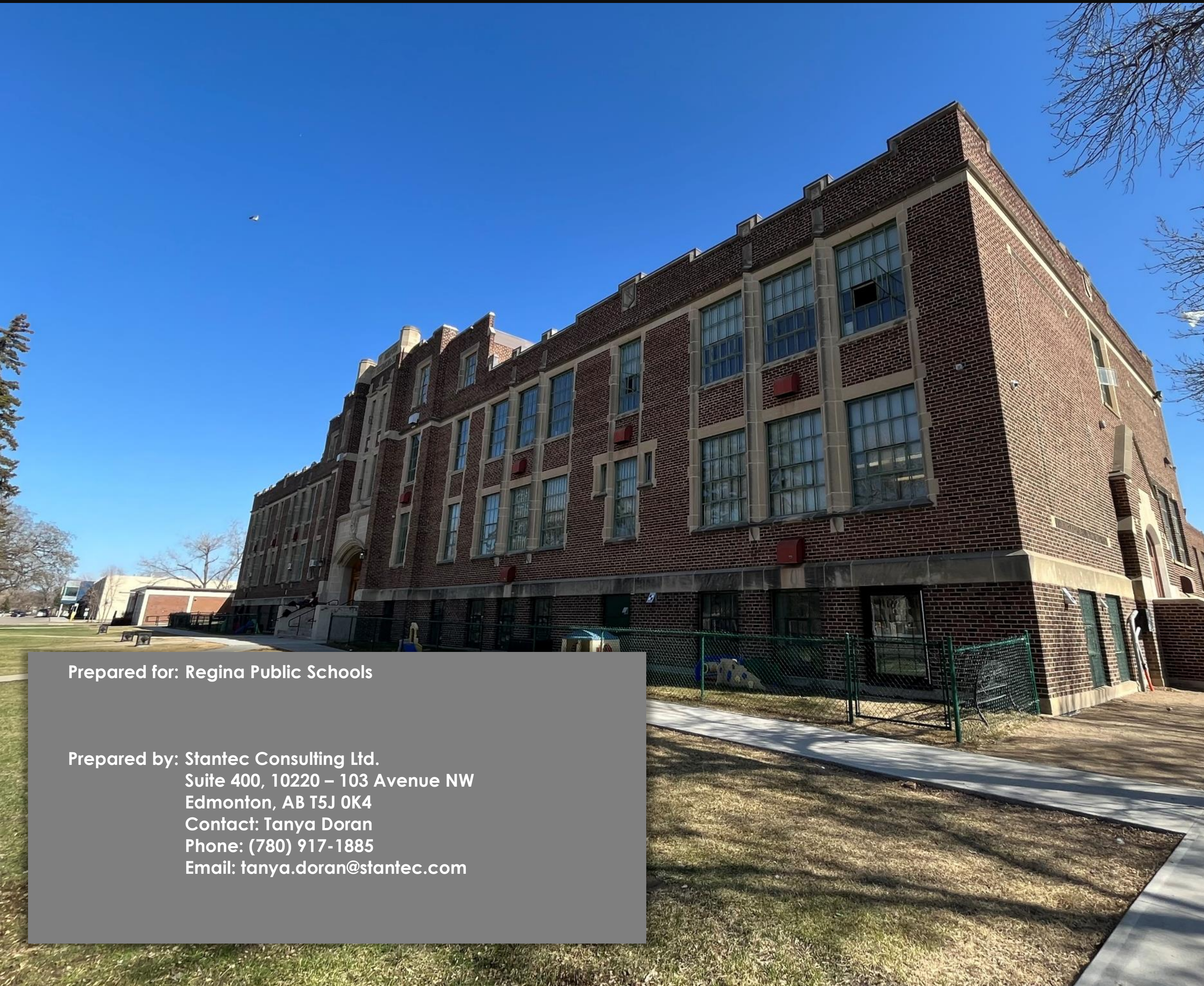

Prepared for: Regina Public Schools

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Sign-off Sheet

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Stantec is pleased to submit this detailed energy assessment report to the Regina Public Schools for review. Should you require clarification of the information contained within this report, please contact the Stantec project manager directly.

Respectfully submitted,

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1.0 Introduction

The Regina Public School Division is at the beginning stages of developing a sustainability plan to upgrade their existing building portfolio and reduce overall greenhouse gas emissions and utility costs. The building portfolio consists of approximately 44 public elementary schools, 8 public high schools, and 1 administration building.

Out of all portfolio buildings, 6 elementary schools and 4 high schools were selected as pilot sites to complete ASHRAE Level II energy audits. These ASHRAE Level II energy audits were completed between May and September of 2023. Information, analysis, and recommendations throughout these energy audits will be used to shape the next steps moving forward for Regina Public Schools (RPS), to aid and advise the decision-making process for RPS regarding future emissions reduction policy, strategies, and next steps.

The schools originally selected for energy audits include:

- F.W. Johnson Collegiate
- Seven Stones
- Balfour Collegiate
- Henry Braun
- Henry Janzen School
- Marion McVeety School
- Campbell Collegiate
- Winston Knoll Collegiate
- Ruth M. Buck
- Thomson School

This summary report identifies the key findings throughout the detailed building-level energy audits, as well as highlighting the current and projected utility environment within Saskatchewan.

2.0 Portfolio Energy Use Benchmarks

2.1 ENERGY PERFORMANCE METRIC SUMMARY

Total building energy consumption and utility costs are often representative of the size of a building and indicates the scale of energy consumption and related GHG emissions. Total building energy use is important to identify, as facilities with higher energy use emit more GHG emissions and will have a greater overall impact on achieving emissions reduction goals. However, it is also important to consider the Energy Utilization Index (EUI) which quantifies the energy use over the building floor area, expressed in GJ/m². The building EUI represents the relative efficiency of the building and is used to benchmark facility energy performance and allow for easier comparison to other buildings.

The Energy Cost Index (ECI) is another metric used to describe the utility cost efficiency of a building, expressed in utility costs per building floor area ($/m²). Although ECI is also a performance-based metric, it can deviate from energy efficiency due to the difference in utility prices between electricity and natural gas costs, which could result in a higher ECI for a more efficient building that consumes more electricity. Targeting facilities with higher ECIs will help identify which buildings can have the greatest financial savings if Carbon Reduction Measures (CRMs) are applied.

Finally, the Greenhouse Gas Index (GHGI) represents the associated GHG emissions per building floor area, expressed in KgCO2e/m². This value is derived from the energy consumption breakdown of different fuel types within the facility and local fuel emission factors.

2.2 BENCHMARKING RESOURCES

Few resources exist for K-12 schools within similar climate regions (Saskatchewan, Alberta, or Manitoba). Therefore, a sample of higher education and national K-12 schools were used for energy benchmarking comparison.

The Canadian ENERGY STAR Portfolio Manager is developed by Natural Resources Canada (NRCan) that helps organizations measure and track their energy consumption and greenhouse gas emissions in their buildings and facilities. Energy Star has a significant benchmarking database of various building typologies throughout Canda and is a great resource for comparing existing building performance to similar buildings across the country. Energy Star energy benchmarking data is not distinguished by province, therefore, only provides national averages. However, weather-related and occupant adjustments[1] can be completed to better reflect more localized evaluations. For comparison, the national Energy Star Benchmark for K-12 schools is 0.70 GJ/m^2, however, increases to 1.13 GJ/m^2 when adjusted for local Regina weather data and RPS school occupancy.

Additionally, Energy Star also contains Greenhouse Gas Intensity (GHGI) benchmarks database for K-12 schools, which is categorized by province. This data represents a greenhouse gas intensity of 86.7 KgCO$_2$e/m^2 for K-12 schools within Saskatchewan.

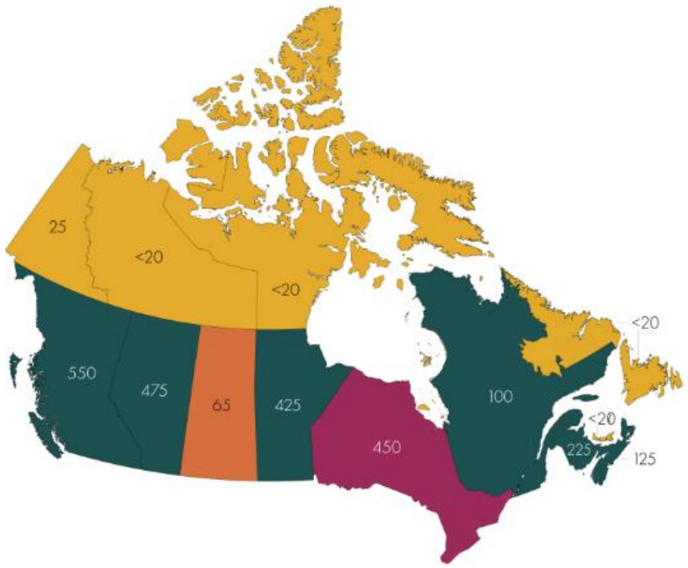

Figure 2-1: Energy Star National K-12 School Sample Locations

RPS schools were also compared to public-source energy benchmarking information from 2020-2023[2] for higher education facilities within Alberta, Saskatchewan, and Manitoba, including the University of Saskatchewan, University of Alberta, Kings College (AB), University of Manitoba, and Red River Polytechnic (MB). These campuses displayed an EUI between 0.89-2.19 GJ/m^2, with an average EUI of 1.98 GJ/m^2. However, it should be noted that these campuses contain high-intensity buildings, such as laboratories and healthcare facilities, and may not truly represent a good comparison to K-12 schools. However, the University of Alberta has independently benchmarked offices & classroom buildings, which displayed an EUI of 1.47 GJ/m^2.

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[1] Adjustments following protocols and regressional formula derived by Energy star, found at 18-01077 K12 Technical Reference - Eng FINAL_REV (2019-03-11)_REV-April-10-19_REV-6d.pdf (canada.ca)

[2] Public higher education benchmarking data derived from the Sustainability Tracking, Assessment & rating System (STARS) program.

2.3 AUDITED SAMPLE BUILDING BENCHMARKING

Ten (10) educational buildings had energy audits completed, totaling a floor area of approximately 88,370 m², representing 29% of total portfolio floor area. These audited buildings were originally selected as they represent different eras in construction type, system type, and student age, demonstrating a good sample of all the different school building types throughout the portfolio.

The audited buildings displayed a total electricity consumption of 6,420,860 kWh, representing 34% of the total portfolio electricity consumption; and 1,577,032 m³ of natural gas, representing 30% of the total portfolio gas consumption. Overall, the selected audited buildings accounted for 33% % of total portfolio utility cost and 32% of overall portfolio emissions.

The historical energy performance and characteristics of the audited buildings are displayed in the table below. This includes Energy Utilization Index (EUI), Energy Cost Index (ECI), and Greenhouse Gas Intensity (GHGI). As seen in the following table, building EUI ranges from 0.67-1.40 GJ/m² for the various audited school buildings, with an average EUI of 0.94 GJ/m². For reference, the adjusted Energy Star benchmark EUI is 1.13 GJ/m² for schools within a similar climate, indicating that the audited portfolio consumes approximately 16% less energy than an average school with similar characteristics. Individual audited schools were observed to range between 0.67-1.40 GJ/m², representing between 41% lower that benchmark data to 24% higher than benchmark data.

Table 2-1: Audited Education Building Asset List and Energy Performance

Facility/Asset	School Grade	Age of Construction	Floor Area (m²)	Energy Utilization Index (GJ/m²)	Energy Cost Index ($/m²)	Greenhouse Gas Index ($kgCO_2e/m^2$)
F.W. Johnson Collegiate	9-12	1985	11,258	0.67	$18.2	81.8
Seven Stones	Pre-K-8, w/ daycare	2014	4,481	0.69	$15.5	68.4
Balfour Collegiate	9-12	1930	17,465	0.85	$14.3	52.0
Henry Braun	K-8	1987	4,821	0.85	$14.1	67.8
Henry Janzen School	Pre-K-8	1975	4,798	0.93	$15.1	70.0
Marion McVeety School	Pre-K-8, w/ daycare	1958	2,977	1.03	$16.6	75.9
Campbell Collegiate	9-12	1964	22,212	1.04	$19.2	92.4
Winston Knoll Collegiate	9-12	1997	12,880	1.08	$22.1	98.7
Ruth M. Buck	K-8, w/ daycare	1974	4,162	1.13	$17.9	82.4
Thomson School	Pre-K-8	1927	3,320	1.40	$19.5	92.4
Total	-	-	**88,374**	**0.94**	**$17.7**	**79.2**

2.4 TOTAL PORTFOLIO BENCHMARKING

Billing data was provided from January 2020 to November of 2022 throughout most facilities. Energy benchmarking was completed for 2021 throughout all facilities.

Two major building types were selected by Regina Public Schools for the sampled audited facilities to demonstrate typical building types throughout the portfolio. These schools included six elementary schools (14% of elementary portfolio) and four high schools (40% of high school portfolio).

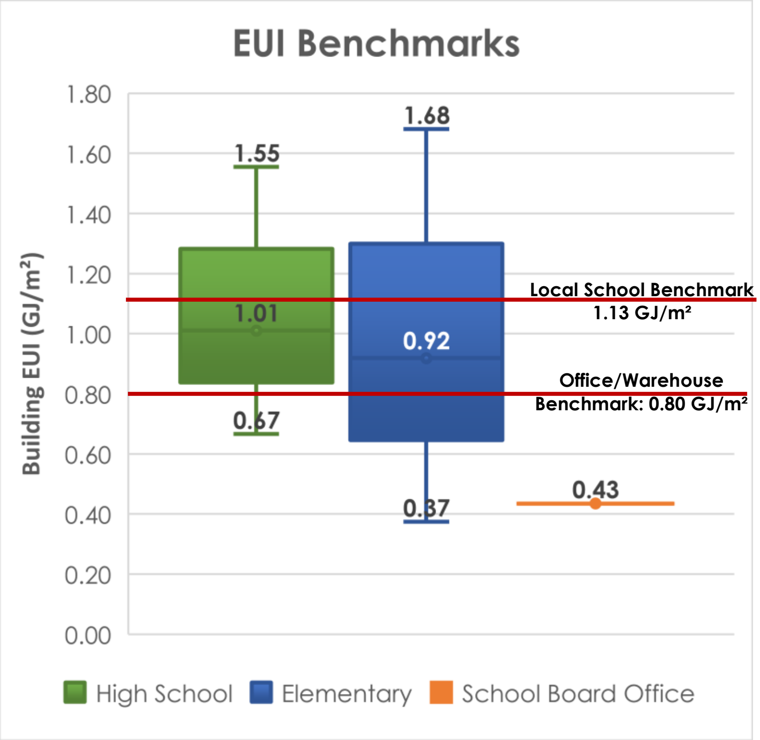

Figure 2-2: EUI of all Portfolio Buildings

The total floor areas and respective performance for audited and non-audited buildings throughout the RPS portfolio is displayed within Figure 2-2, representing an EUI of 0.92 & 1.01 GJ/m² for High schools and Elementary Schools respectively, compared to the locally adjusted benchmark EUI of 1.13 GJ/m². Additionally, the school board office building has an EUI of 0.43 GJ/m², compared to the office/warehouse benchmark EUI of 0.80 GJ/m². Further EUI information is detailed in the table below, including the minimum to maximum ranges of EUIs and ECIs, as well as the combined average.

Table 2-2: Education Building Asset List

Building Type	Audited Buildings				Remaining Buildings			
	Quantity	Total Floor Area (m²)	EUI (GJ/m²)	ECI ($/m²)	Quantity	Total Floor Area (m²)	EUI (GJ/m²)	ECI ($/m²)
High School	4	63,815	0.67-1.08 (0.93)	$14.3-22.1 ($18.3)	6	48,854	0.95-1.55 (1.11)	$13.3-22.2 ($17.1)
Elementary	6	24,559	0.69-1.40 (0.98)	$14.1-19.5 ($16.2)	36	137,932	0.37-1.68 (0.91)	$5.70-28.9 ($16.0)
School Board Offices	0	0	-	-	1	17,480	0.43	$11.1
Total	**10**	**88,374**	**0.67-1.40 (0.94)**	**$14.1-22.1 ($17.7)**	**43**	**204,266**	**0.37-1.68 (0.92)**	**$5.70-28.9 ($15.8)**

Throughout the benchmarking billing period, RPS portfolio buildings had an annual electricity consumption of 19,133 MWh and an annual natural gas consumption of 5,269,305 m³, resulting in a total energy use of 270,487 GJ. This associated energy use results in an approximate utility cost of $4,795,000 per year, emitting almost 22,000 tCO_2e, equivalent to 5,130 homes or 6,710 passenger vehicles, as shown in Figure 2-3 below[i].

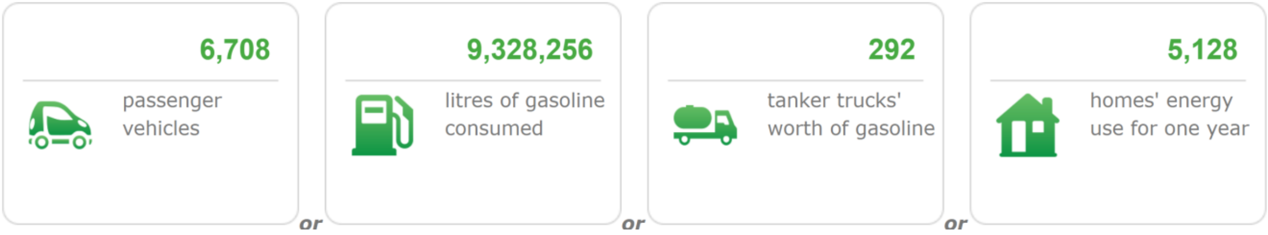

Figure 2-3: Equivalent Emissions to Existing Building Portfolio

Figure 2-4 below displays the breakdown in energy use, energy costs, and GHG emissions throughout all portfolio buildings, categorized by elementary, high school, and office building types.

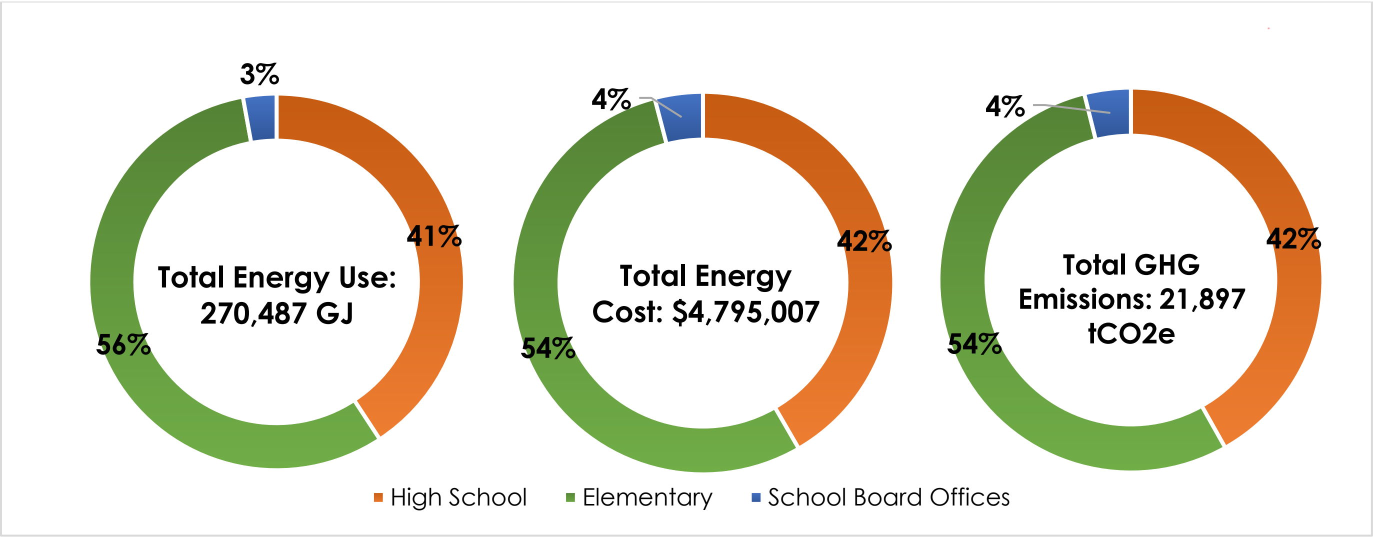

Figure 2-4: Building Type Energy, cost, and Emission Comparison

The facilities within the building portfolio vary in age of construction, with the oldest facility dating back to 1924 and the newest facility being constructed in 2017. This near 100-year time period has overseen many different building codes and construction practices, technology innovations, utility prices, and perception on energy efficiency. Table 2-3 below displays the various building era's, starting in the 1920's and ending in 2017. Some building ages were not available, therefore, were categorized as undetermined,

Table 2-3: Energy Consumption of Portfolio by Building Age

Building Type	Building Quantity	Total Floor Area (m²)	Total Energy Use (GJ)	EUI (GJ/m²)	Energy Cost ($)	ECI ($/m²)	GHG Emissions (tCO2e)	GHGI (KgCO2e/m²)
1920 - 1940	5	33,306	29,884	0.90	$459,434	$13.8	1,896	56.9
1941 - 1960	14	72,271	66,567	0.92	$1,015,052	$14.0	4,777	66.1
1961 - 1980	19	107,540	108,398	1.01	$1,867,769	$17.4	8,779	81.6
1981 - 2000	10	58,867	49,404	0.84	$1,062,786	$18.1	4,739	80.5
2001 - 2020	5	20,656	16,233	0.79	$389,966	$18.9	1,707	82.7
Total	**53**	**292,640**	**270,487**	**0.92**	**$4,795,007**	**$16.4**	**21,897**	**74.8**

As seen in the table above, the majority of buildings were constructed between 1941-1980, totaling 33 buildings, or 61% of the building portfolio. Schools built between 1961 and 1980 were observed to have the highest EUI, at 1.01 GJ/m². An increase in overall efficiency is seen for newer constructed buildings, as seen between 1981-2000, which has an average EUI of 0.84 GJ/m², followed by buildings built after 2001, which displayed an EUI of 0.79 GJ/m². This decrease in EUI is likely a result of increasing energy efficiency over time through the development of building energy codes, as well as an increased focus on energy efficiency and reduced utility costs by building owners and operators.

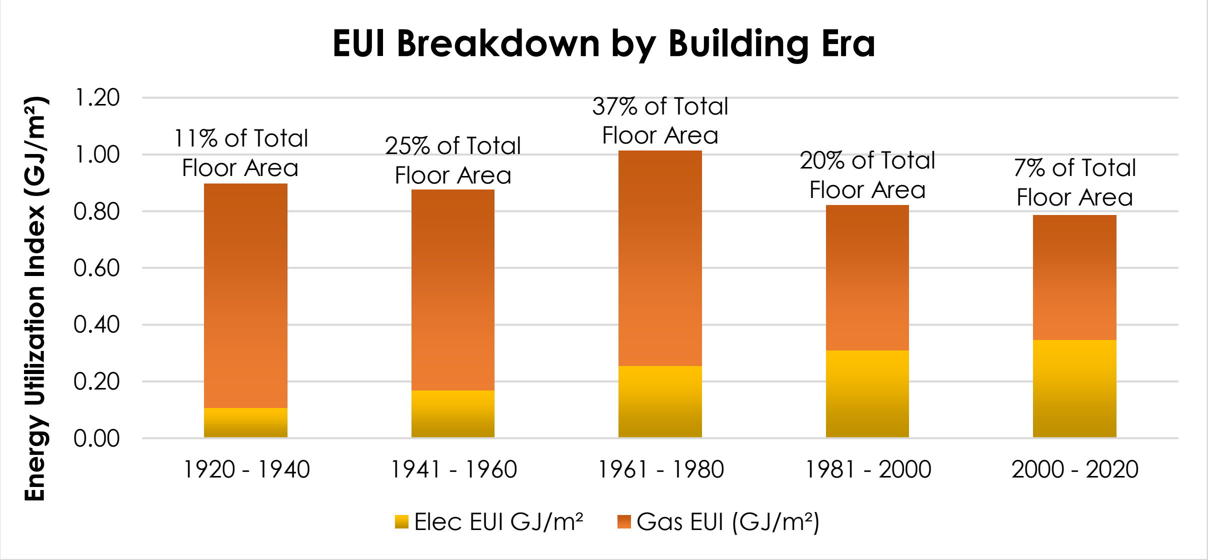

Figure 2-5: EUI Breakdown of Portfolio Buildings by Construction Era

Although newer buildings appear to be increasing in energy efficiency, higher respective utility costs and emissions were observed. This is primarily a result of increased electricity consumption within the facilities, which has trended upward throughout each construction era, as seen in the figures below. This illustrates the importance of different fuel consumption on-site, and the impact on energy use, utility cost, and emissions.

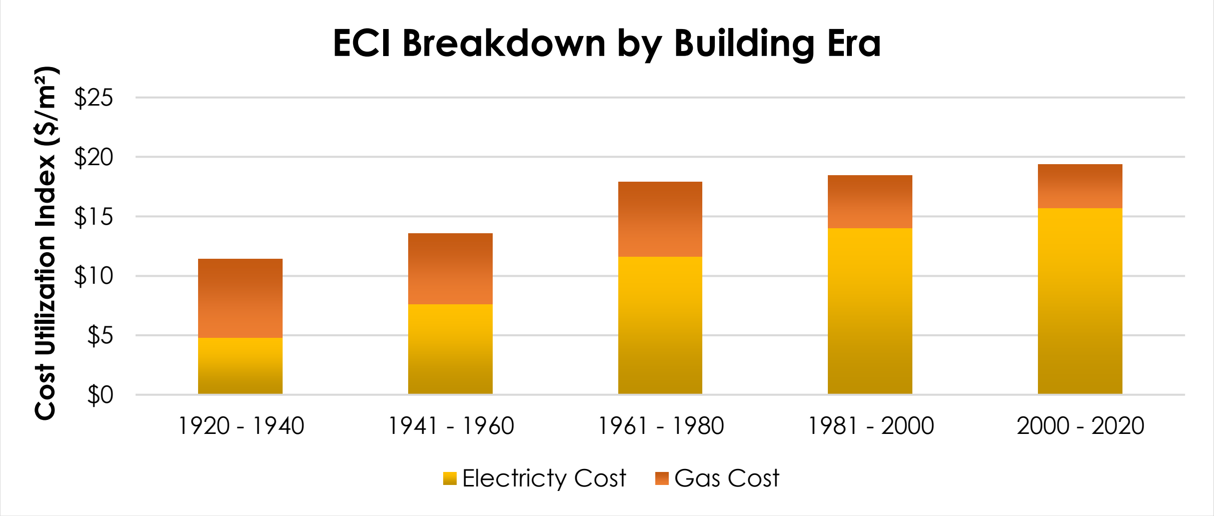

Figure 2-6: ECI Breakdown of Portfolio Buildings by Construction Era

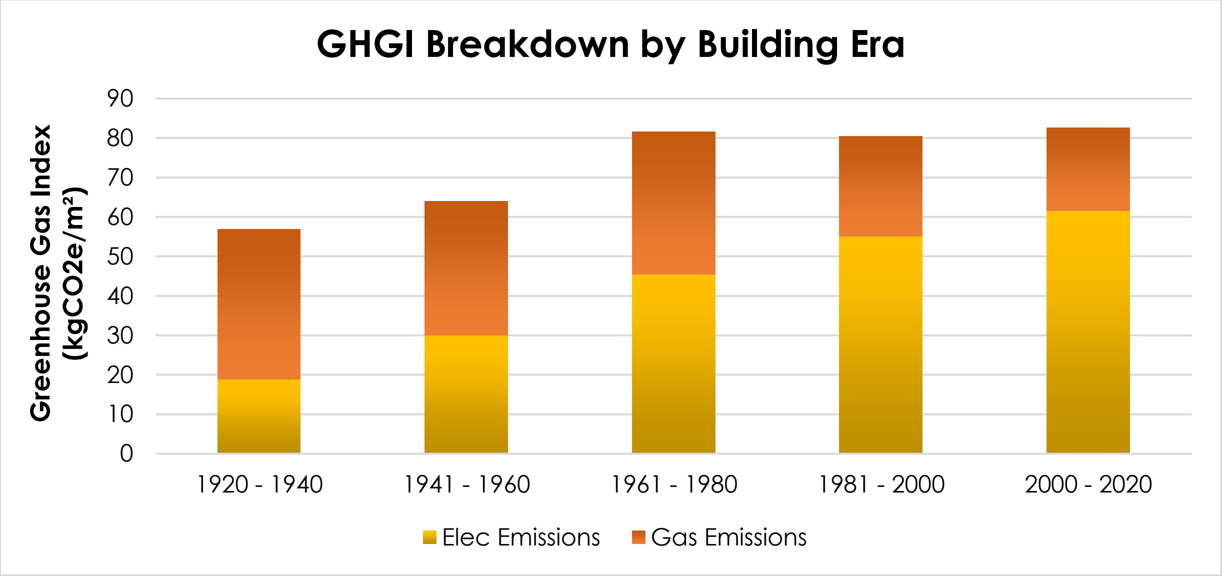

Figure 2-7: GHGI Breakdown of Portfolio Buildings by Construction Era

Although newer buildings have high operating costs and GHG emissions, they only make up a small percentage of the overall portfolio. Buildings built between 1941-2000 make up 80% of the total building portfolio floor area, and as such total approximately 80%+ or portfolio energy use, utility costs, and emissions. Therefore, these buildings should be targeted firstly to have the greatest overall impact on total portfolio cost and emissions.

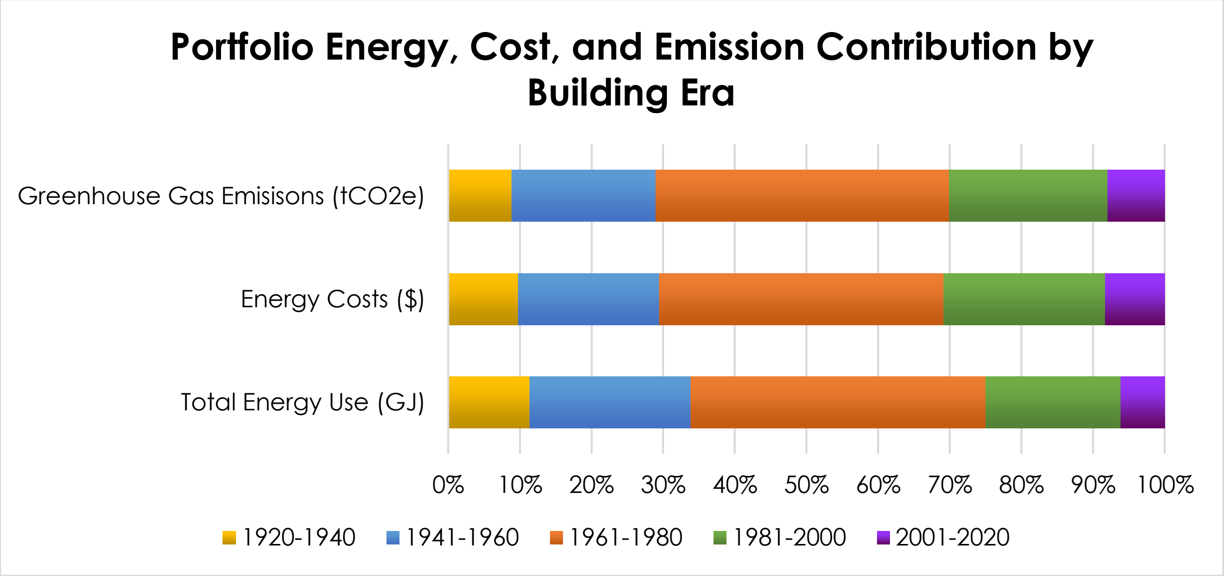

Figure 2-8: Portfolio Energy, Cost, and Emission Contribution by Building Era

2.5 VEHICLE FLEET BENCHMARKING

The vehicle fleet for Regina Public Schools consists of light duty vehicles for staff and supply transport. Fuel bills were provided by RPS from January 2020 to February 2023, however, billing data was missing for February 2022.

Fuel bills displayed a total annual average gasoline consumption of 41,411 liters (94% of fleet energy usage), with a diesel consumption of 2,590 liters (6% of fleet energy usage). This results in an annual average fuel cost of $53,155, resulting in 98.4 tCO2e of greenhouse gas emissions, as shown in Table 2-4 below.

Table 2-4: Vehicle Fleet Fuel Data (2020-2023)

Year	Gasoline (L)	Deisel (L)	Total Fuel Cost ($)	Fleet Emissions (tCO2e)
2020	37,276	1,997	$35,745	87.7
2021	45,088	2,986	$56,067	107.6
2022 (Missing Feb)	38,275	2,487	$64,255	91.2
2023 (Jan-Feb)	6,707	810	$11,812	17.0
Total	**41,411**	**2,590**	**$53,155**	**98.4**

Vehicle fleet fuel use consumption and associated emissions are relatively small compared to the energy consumption and emissions from the RPS building portfolio. As seen in Figure 2-9 through Figure 2-11 below, vehicle related fuel use, costs, and emissions make up 1% or less of total RPS operational energy, costs, and emissions.

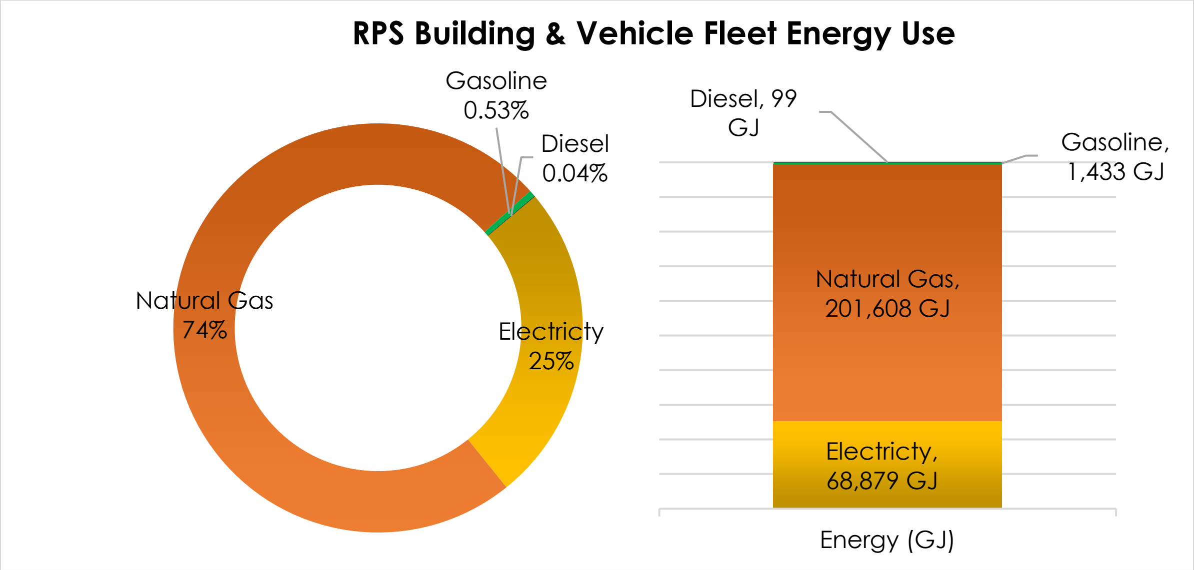

Figure 2-9: Building Portfolio and Vehicle Fleet Annual Energy Use

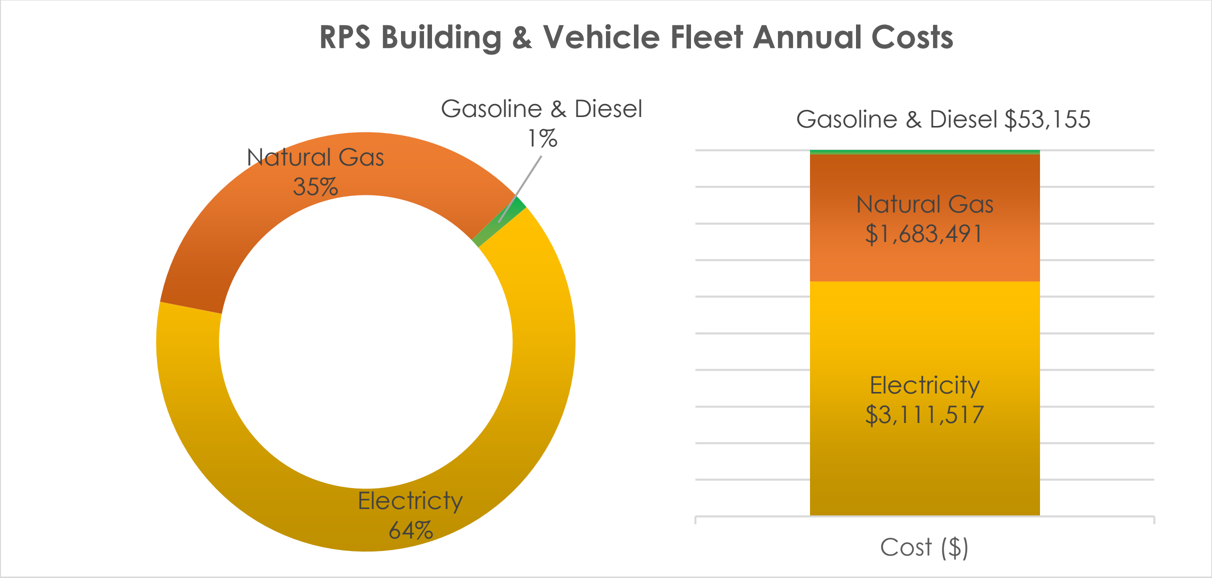

Figure 2-10: Building Portfolio and Vehicle Fleet Annual Costs

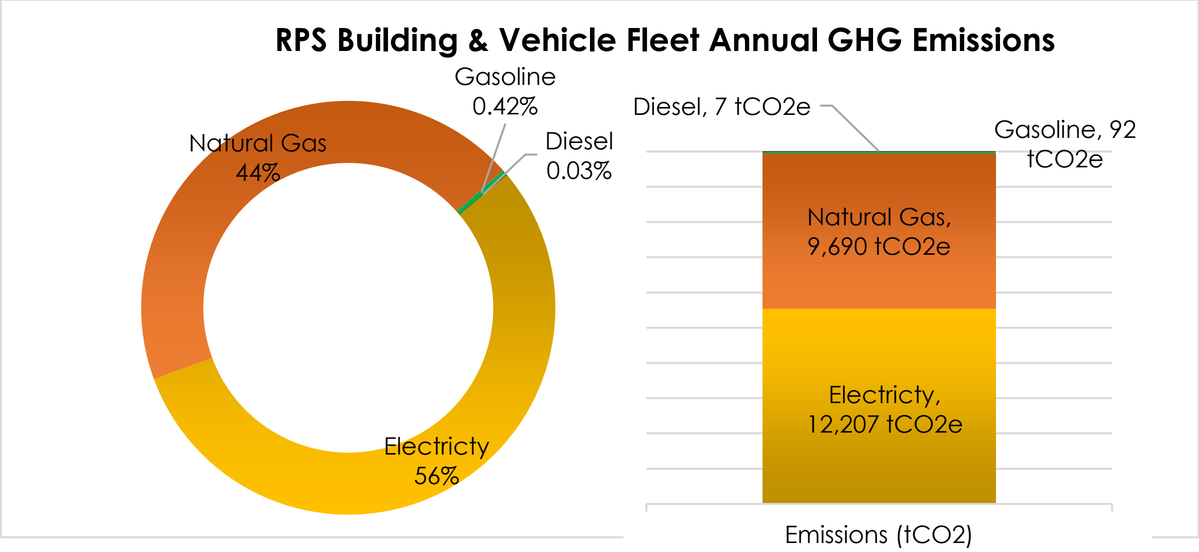

Figure 2-11: Building Portfolio and Vehicle Fleet Annual Emissions

Replacing internal combustion and diesel fleet vehicles with electric vehicles (EVs) may be desired in future years to reduce fossil fuel related transportation emissions. With the replacement of all existing fossil fuel power vehicles with EVs, related transportation energy usage is expected to reduce by 77%, from 1,532 GJ down to 347 GJ. Similarly, related fuel costs are also expected to reduce by 78%, from $53,155 down to $11,570 per year; however, excludes associated demand charges which would be specific to each building/charging station. Finally, a 37% annual emissions reduction is expected (as of 2023), from 98 tCO2e down to 62 tCO2e, which will further decrease as electricity grid emission intensity improves throughout coming years.

This high-level fleet electrification analysis was completed using an estimated fuel efficiency of 10.2 L/100 km for fossil fuel powered vehicles, and 19 kWh/km for EVs, with an additional 85% de-rate for round trip battery charging efficiency, supplementary battery heating, etc.

3.0 Utility and Grid Analysis

3.1 EMISSION FORECASTING

Carbon pricing for electricity consumption can change depending on electricity grid emission intensity, while carbon pricing for direct on-site natural gas consumption is relatively fixed. The current fuel mix for SaskPower[3] is comprised of hydro (334 MW), wind (182 MW), solar (8 MW), natural gas (1,145 MW), coal (1,112 MW), and a combination of other miscellaneous sources (94 MW).

Natural gas has an emission intensity of 1.84 tCO_2e/m^3[4] and is expected to remain constant for the near future. The SaskPower electricity grid emission intensity is expected to be reduced throughout the coming years, as SaskPower has committed to a 50% reduction in emissions by 2030 compared to 2005 levels. As per current federal emissions accounting, the Saskatchewan electricity grid has an emission intensity of 638 tCO2e/GWh. Future electricity grid intensity is expected to decline until a projected 405 tCO_2e/GWh in 2030.

Grid emission intensity estimates from 2030-2050 are based on current federal projections from Environment and Climate Change Canada (ECCC)[5], displayed in Figure 3-1 below.

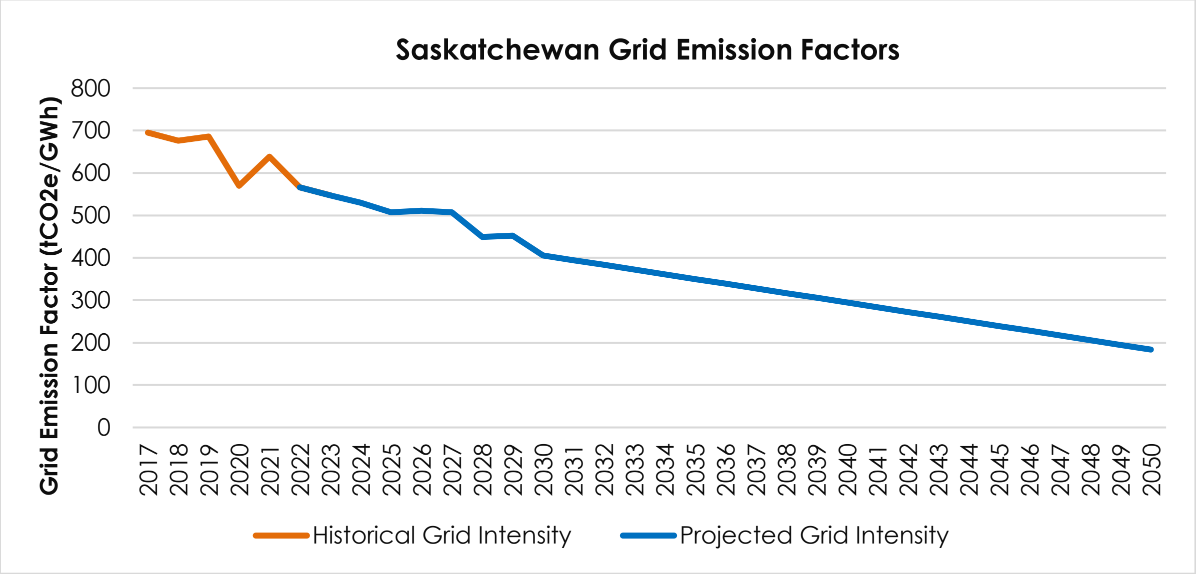

Figure 3-1: Saskatchewan Grid Emission Intensity

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[3] Where Your Power Comes From (saskpower.com)
[4] En81-4-2020-2-eng.pdf (publications.gc.ca)
[5] Home - Environment and Climate Change Canada Data

3.2 BUILDING ELECTRIFICATION

Building electrification will play a significant role in the reduction of energy and greenhouse gas emissions throughout the RPS building portfolio. However emissions reductions are heavily dependent on electricity grid emission intensity and grid greening. Currently, the RPS building portfolio emits approximately 21,897 tCO_2e annually. It is estimated that building emissions would decrease by 20% and 39% by 2030 and 2050, respectively, if no efficiency upgrades are implemented and only grid greening is achieved.

The move to clean heating and building electrification typically involves s the replacement of existing on-site gas combustion equipment (furnaces, boilers, water heaters, etc.) with electric heating equipment. Various electrification technologies were compared, including replacing gas fired equipment with electric resistance equipment, replacing gas equipment with air-source heat pumps (ASHP); and replacing gas equipment with water source heat pumps (WSHP) with ground loop storage and integrated solar PV/thermal (PVT) modules.

3.2.1 Electrification Technology Comparison

Table 3-1: Electrification Technology Comparison

Electrification Type	Pros	Cons
Electric Resistance	-Can easily retrofit existing systems -No/minimal moving parts (low maintenance) -Low upfront cost -Similar operation and controls to typical gas fired systems	-Likely requires electrical service upgrade -Max efficiency is 100% -High electric demand, associated demand costs, and grid capacity requirements -High energy and operating costs -Low emission savings
Air Source Heat Pumps	-Efficiency can exceed 100% during moderate weather conditions -Can utilize existing system distribution infrastructure -Can provide heating and cooling -Packaged units available for hydronic systems or air systems -Moderate operating costs -Moderate emission savings	-Requires electric back-up heating, and likely electrical service upgrades -Poor heating performance during cold weather (below -15°C), resulting in the utilization of back-up heating -Many moving parts (high maintenance) -Low temperature heating, may require moderate/major distribution retrofits or deep energy retrofits to reduce building demand -Moderate/High upfront costs
Water Source Heat Pumps w/ Thermal Storage and Solar PVT	-Efficiency can exceed 100% in all weather conditions -Reduced heat pump sizing and related ampacity requirements. Electrical service upgrades may be eliminated. -Integration of Solar PV-thermal results in significantly reduced thermal storage and equipment sizing compared to traditional systems -No back-up heating sources required -Low operating costs -High emission savings	-Many moving parts (high maintenance) -Requires available space for thermal storage and PV-thermal modules -Low temperature heating, requires moderate/major distribution retrofit or deep energy retrofits to reduce building demand -High upfront costs

Throughout the various electrification technologies analyzed in Table 3-1 above, electric resistance heating and air source heat pumps resulted in increased utility costs and GHG emissions, due to the increased cost of electricity compared to natural gas, increased electrical demand, lower annual average efficiencies than rated heat pump efficiencies, and poor electricity grid emission intensity. These electrification technologies have moderate equipment and installation costs, however, may require building or utility infrastructure upgrades, which may result in significant project expenses.

Water source heat pumps with thermal storage and solar PVT results in a decrease in utility costs and related emissions due to the high system efficiency and year-round heating/cooling capabilities. However, this option results in significant upfront equipment and installation costs, therefore, does not typically see paybacks within the equipment lifetime.

As a result, electrification options for heating and cooling are not currently recommended at this time and will require careful consideration if implemented in future years to ensure emissions are reduced throughout the electrification process.

Table 3-2 below displays the maximum grid intensity required depending on the existing gas fired equipment efficiency and the proposed electric system. The proposed electric efficiencies were used within the above system comparisons, and illustrate the efficiencies for an electric boiler, air source heat pump with electric back-up, and water source heat pump with solar PV-thermal. For reference, most gas fired equipment used within the audited schools had efficiencies of 65-75%, with a current grid emission intensity of 638 tCO2e/GWh.

Table 3-2: Maximum Grid Emission Factors (tCO2e/GWh) for Emissions Reductions Through Electrification

Existing Gas Heating Efficiency → **Proposed Electric Heating Efficiency ↓**	**85%**	**75%**	**65%**	**55%**
100% (Electric Boiler)	209	237	274	324
167% (Annual Average for ASHP)	350	396	457	541
260% (ASHP at Rated Conditions)	545	617	712	842
480% (Annual Average for WSHP with PVT)	1,000	1,134	1,308	1546

As seen in the table above, electric boilers require a maximum grid emission intensity of 209-324 tCO_2e/GWh to achieve emissions reductions, which is not expected until 2043.

Similarly, the annual average heat pump COP was calculated at 1.67 kW/kW, using a peak COP of 2.60 kW/kW at 8°C (rated conditions) and a minimum COP of 1.8 kW/kW at -15°C (minimum conditions), with electric backup engaged below -15°C. This displays a maximum grid intensity of 350-541 tCO_2e/GWh, expected to occur in 2029.

Finally, the WSHP with PVT system displays a maximum grid intensity of 1,000-1,546 tCO_2e/GWh. The current electricity grid is below all scenarios for existing equipment efficiency and can be implemented for immediate emission reductions.

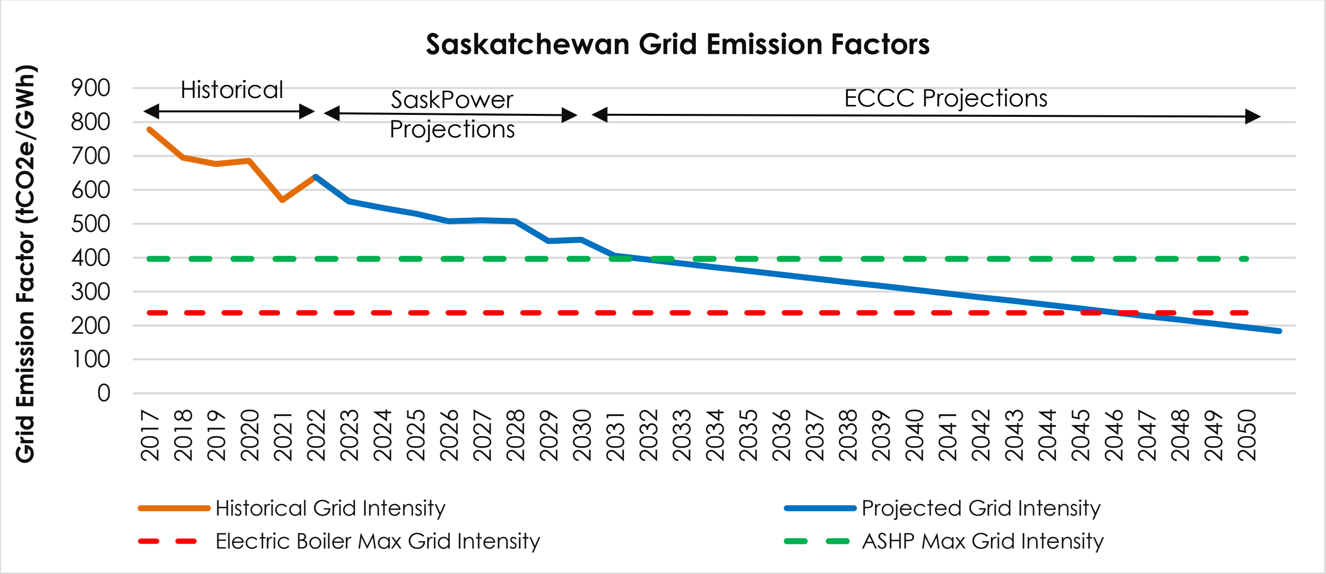


Figure 3-2: SaskPower Grid Emission Intensity

3.3 UTILITY RATE FORECASTING

The federal carbon levy was introduced nationally in 2019, resulting in a price on carbon starting at \$20/tCO₂e in 2019, raising to \$50/tCO₂e in 2022, with further incremental increases until 2030 to a maximum of \$170/tCO₂e. This results in an annual increase of \$0.03/m² of natural gas (\$0.79/GJ).

Electricity prices are also affected by the carbon levy, which are recovered from end-use consumers through monthly electricity bill charges. Since electricity grid emissions are subject to change through grid greening, associated carbon costs for electricity will also change over time. Therefore, higher carbon costs would be seen for dirtier grids and lower carbon costs for cleaner grids. As such, an average annual increase of \$0.008/kWh is present for the current electricity grid, assuming no grid greening throughout future years. Reduced carbon costs will be seen if grid greening occurs, which is expected to only result in an average annual increase of \$0.005/kWh.

Although carbon pricing past 2030 is uncertain, speculation by the federal government have indicated a potential increase to \$300/tCO₂e by 2050, which would result in an annual incremental increase of \$6.50/tCO₂ per year after 2030, as detailed in Table 3-3 below.

Table 3-3: Legislated and Projected Carbon Pricing

Year	Carbon Price ($/tCO$_2$e)	Natural Gas Carbon Cost ($/m³)	Electricity Carbon Cost (No Grid Greening) ($/kWh)	Electricity Carbon Cost (Grid Greening) ($/kWh)
BASELINE	$0	$0	$0	$0
2023	$65	$0.13	$0.037	$0.036
2024	$80	$0.16	$0.045	$0.042
2025	$95	$0.19	$0.054	$0.048
2026	$110	$0.23	$0.062	$0.056
2027	$125	$0.26	$0.071	$0.063
2028	$140	$0.29	$0.079	$0.063
2029	$155	$0.32	$0.088	$0.070
2030	$170	$0.35	$0.096	$0.069
2040	$235	$0.48	$0.133	$0.069
2050	$300	$0.62	$0.170	$0.055

As seen above, natural gas costs are expected to rise significantly between 2023 through 2030 and onward. Similarly, electricity related carbon costs are also expected to rise steadily throughout future years if no grid greening is present. However, electricity carbon costs flatline around 2029 if projected grid greening is achieved, as the reduction in grid emission intensity offsets increased carbon costs.

Currently, the RPS building portfolio carbon tax contributions are detailed in Table 3-4 below. Two scenarios are portrayed, including carbon tax contributions with and without grid greening.

Table 3-4: Expected Annual Carbon Costs

Year	Carbon Price ($/tCO2e)	BAU-No Grid Greening	BAU-With Grid Greening
Baseline	$0	$0	$0
2023 (Current)	$65	$1,407,000	$1,384,000
2027	$125	$2,705,000	$2,565,000
2030	$170	$3,679,000	$3,157,000
2040	$235	$5,086,000	$3,865,000
2050	$300	$6,493,000	$4,298,000

4.0 Carbon Reduction Opportunities

4.1 FINANCIAL PERFORMANCE ANALYSIS

Energy audits and associated Carbon Reduction Measures were analyzed for 10 schools, including four high schools and six elementary schools. Carbon Reduction Measures included low-cost measures; measures targeting a reduction in electricity, electrical demand, natural gas, and water; and renewable energy generation.

Not all measures perform equally, therefore, greenhouse gas reductions and financial performance (net present value) were used as key performance indicators to identify and score top performing CRMs. Higher scoring (positive) measures are considered higher priority CRMs, and should be considered for immediate implementation, while lower-performing (negative) measures should be incorporated into future budget planning, and lifecycle replacement upgrades.

Measures identified within the energy audits were categorized based on marginal abatement rate and are shown below in Figure 4-1. This chart compares the financial performance (net present value) of each CRM over the lifetime of greenhouse gas emissions reductions. An action with a high (positive) marginal abatement rate indicates that money is saved for every tonne of GHG emissions reduced, representing a feasible decarbonization investment with good returns; while measures with low (negative) marginal abatement rates indicate that money is lost for every tonne of GHG emissions reduced. Net present value calculations are non-discounted.

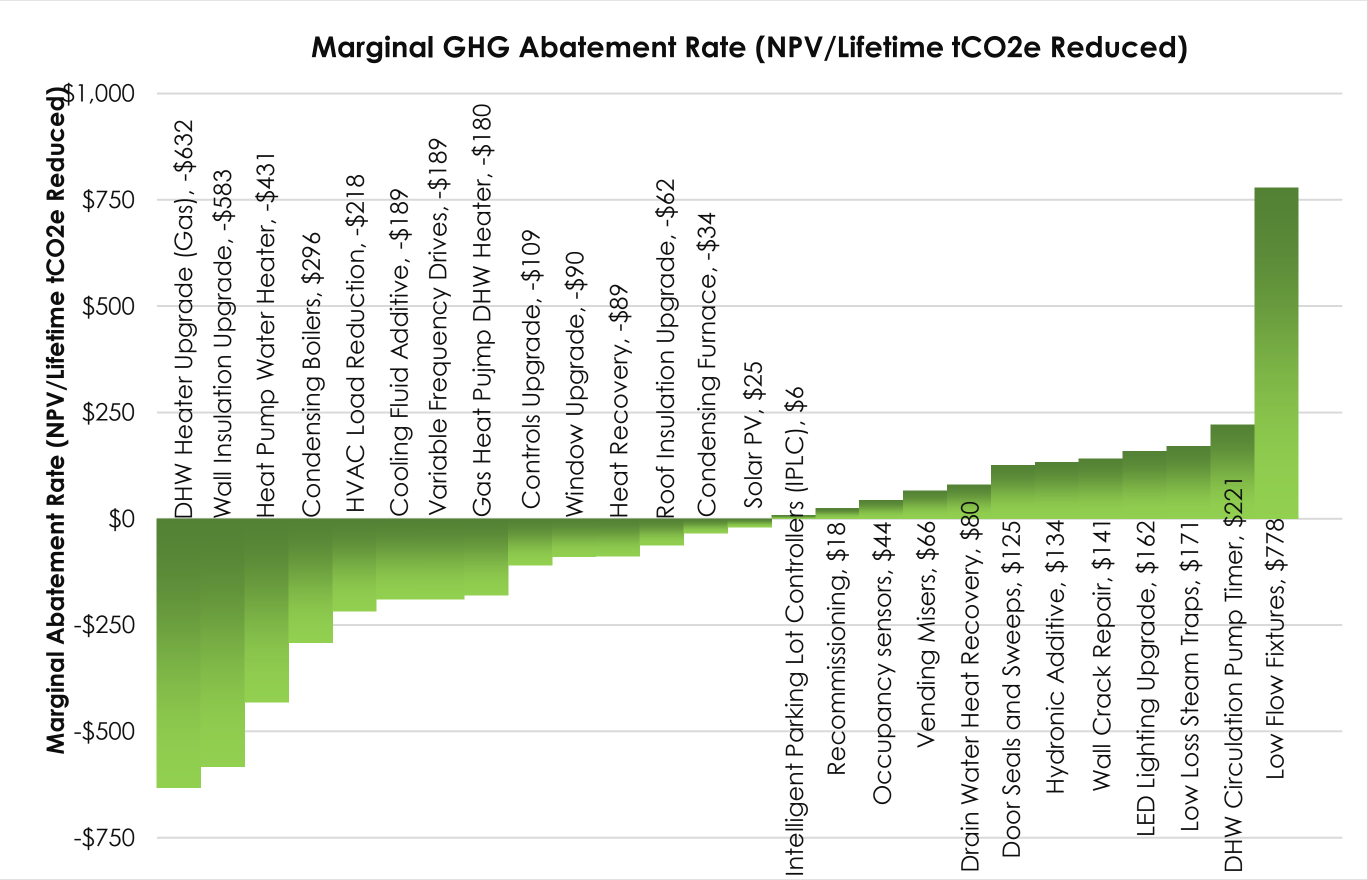


Figure 4-1: Marginal Abatement Rates of Carbon Reduction Measures

As seen in the figure above, top performing CRMs include low flow water fixtures; low-cost measures such as DHW Circulation pumps, envelope crack repairs, door seals and sweeps, and vending misers; and more capital-intensive measures, such as lighting upgrades, heating fluid additives, recommissioning, occupancy controls, and car plug controls. These measures all have positive marginal GHG abatements rates and indicate good financial and GHG emission performance.

Slightly lower performing measures include solar PV, heat recovery opportunities, incremental roof insulation upgrades, high performance windows, control upgrades and optimization, and some equipment lifecycle replacement, such as condensing furnaces. These measures have negative marginal GHG abatement rates, indicating reduced financial performance, however, still result in significant emissions savings.

As expected, measures with lower marginal abatement rates typically consist of the remaining lifecycle upgrades (boilers and DHW heaters) and wall insulation upgrades. Variable frequency drives (VFDs) are typically a good CRM, however, due to the intensive system upgrades required for VFD compatibility, partnered with lower annual run times of the systems, results in lower performance.

Although it is ideal that measures with higher marginal abatement rates be implemented first, lifecycle upgrades (such as boiler and furnace upgrades) may take priority over efficiency upgrades, to reduce potential redundant replacement costs.

4.2 GREENHOUSE GAS EMISSION ANALYSIS

Figure 4-2 below displays the annual emissions reductions for each analyzed CRM, resulting in significant emissions reductions for Solar PV, condensing boiler upgrades, window and roof insulation and LED lighting.

Solar PV and LED lighting upgrades save significantly less energy than boiler and envelope upgrades, however, have similar annual GHG emissions reductions due to the higher carbon intensity of the SaskPower electricity grid. Condensing Boilers, window upgrades, and incremental roof insulation upgrade savings have significant energy and emission savings and can be attributed to the poor performing qualities of the selected audited buildings, which utilize older steam-fired boiler systems with low operating efficiency, low roof insulation levels, and poor performing windows.

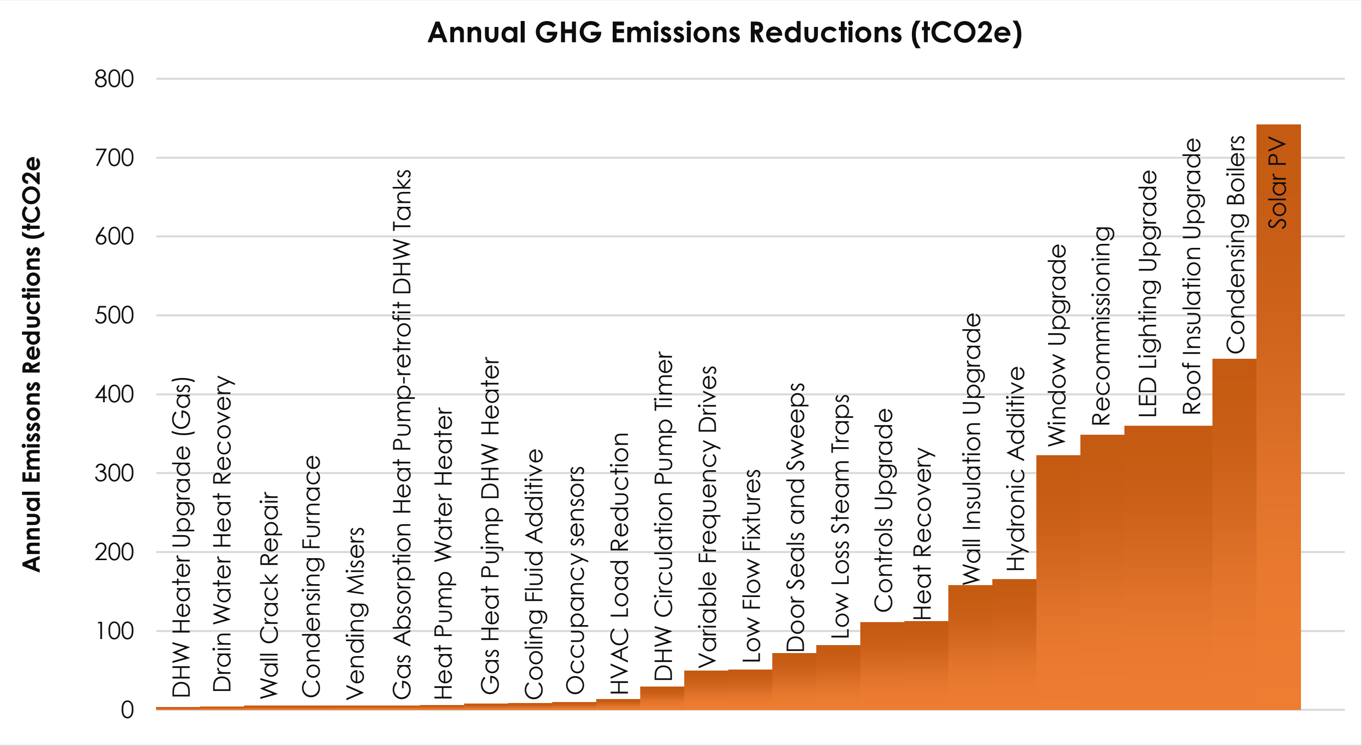


Figure 4-2: Annual GG Emissions Reductions of Carbon Reduction Measures

4.3 IMPLEMENTATION STRATEGIES

Comparing the above Figure 4-1 to Figure 4-2 shows an inverse relationship between marginal abatement rates and annual GHG emission reductions for many of the measures, with higher marginal abatement rate CRMs resulting in less annual GHG emissions, and CRMs with moderate/lower marginal abatement rates having lower annual GHG savings. Therefore, it is recommended financial metrics and actual emissions reduction impacts of each measure be considered through the creation and generation of RPS goals and targets.

Measures with positive marginal abatements rates should be implemented first, including low flow water fixtures, DHW pump controls, hydronic heating additives, door seals and sweeps, drain water heat recovery, LED lighting upgrades, vending misers, and integrated parking lot controllers. These measures all have a relatively low cost, except for some LED lighting projects.

Some measures will see implementation synergies with lifecycle upgrades and can be partnered to incorporate energy efficiency into existing end-of-life equipment replacement projects. This could include envelope upgrades, such as additional roof insulation during roof membrane replacement or coordinating boiler upgrades with heat recovery measures and hydronic heating additives.

Moderate performing CRMs include measures such as heat recovery, solar PV, and control system upgrades. These measures have moderate financial and emission performance and should target implementation within 5-10 years.

Poor preforming CRMs include measures such as high efficiency DHW heater upgrades, cooling fluid additives, HVAC load reduction, envelope upgrades, and variable frequency drives. These measures were typically observed to be financially unfeasible and are recommended for long term planning more than 20 years, or sooner if funding becomes available to improve financial feasibility.

4.3.1 Recommissioning, Ongoing Optimization, and Measurement and Verification

Over time, buildings may undergo changes to their equipment, occupancy, or overall use. Additionally, equipment operating parameters and components may drift or fail. If left unnoticed, the combination of equipment drift/failure and building operating changes can result in sub-optimal performance, resulting in excessive and unnecessary energy use. Recommissioning (RCx) involves a systematic approach to evaluate and improve the current operating conditions and procedures of building equipment. This can target known operating issues and resolve unknown equipment deficiencies developed over time, often resulting in increased energy efficiency. Additionally, recommissioning has non-energy related benefits, such as increased equipment life, improved thermal comfort, reduced future maintenance costs, etc.

Once recommissioning is initially completed, on-going or monitoring based commissioning should be considered to observe and maintain building performance. On-going Commissioning (OCx) includes regular recommissioning intervals, which would typically occur every 5 years; while Monitoring Based Commissioning (MBCx) includes the continuous monitoring and optimisation of systems, allow for quick corrective actions and continuous efficiency improvements. The following Figure 4-3 illustrates the effects of each type of commissioning on energy use over time.

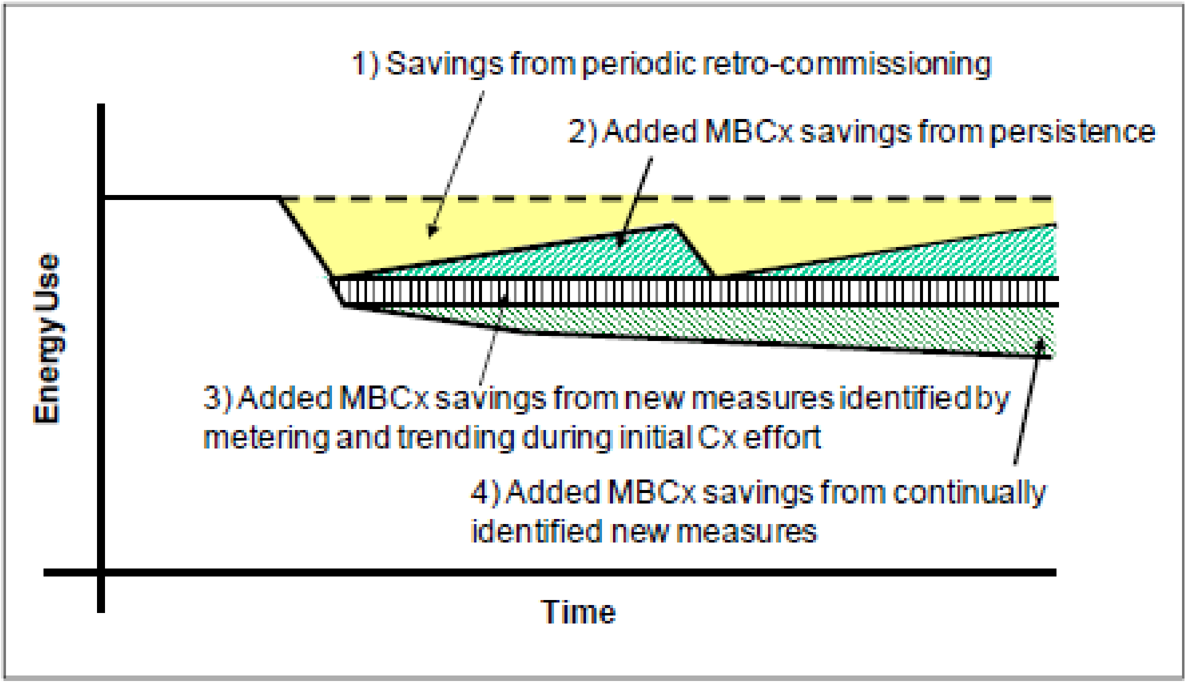


Figure 4-3: Ongoing Commissioning Savings Potential

5.0 Conclusion

Various building upgrades and measures were simulated on the 10 audited buildings, with energy savings ranging from 23-51%, with an average energy savings of 33%. A proposed case was created for each facility, which included individually selected measures with good financial performance and emission savings, while also considering lifecycle measures to replace existing aged equipment that has surpassed its rated life expectancy.

The energy, cost, and emission characteristics of the proposed audited building scenarios are displayed within Table 5-1 below.

Table 5-1: Proposed Project Characteristics of Audited Buildings

Building	Annual Electricity Savings (kWh)	Annual Gas Savings (m³)	Annual GHG Savings (tCO2e)	Lifetime (Years)	Lifetime GHG Savings (tCO2e)	Total Cost	Annual Cost Savings ($)	Simple Payback (Years)
F.W. Johnson	400,698	47,606	343	24	8,233	$1,599,150	$77,493	21
Thomson	132,923	48,782	175	24	4,274	$1,360,300	$44,239	30
Campbell	211,606	206,939	516	32	16,603	$4,092,179	$130,013	29
Henry Janzen	137,015	15,108	115	21	2,476	$330,481	$33,462	10
Marion McVeety	156,008	23,655	143	25	3,555	$579,195	$36,770	16
Seven Stones	164,417	23,970	149	23	3,461	$316,000	$36,513	9
Balfour	295,527	141,895	450	28	12,550	$1,591,315	$128,924	13
Henry Braun	210,656	29,087	188	24	4,433	$539,451	$59,229	10
Ruth M. Buck	178,079	37,627	188	27	5,059	$740,000	$57,542	13
Winston Knoll	200,109	55,838	230	20	4,678	$564,000	$71,797	8
Total	**2,087,038**	**630,507**	**2,497**	**25**	**61,913**	**$11,712,071**	**$675,982**	**17**

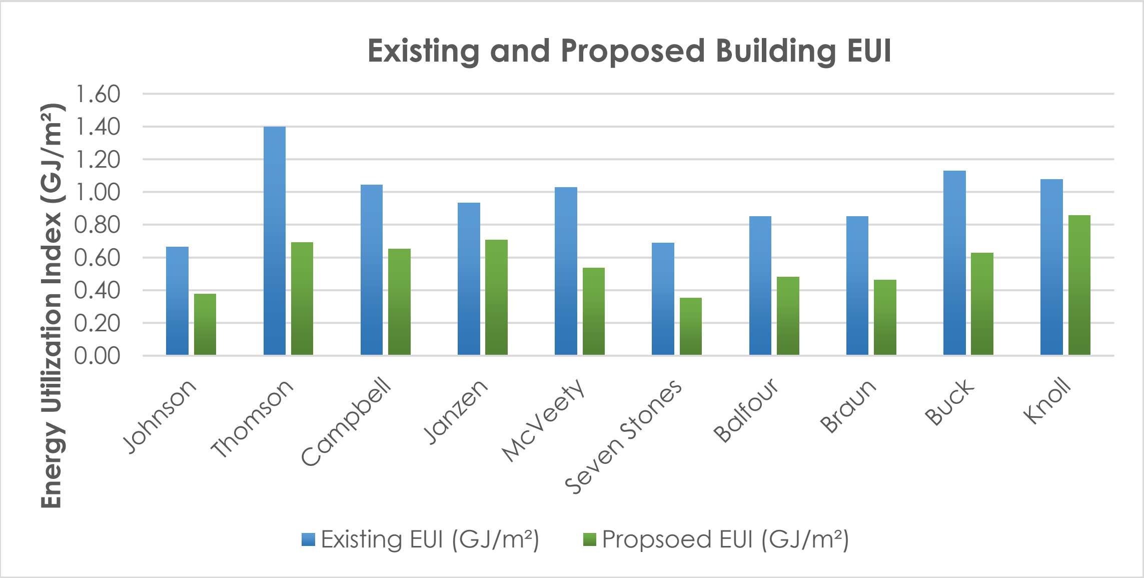


Figure 5-1: Existing vs Proposed Building EUI of Proposed Buildings

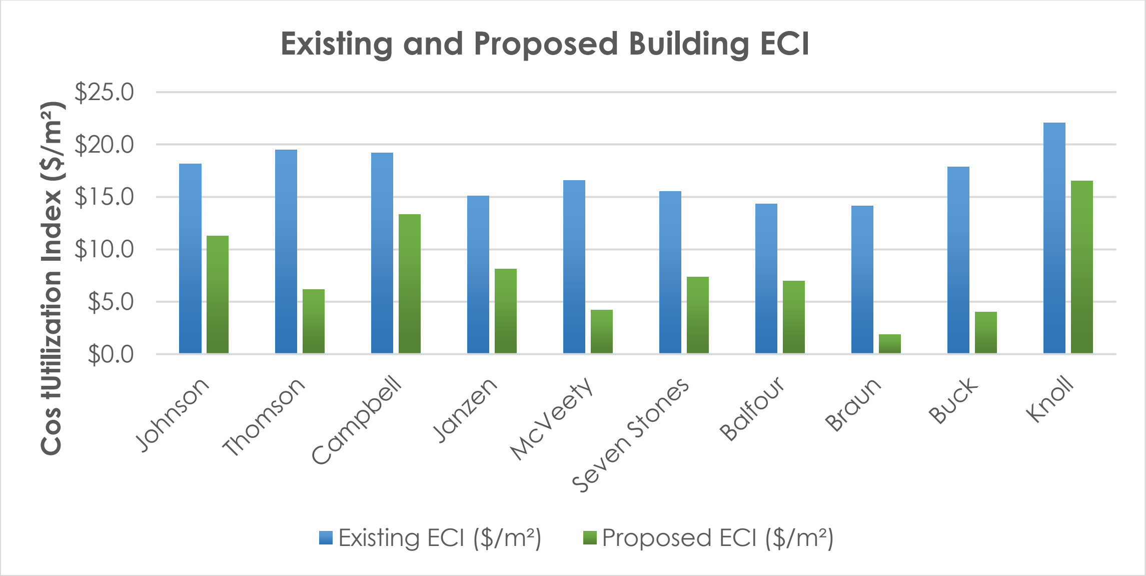


Figure 5-2: Existing vs Proposed Building ECI of Proposed Buildings

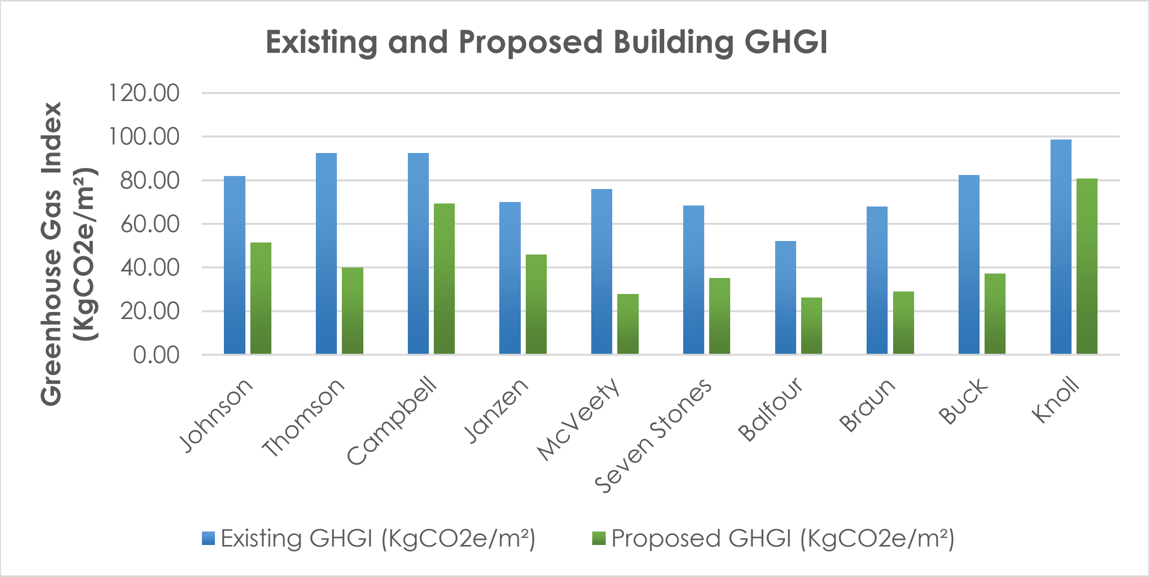


Figure 5-3: Existing vs Proposed Building GHGI of Proposed Buildings

Expected energy savings, utility cost savings, emission savings, and projected project costs have been extrapolated from the energy audited results throughout remaining portfolio buildings, to determine the potential order of magnitude of energy savings and expected costs.

The expected capital cost for the remaining portfolio buildings is estimated to total approximately $27.1 million dollars, resulting in an estimated 4,824 MkWh and 1.46 million m³ of natural gas of annual energy savings. This energy savings is expected to reduce utility costs by $1.56 million dollars per year, resulting in a payback of 17 years, as shown in Table 5-2 below.

Table 5-2: Expected Total Building Portfolio CRM Savings

Building	Annual Electricity Savings (kWh)	Annual Gas Savings (m³)	Annual GHG Savings (tCO2e)	Total Cost	Annual Cost Savings ($)	Simple Payback (Years)
Audited Buildings	2,087,038	630,507	2,497	$11,712,070	$675,980	17.3
Remaining Portfolio	4,823,940	1,457,342	5,758	$27,071,060	$1,562,452	17.3
Total	**6,910,978**	**2,087,849**	**8,254**	**$38,783,130**	**$2,238,432**	**17.3**

Overall, the recommended CRMs are expected to reduce total building portfolio energy usage by 6,911 MWh of electricity and 2.09 million m³ of natural gas, resulting in 8,254 tCO2e of annual GHG emissions savings. This results in a potential energy reduction of 39%, a cost reduction of 47%, and a GHG emission reduction of 38% compared to the existing school portfolio, as seen in Figures 5-4 through Figure 5-6 below.

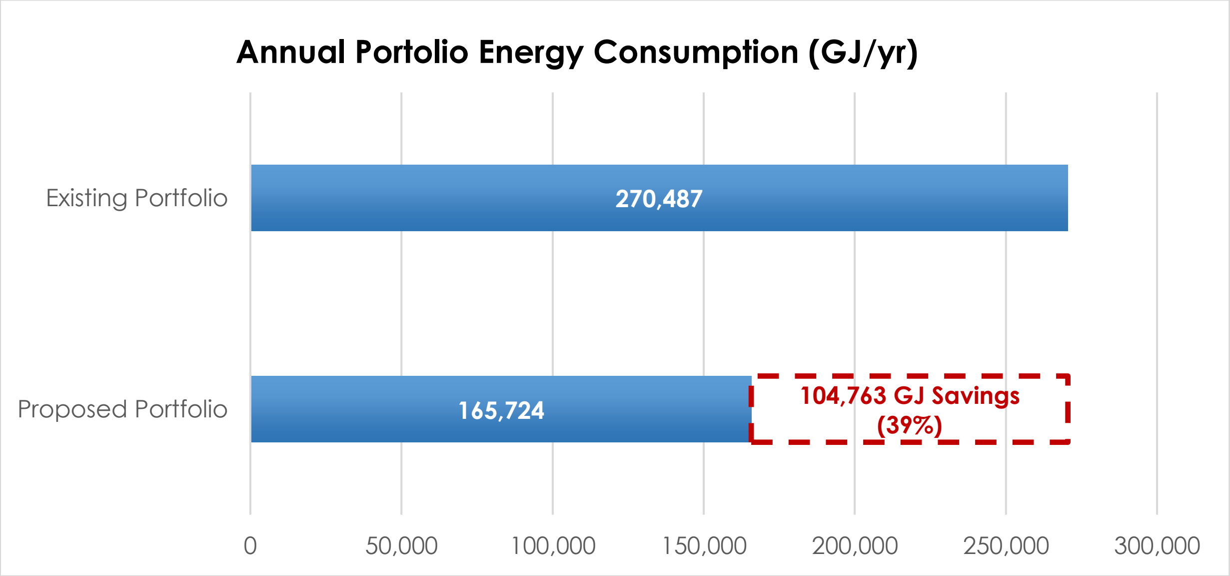


Figure 5-4: Existing vs Proposed Energy Usage of RPS Portfolio

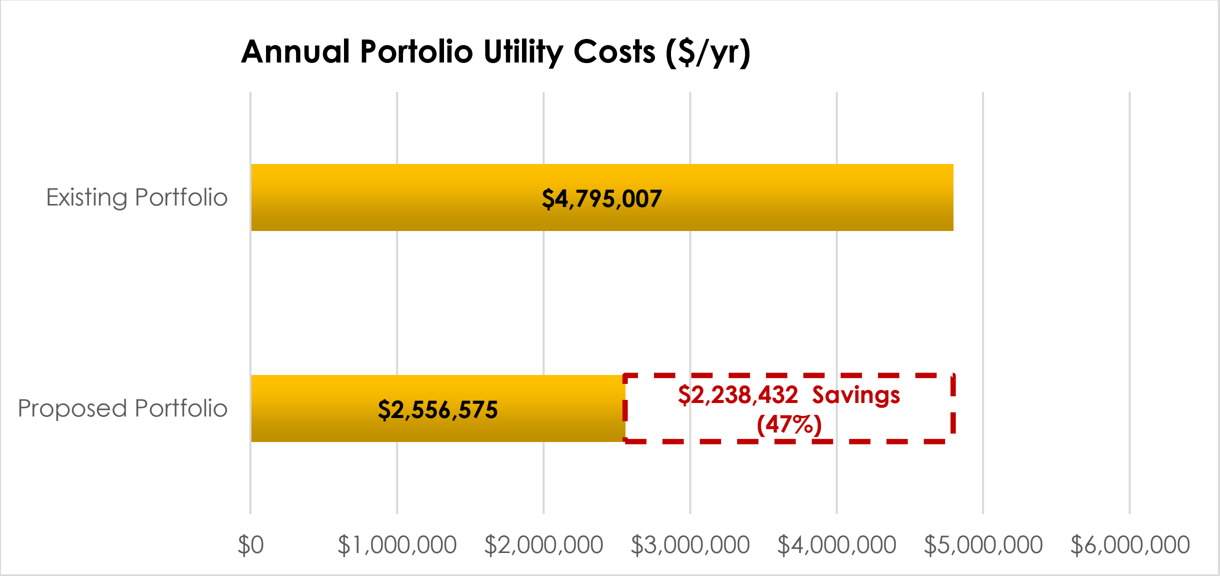


Figure 5-5: Existing vs Proposed Energy Costs of RPS Portfolio

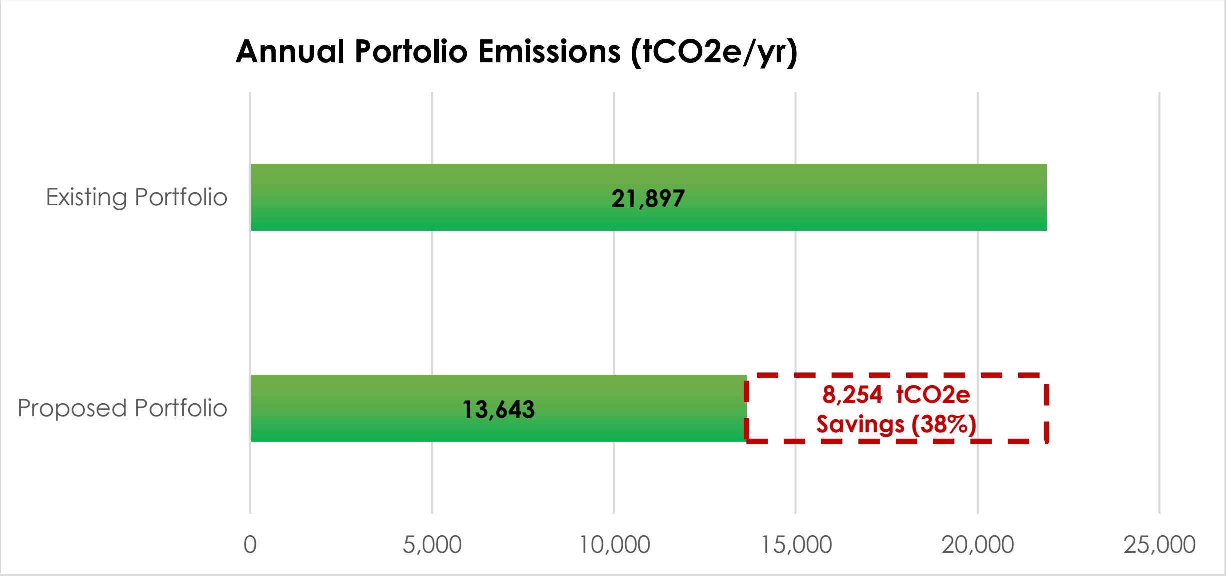


Figure 5-6: Existing vs Proposed GHG Emissions of RPS Portfolio

Appendix A : Building Breakdown CRM List

Table A-1: Johnson CRM Summary

CRM Description	Annual Savings			Lifetime (Years)	Lifetime GHG Savings (tCO2e)	Total Cost	Annual Cost Savings ($)	Simple Payback (Years)
	Electricity (kWh)	Natural Gas (m^3)	GHG (tCO2e)					
LED Upgrade (Fixtures)	100,226	-3,720	57.1	29	1,630	194,000	16,103	12
LED Upgrade (Tubes)	108,217	-4,022	61.6	22	1,362	61,000	17,267	3
Low Flow Sinks and Showerheads	0	3,115	5.7	15	86	5,150	1,699	4
DHW Heater Upgrade (Std-Eff)	0	208	0.4	18	7	13,300	122	109
DHW Heater Upgrade (Hi-Eff)	-64	990	1.8	18	32	25,000	540	45
Condensing Boilers (Baseline)	0	19,863	36.5	25	913	420,000	11,637	37
Condensing Boilers	0	25,613	47.1	25	1,178	740,000	14,404	50
Endotherm	17,128	5,875	21.7	8	174	11,000	4,860	3
Controls Upgrade	44,137	24,553	73.3	25	1,833	440,000	18,632	24
VFDs (P-3-4 & CT)	46,412	-275	29.1	15	437	44,000	4,923	9
Window Upgrade (Double Pane)	34,151	13,552	46.7	25	1,168	330,000	11,822	29
Window Upgrade (Triple Pane)	39,419	15,329	53.3	25	1,334	400,000	12,929	31
Roof Upgrade	20,356	8,712	29	30	870	230,000	7,161	32
Wall Insulation Upgrade	14,518	6,006	20.3	30	609	2,140,000	4,990	>100
Parking Lot Solar PV	76,068	0	48.5	25	1,213	278,000	7,793	36
Rooftop Solar PV	118,925	0	75.9	25	1,897	250,000	12,183	21
Recommissioning	61,352	5,099	48.5	5	243	38,000	9,087	4
Proposed Case	**400,698**	**47,606**	**343.2**	**24**	**8,233**	**1,599,150**	**77,493**	**21**

Table A-2: Thomson CRM Summary

CRM Description	Annual Savings			Lifetime (Years)	Lifetime GHG Savings (tCO2e)	Total Cost	Annual Cost Savings ($)	Simple Payback (Years)
	Electricity (kWh)	Natural Gas (m³)	GHG (tCO2e)					
Low Flow Water Fixtures	3,338	1,698	5.3	15	79	1,300	1,486	1
Drain Water Heat Recovery	3	770	1.4	10	14	2,000	408	5
DHW Heater Upgrade (Gas)	0	544	1	18	18	10,000	304	32
DHW Heater Upgrade (Electric)	-20,799	2,648	-8.4	18	-151	8,000	-3,830	-2
Condensing Boilers	-7,802	24,687	40.4	25	1,011	700,000	12,740	54
Condensing Furnace	291	2,586	4.9	18	89	22,000	1,492	15
Controls Upgrade	19,309	11,276	33.1	25	826	220,000	9,590	23
Variable Frequency Drives	35,133	-1,203	20.2	15	303	210,000	5,130	41
HVAC Load Reduction	-2,828	8,187	13.3	15	199	70,000	2,347	23
Window Upgrade (Triple Pane)	53	13,086	24.1	25	603	170,000	7,444	23
Window Upgrade (Double Pane)	47	12,206	22.5	25	562	140,000	7,233	20
Rooftop Solar PV	121,107	0	77.3	25	1,932	250,000	14,526	17
Recommissioning	9,865	4,670	14.9	5	74	25,000	3,835	6
Proposed Case	**132,923**	**48,782**	**174.5**	**24**	**4,274**	**1,360,300**	**44,239**	**30**

Table A-3: Campbell CRM Summary

CRM Description	Annual Savings			Lifetime (Years)	Lifetime GHG Savings (tCO2e)	Total Cost	Annual Cost Savings ($)	Simple Payback (Years)
	Electricity (kWh)	Natural Gas (m³)	GHG (tCO2e)					
Wall Insulation Upgrade	6,552	47,173	90.9	50	4,547	1,192,536	16,500	43
Roof Insulation Upgrade	4,670	54,161	102.6	30	3,078	785,000	31,278	25
Window Upgrade	15,210	26,211	57.9	30	1,737	820,800	16,476	49
Door Seals and Sweeps	574	4,738	9.1	5	45	9,192	2,272	4
Condensing Boilers	0	93,271	171.6	25	4,289	1,483,750	52,631	28
Run Around Heat Recovery	-17,697	24,969	34.6	20	693	192,000	12,098	16
Low Loss Steam Traps	0	44,317	81.5	10	815	64,000	23,288	3
Gas Absorption Heat Pump-retrofit DHW Tanks	0	2,951	5.4	25	136	49,625	1,665	30
Solar PV	115,642	0	73.8	25	1,844	250,000	11,958	21
Hydronic Additive	5,993	37,653	73.1	8	585	46,757	19,798	3
Recommissioning	91,668	20,692	96.5	5	483	68,944	19,142	4
Proposed Case	**211,606**	**206,939**	**515.6**	**32**	**16,603**	**4,092,179**	**130,013**	**29**

Table A-4: Janzen CRM Summary

CRM Description	Annual Savings			Lifetime (Years)	Lifetime GHG Savings (tCO2e)	Total Cost	Annual Cost Savings ($)	Simple Payback (Years)
	Electricity (kWh)	Natural Gas (m^3)	GHG (tCO2e)					
Wall Insulation Upgrade	1,060	12,190	23.1	50	1,155	971,000	4,301	132
Roof Insulation Upgrade	677	10,237	19.3	30	578	246,600	5,996	41
Window Upgrade	910	2,432	5.1	30	152	91,400	1,508	60
Door Seals and Sweeps	219	3,523	6.6	5	33	4,536	1,704	3
Condensing Boilers	0	12,824	23.6	25	590	244,800	7,361	33
Run Around Heat Recovery	-1,992	2,838	3.9	20	79	25,500	1,389	19
Occupancy sensors	17,258	-942	9.3	9	84	7,832	1,421	5
Low Flow Water fixtures	0	1,276	2.3	5	12	15,695	11,033	1
Solar PV	111,415	0	71.1	25	1,777	250,000	12,384	20
Hydronic Additive	0	9,134	16.8	8	134	9,040	4,741	2
Recommissioning	10,507	4,355	14.7	5	74	15,778	3,244	5
Control for Soffit Ventilation	6,737	0	4.3	5	43	2,100	749	3
Proposed Case	**137,015**	**15,108**	**115.2**	**21**	**2,476**	**330,481**	**33,462**	**10**

Table A-5: McVeety CRM Summary

CRM Description	Annual Savings			Lifetime (Years)	Lifetime GHG Savings (tCO2e)	Total Cost	Annual Cost Savings ($)	Simple Payback (Years)
	Electricity (kWh)	Natural Gas (m^3)	GHG (tCO2e)					
Wall Insulation Upgrade	235	12,538	23.2	50	1,161	595,874	4,321	81
Roof Insulation Upgrade	193	10,321	19.1	30	573	120,000	5,929	21
Glass Block Upgrade	0	3,678	6.8	30	203	27,500	2,104	14
Door Seals & Sweeps	26	2,024	3.7	5	19	1,776	956	2
Condensing Boilers	0	11,506	21.2	25	529	120,000	6,533	19
Solar PV	114,465	0	73	25	1,826	250,000	14,454	17
Heating Additives	0	3,858	7.1	8	57	7,520	1,978	4
Recommissioning	2,666	3,921	8.9	5	45	9,391	2,181	4
Hot Water - Low Flow Fixtures	0	1,010	1.9	5	9	285	2,287	0
Cold Water - Low Flow Fixtures	0	0	0	20	0	19,910	4,547	4
Lighting Upgrade	41,517	-2,859	21.2	9	191	22,814	3,751	6
Proposed Case	**156,008**	**23,655**	**143**	**25**	**3,555**	**579,195**	**36,770**	**16**

Table A-6: Seven Stones CRM Summary

CRM Description	Annual Savings			Lifetime (Years)	Lifetime GHG Savings (tCO2e)	Total Cost	Annual Cost Savings ($)	Simple Payback (Years)
	Electricity (kWh)	Natural Gas (m³)	GHG (tCO2e)					
Door Seals, Sweeps, & Kinder Room Wall-Roof Seal	2,778	7,797	16.1	10	161	6,300	3,675	2
Low-Flow Water Fixtures	4,663	34	3	15	46	700	589	1
Drain Water Heat Recovery - Daycare	6,085	0	3.9	25	97	3,500	749	5
LED lighting	15,373	-955	8.1	31	249	60,000	3,379	17
Heating Fluid Additive	0	4,651	8.6	8	68	10,000	1,913	6
Cooling Fluid Additive	3,466	0	2.2	8	18	7,000	426	16
Heat Pump Water Heater - Daycare	8,642	0	5.5	15	83	6,000	1,063	6
Heat Pump Water Heater - Main	-5,367	1,956	0.2	15	3	23,000	-1,775	Never
DHW Circulation Pump Timer	4,860	302	3.7	10	37	1,600	727	2
Roof insulation Upgrade	2,871	8,299	17.1	30	513	100,000	4,259	24
Recommissioning	16,847	6,069	21.9	5	110	27,000	4,313	6
Rooftop Solar PV	123,286	0	78.7	25	1,966	200,000	15,170	13
Proposed Case	**164,417**	**23,970**	**149**	**23**	**3,461**	**316,000**	**36,513**	**9**

Table A-7: Winston Knoll CRM Summary

CRM Description	Annual Savings			Lifetime (Years)	Lifetime GHG Savings (tCO2e)	Total Cost	Annual Cost Savings ($)	Simple Payback (Years)
	Electricity (kWh)	Natural Gas (m³)	GHG (tCO2e)					
Door Seals & Sweeps	194	4,578	8.5	10	85	5,100	2,396	3
Low-Flow Water Fixtures	2,100	14,285	27.6	15	414	8,500	21,030	0.3
Intelligent Parking Lot Controller	6,195	0	4	30	119	10,500	680	15
LED lighting	62,281	-4,871	30.8	18	569	50,000	7,008	7
Heating Fluid Additive	0	20,629	37.9	8	304	65,000	10,365	7
Cooling Fluid Additive	9,178	0	5.9	8	47	16,000	1,007	16
DHW Circulation Pump Timer	1,240	13,261	25.2	10	252	2,000	7,014	0
Window Replacement	783	9,089	17.2	30	517	86,000	5,191	17
Wall Crack Repair	278	2,540	4.8	10	48	5,000	1,348	4
Boiler Upgrade	0	36,397	66.9	25	1,674	1,420,000	20,288	68
Heat Recovery	-8,164	42,966	73.8	20	1,476	470,000	22,777	21
Vending Miser	9,820	-764	4.9	10	49	2,000	681	3
Recommissioning	65,483	14,425	68.3	5	342	69,000	13,822	5
Rooftop Solar PV	106,671	0	68.1	25	1,701	260,000	11,703	22
Proposed Case	**200,109**	**55,838**	**230.4**	**20**	**4,678**	**564,000**	**71,797**	**8**

Table A-8: Balfour CRM Summary

CRM Description	Annual Savings			Lifetime (Years)	Lifetime GHG Savings (tCO2e)	Total Cost	Annual Cost Savings ($)	Simple Payback (Years)
	Electricity (kWh)	Natural Gas (m³)	GHG (tCO2e)					
Door seals	0	7,307	13.4	5	67	7,553	2,859	3
Window Upgrade	0	75,003	138.0	30	4,139	640,500	36,964	22
Electrification - ASHP	-1,745,176	419,032	-342.7	25	-8,567	6,510,000	-158,250	Never
Low Flow Water Fixtures	0	1,297	2.4	20	48	43,702	10,349	4
Solar PV	115,670	0	73.8	25	1,845	250,000	11,400	22
Roof Insulation Upgrade	0	64,585	118.8	30	3,564	573,029	31,830	19
Intelligent Parking Lot Controllers (IPLC)	2,446	0	1.6	30	47	4,750	241	20
LED Upgrades w/ Sensors	177,411	-6,297	101.6	10	1,016	71,781	33,817	3
Vending Misers	301	-2	0.2	10	2	825	29	29
Building Recommissioning	27,273	20,023	54.2	5	271	64,262	10,522	6
Proposed Case	**295,527**	**141,895**	**449.5**	**28**	**12,550**	**1,591,315**	**128,924**	**13**

Table A-9: Braun CRM Summary

CRM Description	Annual Savings			Lifetime (Years)	Lifetime GHG Savings (tCO2e)	Total Cost	Annual Cost Savings ($)	Simple Payback (Years)
	Electricity (kWh)	Natural Gas (m³)	GHG (tCO2e)					
Door Seals	0	3,990	7.3	5	37	3,000	1,570	2
Window Upgrade	0	6,450	11.9	30	356	47,250	3,193	15
Electrification - ASHP	-288,693	82,374	-32.7	25	-817	1,270,000	-33,396	Never
Low Flow Water Fixtures	0	684	1.3	20	25	19,270	7,320	3
Solar PV	115,670	0	73.8	25	1,845	250,000	14,980	17
Condensing Boilers	0	18,255	33.6	25	839	164,000	8,958	19
Intelligent Parking Lot Controllers (IPLC)	1,159	0	0.7	30	22	3,500	150	23
LED Upgrades w/ Sensors	82,381	-3,573	46.0	10	460	38,431	19,360	2
Building Recommissioning	11,446	3,281	13.3	5	67	14,000	2,773	5
Proposed Case	**210,656**	**29,087**	**187.9**	**24**	**4,433**	**539,451**	**59,229**	**10**

Table A-10: Buck CRM Summary

CRM Description	Annual Savings			Lifetime (Years)	Lifetime GHG Savings (tCO2e)	Total Cost	Annual Cost Savings ($)	Simple Payback (Years)
	Electricity (kWh)	Natural Gas (m³)	GHG (tCO2e)					
Door Seals	357	2,933	5.6	5	28	3,000	1,232	3
Window Upgrade	0	8,637	16.5	30	495	68,000	4,493	16
Electrification - ASHP	-391,688	99,788	-66.4	25	-1,659	3,214,064	-123,298	Never
Low Flow Water Fixtures	1,977	0	1.3	20	25	3,000	848	4
Solar PV - Roof	75,428	0	48.1	25	1,203	164,000	13,617	12
Solar PV - Parking	36,580	0	23.3	25	583	190,000	6,604	29
Roof Renovation	3,558	28,163	54.1	30	1,622	276,000	14,716	19
Intelligent Parking Lot Controllers (IPLC)	1,673	0	1.1	30	32	5,000	302	17
LED Upgrades w/ Sensors	58,506	-2,106	33.5	16	535	31,000	17,626	2
Building Recommissioning	9,964	472	7.2	5	36	14,362	1,987	7
Proposed Case	**178,079**	**37,627**	**188.2**	**27**	**5,059**	**740,000**	**57,542**	**13**

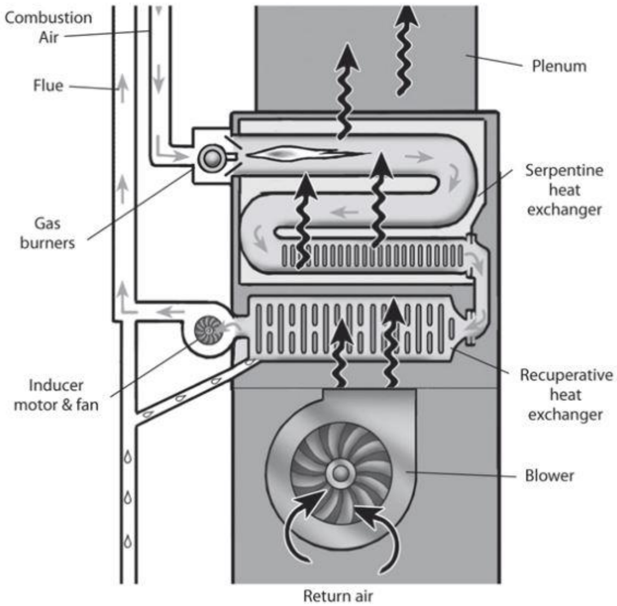
Appendix B : Portfolio Characteristics

School/Asset	School Type	Age	Floor Area (m²)	Total Gas Use (m³)	Total Gas Cost ($)	Total Electricity Use (kWh)	Total Electricity Cost ($)	EUI (GJ/ m²)	Total GHG Emissions (tCO2e)
Adult Campus/Allan Blakeney	High School	N/A	4,795	174,192	55,173	219,800	34,312	1.55	461
Albert	Elementary	1985	2,825	46,483	15,206	215,760	34,481	0.90	223
Arcola School	Elementary	2011	5,256	79,432	25,462	524,800	82,763	0.94	481
Argyle	Elementary	1954	2,676	52,146	17,202	90,150	16,071	0.87	153
Balfour Collegiate	High School	1930	17,465	349,736	108,215	414,800	142,352	0.85	908
Burnett Centre	School Board Office	1956	17,480	101,043	32,669	1,038,240	161,004	0.43	848
Campbell Collegiate	High School	1964	22,212	414,861	129,065	2,021,760	297,335	1.04	2053
Campus Regina Public	High School	1970	11,170	246,877	77,357	1,182,560	170,022	1.23	1208
Centennial	Elementary	1981	4,522	50,889	16,476	320,100	47,511	0.69	298
Connaught	Elementary	2016	5,855	58,610	16,550	391,680	70,903	0.62	358
Coronation Park	Elementary	1957	4,795	50,450	16,722	98,200	17,230	0.48	155
Dieppe	Elementary	1971	5,790	47,295	15,596	97,740	17,383	0.37	149
Douglas Park School	Elementary	2011	5,064	49,806	16,407	738,017	108,311	0.90	562
Dr. A.E. Perry School	Elementary	1976	3,396	79,559	25,512	190,800	33,405	1.10	268
Dr. George Ferguson School	Elementary	1967	2,901	45,580	14,894	198,000	33,190	0.85	210
Dr. L.M. Hanna School	Elementary	1977	4,325	99,277	31,996	269,920	46,616	1.10	355
Elsie Mironuck School	Elementary	1962	5,014	88,887	29,020	244,320	39,958	0.85	319
Ethel Milliken School	Elementary	1973	3,439	98,022	31,899	258,600	41,267	1.36	345
F.W. Johnson Collegiate	High School	1985	11,258	82,422	26,913	1,205,100	177,622	0.67	920
George Lee School	Elementary	1977	3,370	52,853	17,216	201,720	36,217	0.82	226
Gladys McDonald School	Elementary	1966	1,846	63,169	21,296	190,400	32,028	1.68	238
Glen Elm School	Elementary	1959	2,521	39,393	12,865	142,000	25,504	0.80	163
Grant Road School	Elementary	1959	3,109	85,860	28,028	128,080	22,642	1.20	240
Henry Braun	Elementary	1987	4,821	80,904	25,912	279,400	42,287	0.85	327
Henry Janzen School	Elementary	1975	4,798	92,389	30,122	259,840	42,269	0.93	336
Imperial School	Elementary	1950	3,258	98,166	31,517	241,300	37,694	1.42	334
Jack MacKenzie School	Elementary	1999	4,976	64,297	21,325	404,700	73,142	0.79	376
Judge Bryant	Elementary	1976	4,020	106,518	34,256	277,920	43,710	1.26	373
Kitchener School	Elementary	1924	4,624	67,026	22,005	203,440	33,882	0.71	253
Lakeview School	Elementary	1926	4,554	77,569	24,951	102,960	18,290	0.73	208

M.J. Coldwell	Elementary	1967	2,321	61,448	19,908	124,320	21,986	1.21	192
MacNeill School	Elementary	1985	3,679	41,209	13,493	242,080	40,633	0.67	230
Marion McVeety School	Elementary	1958	2,977	64,022	21,015	169,400	28,336	1.03	226
Martin Collegiate	High School	1958	9,374	198,522	62,427	354,720	62,322	0.95	591
Massey School	Elementary	1960	3,636	93,652	31,083	103,840	18,442	1.09	238
McDermid School	Elementary	1960	2,077	49,635	16,391	103,880	18,448	1.09	158
McLurg School	Elementary	1979	4,821	91,241	29,611	250,720	40,621	0.91	328
Rosemont School	Elementary	1957	2,879	89,547	29,187	111,180	19,714	1.33	236
Ruth M. Buck	Elementary	1974	4,162	98,893	31,783	252,320	42,554	1.13	343
Ruth Pawson School	Elementary	1976	3,574	57,046	18,451	210,840	36,368	0.82	239
Seven Stones	Elementary	2014	4,481	48,801	13,450	339,600	56,120	0.69	306
Sheldon-Williams Collegiate	High School	1955	10,460	257,192	80,201	497,280	76,516	1.11	790
The Crescents	Elementary	1929	3,343	89,365	29,172	86,565	15,904	1.12	220
Thom Collegiate	High School	N/A	13,055	239,314	75,556	979,300	139,210	0.97	1065
Thomson School	Elementary	1927	3,320	104,444	34,115	179,760	30,547	1.40	307
W.F. Ready School	Elementary	N/A	4,843	52,971	17,209	391,200	60,462	0.71	347
W.H. Ford School	Elementary	1979	3,664	61,665	20,561	283,080	45,246	0.92	294
W.S. Hawrylak School	Elementary	N/A	5,105	106,829	34,810	486,200	75,874	1.14	507
Wilfred Hunt School	Elementary	1977	3,662	66,143	22,302	180,360	31,985	0.87	237
Wilfrid Walker School	Elementary	1982	3,958	46,297	15,212	240,780	39,713	0.67	239
Winston Knoll Collegiate	High School	1997	12,880	240,560	75,129	1,298,880	209,374	1.08	1271
Walker School	Elementary	1959	2,234	66797	20,597	94,511	21,741	1.30	183
Mamaweyatitan	High School	2017	4,795	N/A	N/A	N/A	N/A	N/A	N/A
Total	**-**	**-**	**292,640**	**5,269,305**	**1,683,491**	**19,132,923**	**3,111,517**	**0.92**	**21897**

Appendix C : General CRM Descriptions

C.1 CONDENSING FURNACES

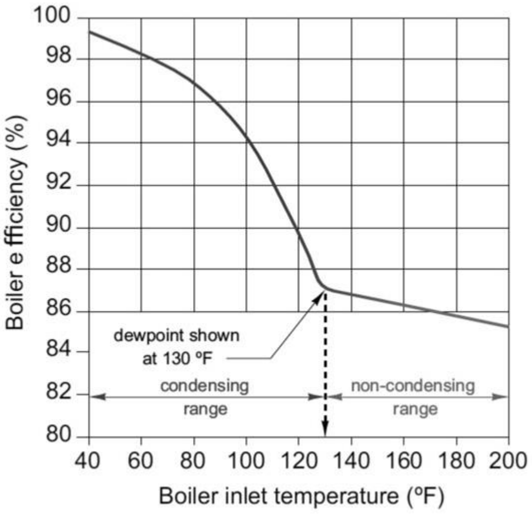


Condensing furnace CRMs includes the installation of high-efficiency condensing furnaces in replacement of existing furnaces. Seasonal efficiencies of traditional, non-condensing furnaces are typically in the range of 78-84% when new, however, can often see reduced efficiencies from age and maintenance-related degradation. Condensing furnaces can reach seasonal efficiencies up to 98%, but are often seen around 94%+.

Most existing furnaces can be directly switched out for condensing furnaces to achieve an instant increase in heating efficiency, however, will require modification to the exhaust flue venting, and the use of a near-by drain for condensate removal. Condensing furnaces recover heat from exhaust gasses by circulating them through a secondary heat exchanger. When this heat is recovered, the flue temperature will decrease and return air from the distribution system will be pre-heated. As a result, water vapour within the flue gas will condense, which must be filtered and plumbed to the nearest drain.

C.2 CONDENSING BOILERS

Condensing boiler CRMs include the installation of high-efficiency condensing boilers in replacement of existing boilers. Depending on the existing systems and building, the hydronic distribution may require retrofit to achieve high efficiency combustion and complete condensation.



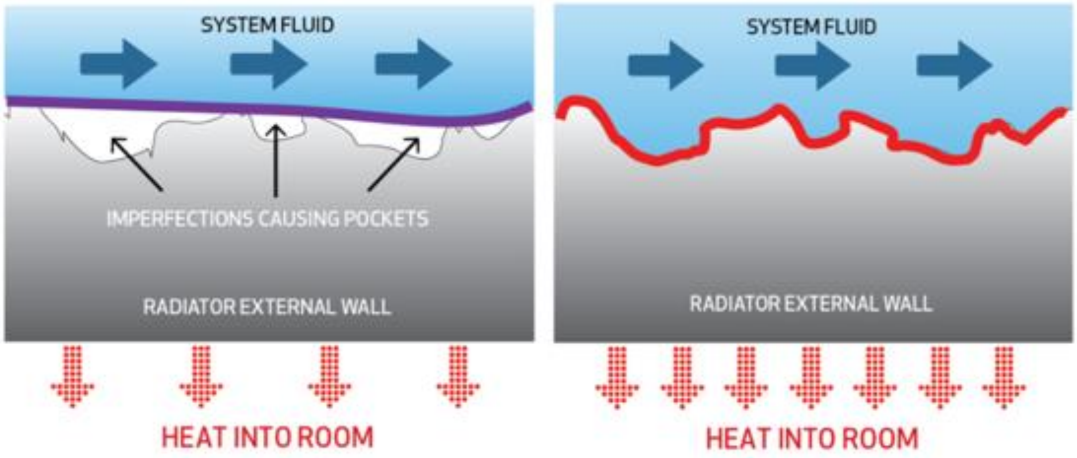
Typical non-condensing boilers consume natural gas to provide hot water between 200-150°F. Non-condensing boilers are limited to this temperature range, as going below 150°F (with returning water below 130°F) can result in flue condensation, which can corrode internal components. Older non-condensing boilers are limited to a peak thermal efficiency of 80-81%.

Condensing boilers are preferred to operate below a supply water temperatures of 150°F to improve efficiency, as they recover energy from the water vapor in the flue when return temperatures are below 130°F. This recovered energy is used to pre-heat return water before the main burners. Initial condensation occurs at return water temperatures of 130-135°F, resulting in efficiencies around 87%; with up to 98-99% efficiencies with return water temperatures below 60°F. Due to the required low return water temperatures, condensing boilers may not achieve high-efficiency options unless the system is compatible with low water temperatures, or strategies are implemented for high temperature drops through coils. Additionally, condensing boilers are also fully modulating, resulting in improved heating efficiencies at part load conditions.

C.3 HEATING AND/OR COOLING ADDITIVES

Many heating and cooling systems use water or glycol solutions as the main heat transfer fluid. These solutions are commonly used due to their availability, heat transfer performance, and freeze protection characteristic; however, these solutions have a relatively high surface tension.

Heating/cooling fluid additives reduce the surface tension of the hydronic solutions, resulting in increased thermal contact between the fluid and the pipe walls, increasing available heat transfer surface area. Heating fluid additives can be added to water-only systems, or glycol mix solutions, and does not affect the overall viscosity or freeze protection of the existing solution. Heating/cooling additives have relatively simple installations, ad include draining a small portion of existing working fluid, to be replaced with the heating/cooling additive. Proper water treatment and inhibitors are required prior to the implementation of heating fluid additives, and should be verided on each site prior to implmentation



C.4 DOOR SEALS AND SWEEPS

This Carbon Reduction Measure includes replacing all the damaged and worn door seals and door sweeps on the building. Over time the weather stripping will wear down and gaps will become visible around the perimeter of exterior doors. Poor door seals increase the infiltration/exfiltration rate of the building causing increased energy loss and longer run times on HVAC equipment. Door seals and sweeps can be expected to last from 5-10 years depending on use and should be periodically inspected and replaced as needed. Costs for seal replacement can vary greatly depending on the product chosen and if maintenance staff are able to complete the installation.

C.5 WINDOW UPGRADES

Windows upgrades are proposed in buildings with older or poor-performing windows, and include the direct replacement of existing windows with high-performance double or triple-pane windows. High-performance windows are typically double or triple pane and utilize a gas fill between windowpanes (typically argon), resulting in reduced heat flow through glazed areas. These windows also consist of high-performing insulated frames to reduce thermal bridging. Low-emissivity coatings are applied to any number of window panes (depending on the performance and conditions), which reflects exterior short-wave solar radiation from entering the building to reduce summertime cooling loads and reflects interior long-wave radiation back into the building to reduce heating loads during winter months. For reference, the National Energy Code for Buildings (2017) in Alberta prescribes a window thermal transmittance under U-0.33 BTU/hr/ft²/F°.

C.6 LOW FLOW WATER FIXTURES

Low-flow water fixtures include the replacement of existing domestic hot water fixtures (showerheads & sinks) and/or cold water fixtures (toilets and urinals) with low-flow equivalent fixtures.

Energy and water savings reductions can be present through the implementation of low-flow water fixtures. Various low-cost options for water fixture replacements are available and can be as simple as replacing sink aerators and showerheads, as opposed to replacing the entire water fixture. Low-flow aerators that use 0.5-1.5 GPM can reduce a sink's water flow by 32-67% from the standard flow of 1.5-2.2 GPM without sacrificing performance. Similarly. Implementing these low-cost measures will greatly reduce hot and cold water consumption.

Low-flush toilets and low-flush urinals can also be implemented to reduce cold water consumption. Low flush toilets are commonly available in 1.28 GPM, and can be as low as 0.8 GPF, compared to traditional 1.6-3.4 GPF toilets. Low flush urinals are an alternative to standard flush urinals, at 0.125 GPF compared to standard 1 GPF urinals, with waterless urinals also available.

C.7 SOLAR PV

Proposed solar PV arrays were simulated on available roof and/or parking lot space. A solar PV system would consist of solar modules on the roof/parking lot and an inverter(s) tied into the main breaker panel. When the sun is exposed, the solar modules produce power and the building draws electricity from the PV facility's demand, is fed into the electrical grid. The building draws electricity from the grid whenever the PV system is inactive.

The facility is billed for the power it draws from the grid and gets credit for the amount fed into the grid from the PV system. The size and cost of the required PV system considers clearances of rooftop equipment and the slope and orientation of the roof. The reduction of energy consumption is always the first logical step prior to installing a generation system. It is generally more cost-effective to reduce consumption.

Proposed PV systems are sized based on current guidelines of net metering provided by SaskPower. SaskPower restricts the installation of over 100kw DC of rooftop solar PV systems under the net metering policy.

C.8 ROOF INSULATION

This CRM includes the additional roof insulation to the existing buildings. Roof insulation is proposed to be installed as part of an existing roof membrane upgrade; therefore, only incremental roof insulation and associated labour costs are considered. The performance of roof surfaces is measured in thermal resistance (R-Value). Higher R Values indicate a high thermal resistance and, therefore less heat loss, while lower R-Values indicate higher heat loss. Adding insulation to existing roofs will result in an increased thermal resistance and reduce heat loss. For reference, the National Energy Code for Buildings (2017) in Saskatchewan is prescribed at R-41.

C.9 ENVELOPE (WALL) INSULATION

Envelope (wall) insulation upgrades consider the installation of additional wall insulation and cladding to reduce building heat loss. Envelope upgrade CRMs includes the complete construction project costs, including demolition, cladding, and insulation.

Although adding insulation improves the energy performance of the building, diminishing economic returns are often present. For reference, the National Energy Code for Buildings (2017) in Alberta is prescribed at R-27.

C.10 INTELLIGENT PARKING LOT CONTROLLERS (IPLC)

This CRM will look at the opportunity to install Intelligent Parking Lot Controllers (IPLC) in replacement of existing outdoor parking lot receptacles. An IPLC is a smart power receptacle which can be swapped for the existing parking lot receptacles. These devices incorporate a micro-processor, a temperature sensor, and LED indicator lights.

When a block heater is plugged in, power is cut for the first 2 hours, as the vehicle’s engine will remain warm for that period of time. Afterwards, the IPLC receptacle microprocessor measures temperature and windchill, and cuts the power supply when the temperature is above -5°C. It then varies the power supply from a 10% duty cycle at -5°C, up to a 100% duty cycle at -25°C or colder. Each receptacle supports two separately controlled circuits which can be independently programmed to suit specific needs. LED lights indicate a live outlet, functioning block heater, open circuit, short circuit, or circuit overload. There is also a data connection port which can optionally be used to obtain usage data from each receptacle or program individual options.

C.11 LED LIGHTING UPGRADES AND/OR CONTROLS

LED Lighting upgrades are recommended in buildings that utilize fluorescent, high intensity discharge (HID), compact fluorescent (CFL), halogen, or incandescent lighting. LED lighting upgrades may include the replacement of existing lighting with LED equivalent fixtures, or LED tubes. Additionally, lighting controls may also be recommended to optimize lighting use based on space demands, including the use of occupancy sensors, dimming switches, and photo control.

Light Emitting Diode (LED) lighting technology has revolutionized the lighting industry over conventional lighting types. Various LED lighting styles, luminaires, and lamps can be found to replace almost any traditional luminaires/lamps. LED technology has resulted in lower power requirements for equivalent lighting output levels compared to many other conventional lighting types, resulting in reduced electricity and demand savings. This is due to the high efficacy of LED's, resulting in more of the electricity going into light production and less into heat production. Although this improves electrical performance, it also impacts the heating and cooling system in conditioned building areas, as HVAC systems will need to make up the difference between the heat generation of the new lighting versus the old lighting.

In addition to improved efficacy, LED lighting can also come in a variety of lighting colors, most commonly between 2,700-6,000k (Warm orange/yellow to bright white) but can also come in any variety of other colors and color ranges. LED lighting is also known for its long-life expectancy, typically ranging from 25,000 for lamp replacements to 50,000-100,000 hours for fixture replacements. This can greatly reduce maintenance related costs, as luminaires/lamps do not need to be replaced as frequently.

Lighting controls are an important contributor to energy savings in lighting systems. Various control types exist and can be wall or ceiling-mounted to control an array of luminaires or located on each luminaire to provide individual luminaire control. Various types of controls exist, but most commonly consist of dimming, occupancy sensing, or photocells. Not all LED lighting is compatible with dimming, therefore, correctly specified LED luminaires must be provided to ensure compatibility.

C.12 VENDING MISERS

This CRM includes installing vending misers on refrigerated vending machines to reduce excess energy consumption. Vending misers work by using an occupancy sensor to limit the operation of the vending machine compressor and lighting. The motion sensor on the vending miser has a 15ft range, if no motion is detected within this range for 15 minutes, the vending miser will wait for the cooling cycle to end, and then power down. Vending misers monitor room temperature, depending on the temperature reading, the vending miser will power up the vending machine cooling cycle, typically every 1-3 hours. The use of this device can reduce the energy consumption of a typical vending machine by anywhere between 0% and 83% depending on how frequently occupied its surroundings are, but averages about 46%. Vending misers are not recommended on any machines containing perishable food or beverage products.

C.13 RECOMMISSIONING

Over time, buildings may undergo changes to their equipment, occupancy, or overall use. Additionally, equipment operating parameters and components may drift or fail. If left unnoticed, the combination of equipment drift/failure and building operating changes can result in sub-optimal performance, resulting in excessive and unnecessary energy use.

Recommissioning (RCx) involves a systematic approach to evaluate and improve the current operating conditions and procedures of building equipment. This can target known operating issues and resolve unknown equipment deficiencies developed over time, often resulting in increased energy efficiency. Additionally, recommissioning has non-energy related benefits, such as increased equipment life, improved thermal comfort, reduced future maintenance costs, etc.

Recommissioning is recommended for the various schools due to the age of many existing systems, and proposed upgrades. Recommissioning should be considered after any efficiency measures have been implemented, to allow for a holistic review and optimization of all in-use systems. A recommissioning program is also recommended on a 5-year cycle, to ensure systems, controls, and equipment are functional and operating efficiently. Targeting poor energy-performing buildings can result in greater energy and cost reductions, as well as improved economics. Similarly, targeting high-consuming equipment or key components critical to efficient operation can also improve overall project viability. Some of the top recommissioning practices are listed below:

1. Optimize equipment schedules and setpoints
2. Re-calibrate sensors and thermostats
3. Optimize economizer operation
4. Optimize ventilation airflow rates
5. Ensure proper control valve or damper actuator operation
6. Eliminate unnecessary lighting hours
7. Implementing additional controls

C.14 HOT WATER HEATER UPGRADES

Hot water storage tank upgrades consider the replacement of the existing DHW heaters with electric or high-efficiency gas-fired water heaters. Condensing storage tank heaters utilize condensing burner technology to maximize combustion efficiency, improving thermal efficiencies to 94-99%. This allows most of the combustion energy to be recovered and utilized for DHW heating, as opposed to being lost through the chimney. Condensing DHW heaters also provide increased tank insulation levels compared to standard efficiency DHW heaters to reduce storage-related losses.

C.15 BUILDING CONTROLS UPGRADE

Building control upgrades may consider a wide range of upgrades, such as simple thermostat upgrades and temperature setback/schedule optimization, to a complete electronic controls and Building Management System (BAS) upgrade. It is recommended that individual reports be referenced when investigating building control upgrades to determine the scale and scope of the proposed upgrades.

C.16 VARIABLE FREQUENCY DRIVES

Variable Frequency Drives (VFD) can be installed on pumps, fans, or stand alone motors to improve control and optimize energy use. VFDs can be installed on existing motors, however, require inverter-duty motors with sufficiently rated motor insulation.

Variable Frequency Drives (VFD's) are used most critically on large (typically 3 HP or greater), constant-speed motors, including fans, pumps, or motor-driven equipment. Variable frequency drives can be directly or adjacently mounted to motors and will vary the frequency of the motor based on sensors located throughout the system, or based on pre-programmed sequencing within the drive itself. Variable speed drives provide optimized motor speeds based on real-time system operating conditions, resulting in significant energy savings, as reducing motor speeds has a cubic effect on energy consumption.

When starting up, a VFD will apply a minimal amount of power to the motor, thereby reducing the spike that is usually associated with the start-up. After initial start-up, power will slowly be increased to meet the load requirements (soft start). The same is true when the motor is shutting off- the power will slowly decrease until the pump is eventually shut off. This spares significant wear and tear on equipment, as there will be much less stress of applying large amounts of power on start-up and instant cut off on shutdown.

C.17 HVAC LOAD REDUCTION

This CRM includes installing an HVAC load Reduction (HLR) unit to supplement existing ventilation systems. Ventilating systems are responsible for bringing outdoor air into the building and removing stale, contaminated air. Two major air contaminants categories include occupant contaminants, such as carbon dioxide; and finish-related off-gassing contaminants, such as volatile organic compounds (VOCs) or formaldehyde. A fixed or variable amount of outside air is typically brought into buildings to dilute indoor contaminants, with a similar air volume being exhausted to maintain neutral building pressure.

HVAC load reduction (HLR) systems filter and treat indoor air, which decreases the outdoor air requirements. Re-cycling indoor air results in decreased heating and cooling loads, as the supply air is already at building temperature. HLR systems treat and filter occupant and finishing-related air contaminants, reducing indoor air contaminant levels near or below ASHRAE 62.1 standards. Sensors on the HLR indicate the capacity of filter remaining and enable a regeneration cycle to purge and flush sorbents out of the filter. This regeneration cycle can take several minutes to complete and happens one to three times per day. Once completed, the unit goes back to absorption mode. Outdoor air is typically reduced by 2,500-3,500 CFM per HLR, depending on existing air contaminants and filtering. Carbon dioxide filters require replacement every 2 years, while VOC filters required replacement every 3-5 years.

C.18 DRAIN WATER HEAT RECOVERY

Drain water heat recovery systems recover energy from drain water to pre-heat incoming cold water, prior to being supplied to main water heating equipment. Drain water heat recovery systems utilize a non-contact heat exchanger to avoid potential clogs from solids or debrief in drain water, and can be installed in a variety of orientations.

C.19 DHW CIRCULATION PUMP TIMER

Domestic hot water circulation pumps are used to conserve water and DHW heating energy. When no circulation pump is present and there is a call for hot water, water must travel from the hot water tank to the load (sink). If long runs of pipe are between these two points, water will be wasted waiting for the hot water to reach the demand site. Circulation pumps constantly circulate hot water through the lines and allow for almost instantaneous hot water when demand is needed.

Since the schools are only occupied during school hours, hot water is only potentially needed during these times. A time clock can be installed on the existing DHW re-circulation pumps which will cause the pump to only circulate hot water from the storage tank during specified times.

C.20 WALL CRACK REPAIR

This CRM includes the repair and sealing or wall cracks and penetrations throughout building envelope areas. This CRM includes the use of epoxy injection systems or similar caulking mechanisms for crack repairs and sealing. The steps include cleaning the cracks from loose concrete or dust and then applying the crack sealer. Some products involve inserting injection nozzles at specified distances across the crack before injecting the sealer product deep into the crack. Other types of products involve cutting a V-shaped groove in the interior of the wall along the crack before applying the caulking. Prior to repair, it is recommended that any significant cracking or penetrations be reviewed by a structural engineer.

C.21 HEAT RECOVERY (RUN AROUND COILS)

Heat recovery ventilators (HRV) are mechanical devices used to recover heat from exhausted building air. Warm exhaust air travels through a heat exchanger to the outdoors, while colder fresh air simultaneously travels in the opposite direction, towards the interior of the building. These airstreams never actually mix, and only exchange heat. This allows moist or stale building air to be exhausted, while efficiently increasing fresh air ventilation within the space. Heat recovery ventilators can be incorporated or detached from air handing units. Various types of heat recovery ventilators exist, and can include heat recovery wheels, single or dual core, heat pipes, or run around coils.

A run-around coil heat recovery system is simulated to be installed in the existing ventilation units. Run-around heat recovery systems utilize a coil located in the outdoor and exhaust airstream, with a pump that circulates a glycol solution between the two coils. The coil within the exhaust ducting recover's energy from the exhaust airstream, which is then circulated to the coil within the outdoor ducting to transfer the available energy to the outdoor airstream. Since a run-around coil system utilized multiple coils, this type of heat recovery is among the lowest efficiency, ranging between 30-50%. However, these systems enable heat recovery when the outdoor and exhaust plenums are not adjacent to each other and have no potential for leakage between airstreams.

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[i] Greenhouse Gas Equivalencies Calculator | Natural Resources Canada (nrcan.gc.ca)