Williams Lake Energy Recovery Report

Cariboo Memorial Recreation Complex:

525 Proctor St, Williams Lake, BC V2G 4J1

POLAR ENGINEERING

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1.0 Introduction

Hello Stacey, Brandy & Kaitlyn,

Thank you for giving Polar Engineering the opportunity to provide you with a detailed engineering analysis and proposal for the CleanBC Grant. The purpose of this document is to outline how the City of Williams Lake is the prime candidate for the CleanBC grant. To accurately depict this information, we have analyzed the past, present, and future energy demands of the facility. We will also be outlining how our proposed low carbon emission (LCE) system will lead to a significant reduction in greenhouse gas (GHG) emissions for the facility and will be extremely beneficial to the City of Williams Lake and British Columbia as a whole. Please let us know if there is any further information you require, or if anything below needs to be expanded upon. We are very happy to help.

2.0 Summary

This section will provide a summary of the detailed engineering calculations and data that is provided in sections 3-5.

The City of Williams Lake has hired Polar Engineering to design and conduct a detailed engineering analysis for a low carbon emission (LCE) heat recovery system at the Cariboo Memorial Recreation Complex (CMRC). The CMRC consists of one NHL sized arena, one ¾ NHL sized arena and multiple pools. The ammonia refrigeration system within the CMRC will be the subject of energy reclamation for the proposed LCE Project.

The refrigeration plant at the CMRC consists of four compressors, two Mycom N4Ms and two Mycom N6WAs. Only the two Mycom N4M compressors have been operating at the refrigeration plant due to maintenance issues with the other two. Currently the CMRC uses a BAC evaporative condenser to reject heat from the two Mycom compressors inside the arena refrigeration plant.

The CMRC has two boiler rooms, with a total of 4 boilers providing heat to the entire facility. One of the boiler rooms supplies heating for the arena side and the other is for the pool side. For the purpose of this study Polar will be focusing on the pool side boiler room, since that is the boiler loop the proposed LCE system will integrate with. The two boilers on the pool side of the facility provide heat to the domestic hot water (DHW) system on the pool side, heat exchangers for the pools, AHU 201 (leisure pool side) and AHU 202 (lane pool side). Recently the facility has installed a couple of new natural gas Trane rooftop units which have heat recovery measures built in, and therefore didn't make sense to integrate with for this LCE system.

Polar has proposed the idea of installing a high temperature heat pump which will recapture the waste heat from the refrigeration plant and redistribute this heat towards the boiler loop on the pool side of the facility. Recovering this excess heat enables us to offset the natural gas usage required to heat the CMRC pool, DHW, AHU 201 and AHU 202. This will lead to a significant reduction in natural gas usage at the CMRC pool side, which translates to operating cost savings for the facility.

To determine if a high temperature heat pump would be feasible at the facility, it was necessary to calculate how much heat is available for recovery from the CMRC. Polar analyzed the CMRC's refrigeration system based on compressor run time, and the heating capacity of the two Mycom compressors. Based on our calculations, an average of 737 GJ of energy per month was available to be recovered from the arena using the two compressors. The arena is closed from May – July, therefore during these months there will no heat to recover. Annually there is an average of 6,635 GJ of heat which can be recaptured by Polar's proposed LCE system to offset the natural gas usage of their two natural gas boilers on the pool side.

Once Polar determined how much heat was available to be sent to various amenities at the CMRC, it was essential to calculate how much heat is required by these amenities throughout the year. Polar analyzed every system at the CMRC which is currently getting heat from the two natural gas boilers in the pool boiler mechanical room. Polar used industry standard practices to perform these calculations. Further details about these calculations are highlighted in section 4 of this report and all detailed calculations are shown in the accompanying Excel document submitted with this report. A summary of these results are depicted in Figure 1.

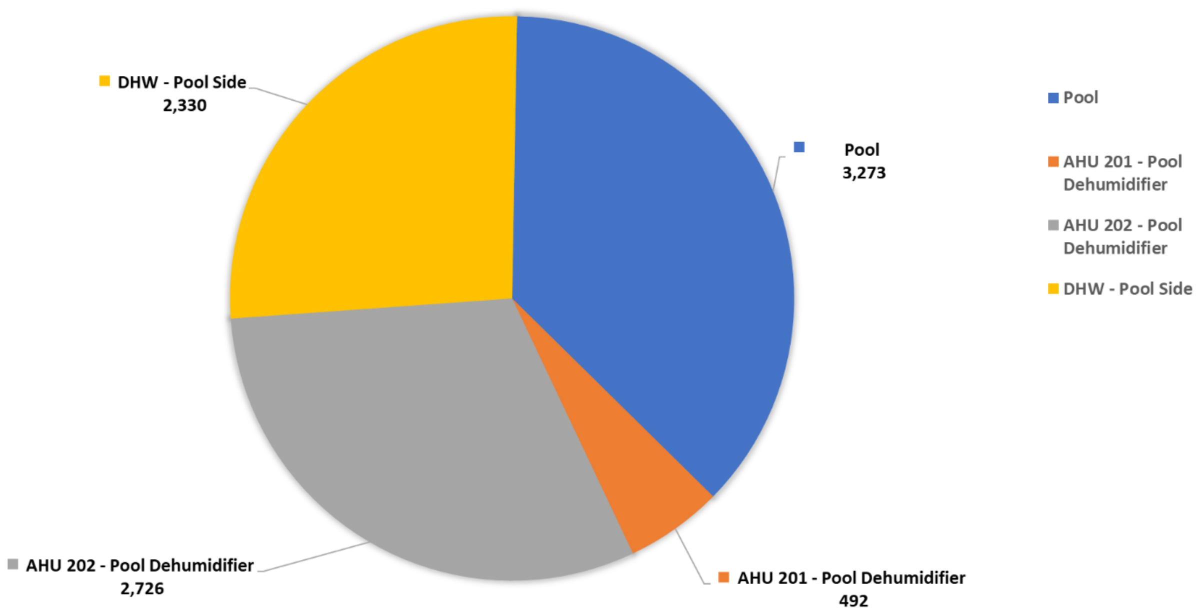

Figure 1: Natural Gas Usage at the CMRC - Pool Side

Through completing this detailed energy study, Polar concluded that installing a high temperature heat pump at the Cariboo Memorial Recreation Complex would lower their natural gas usage from 9,912 GJ/year to 3,055 GJ/year therefore saving 6,857 GJ of natural gas annually. This translates to GHG reductions of 340 tonnes CO2 per year. After analyzing the natural gas billing information provided by the CMRC, it was found that annual natural gas costs would be reduced by $61,297 by installing this LCE system at the facility. Taking into consideration the increase in electrical usage due to the high temperature heat pump and reduction in electrical usage of the BAC Evaporative Condenser's fan and pump, the CMRC would expect an annual reduction in operating costs of $39,880. The total project cost was calculated to be $600,000 through talking to contractors about the scope of the project and receiving quotations from equipment manufacturers.

Visual depiction of the proposed natural gas usage, GHG emissions, and combined energy cost once the high temperature heat pump is installed are shown below:

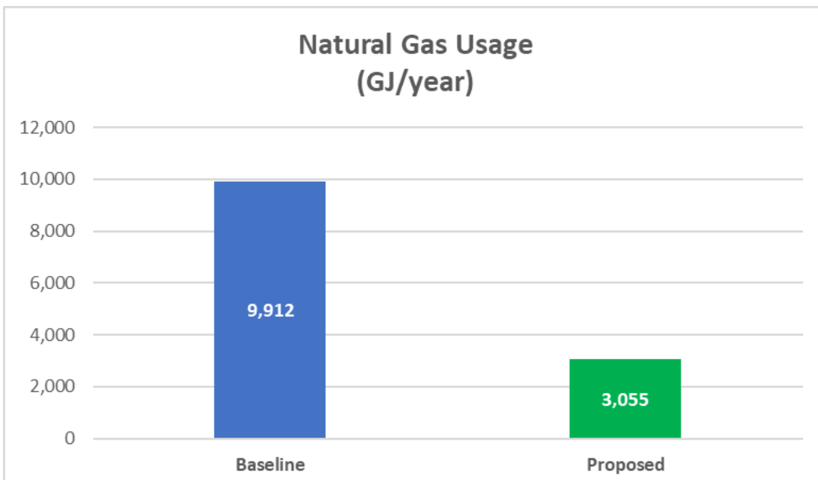

Figure 2: Proposed Natural Gas Savings

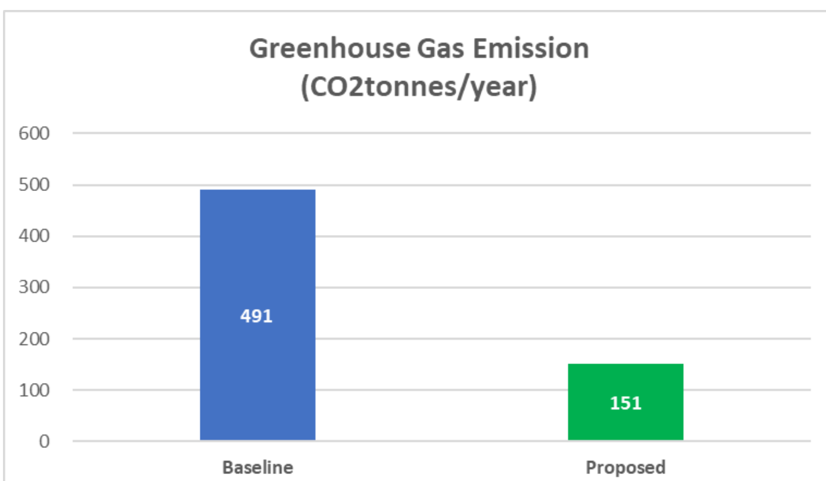

Figure 3: Proposed Reduction in GHG Emissions

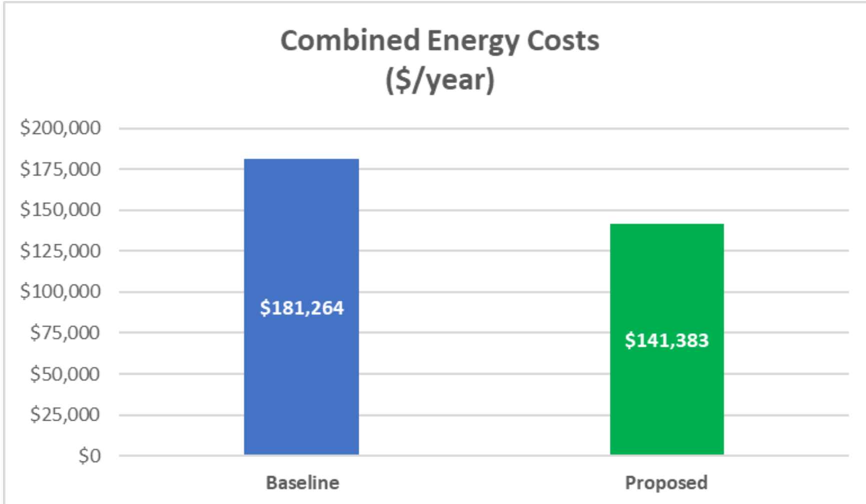

Figure 4: Proposed Combined Energy Cost Savings

3.0 System Description

This section of the report will give an overview of the existing system at the CMRC. It will also discuss the proposed LCE system Polar is planning on installing at the CMRC.

3.1 Existing System – Cariboo Memorial Recreation Complex

The Cariboo Memorial Recreation Complex features one NHL-sized arena, one ¾ NHL-sized arena, hot tub, steam room and leisure pool. The aquatic center's public operating hours are from 6am-8pm daily on weekdays, and 8am-6pm on weekends. The arena's hours are from 6am-12pm during the operating months of August-April. Both the ice sheets are taken out from May-July.

The ammonia refrigeration plant at the CMRC consists of four compressors, two Mycom N4Ms and two Mycom N6WAs. Only the two Mycom N4M compressors are being used to cool the arena due to maintenance issues with the other two. To provide the cooling necessary to maintain a high-quality ice surface of the arena, a calcium chloride brine solution is pumped through a series of pipes embedded within the concrete below each ice surface. These are referred to as arena cooling floors. The heat which is collected through this brine loop is transferred into the ammonia loop via a heat exchanger, also known as the evaporator. The gaseous ammonia is then sent to one of the Mycom N4M compressors, where it is compressed and turns into a high-pressure ammonia vapor which is superheated.

This superheated vapor is then sent to another heat exchanger, also known as a plate & frame condenser, where it transfers some heat to the glycol loop used for compressor cooling. The remaining flow of vaporized ammonia is sent to the BAC Evaporative Condenser (Figure 5) where it rejects this heat to the atmosphere. Inside this type of heat exchanger, the ammonia refrigerant is passed through a series of pipes whose exterior surfaces are constantly sprayed with a stream of water. The heat from the vaporized ammonia transfers through these pipes, causing the stream of water to evaporate. This extracts a large amount of thermal energy from the flow of ammonia, allowing it to condense back into liquid form. The heat rejected by this condenser is considered waste heat, as it does not provide any benefit to the facility.

After this, the hot ammonia liquid is sent to an expansion valve where isobaric expansion occurs, the pressure of the hot ammonia liquid drop, but nothing happens to the volume. The liquid/vapor mixture is then sent to the evaporator and the process is repeated. For a detailed P&ID of this refrigeration system, please check the appendices of this report.

The CMRC currently has two separate boiler rooms at the facility, each with two boilers. The first boiler room has two boilers and provides heating to the arena side. The second boiler room has another two boilers which provide heating to the pool side. For the purpose of this study, we will only be integrating with the 2nd boiler loop on the pool side of the facility. This boiler loop provides heating to the DHW on the pool side, AHU 201, AHU 202 and various pool heat exchangers. There are three different heat exchangers for the pools: lap pool, leisure pool and the swirl pool. Figure 6 shows a DDC Screenshot of the boilers on the pool side of the facility and the amenities they provide heating to. There are a couple natural gas Trane rooftop units that were recently installed at the facility, and have heat recovery measures built in. Therefore, we will not be integrating with these rooftop-top units: AHU 001 (changeroom), AHU 003 (office), AHU 204 (fitness room) and AHU 205 (fitness room).

Figure 5: BAC Evaporative Condenser at CMRC

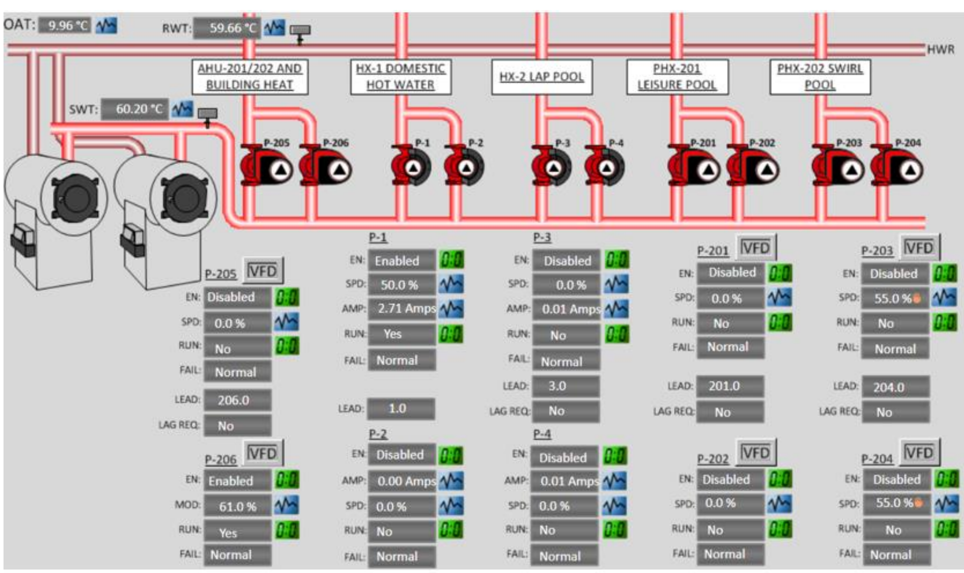

Figure 6: Boiler Loop Integration at the CMRC - Pool Side

3.2 Proposed LCE Heat Recovery System

Polar recognized that the heat currently being rejected by the BAC condenser at the CMRC could be harnessed to provide a large portion of the thermal energy required by the amenities on the pool side of the facility. The proposed LCE heat recovery system will capture the excess heat from the ammonia refrigeration plant and use that thermal energy to provide heating to the domestic hot water, pool, AHU 201 and AHU 202. A schematic of the proposed heat recovery loop can be seen below in Figure 7.

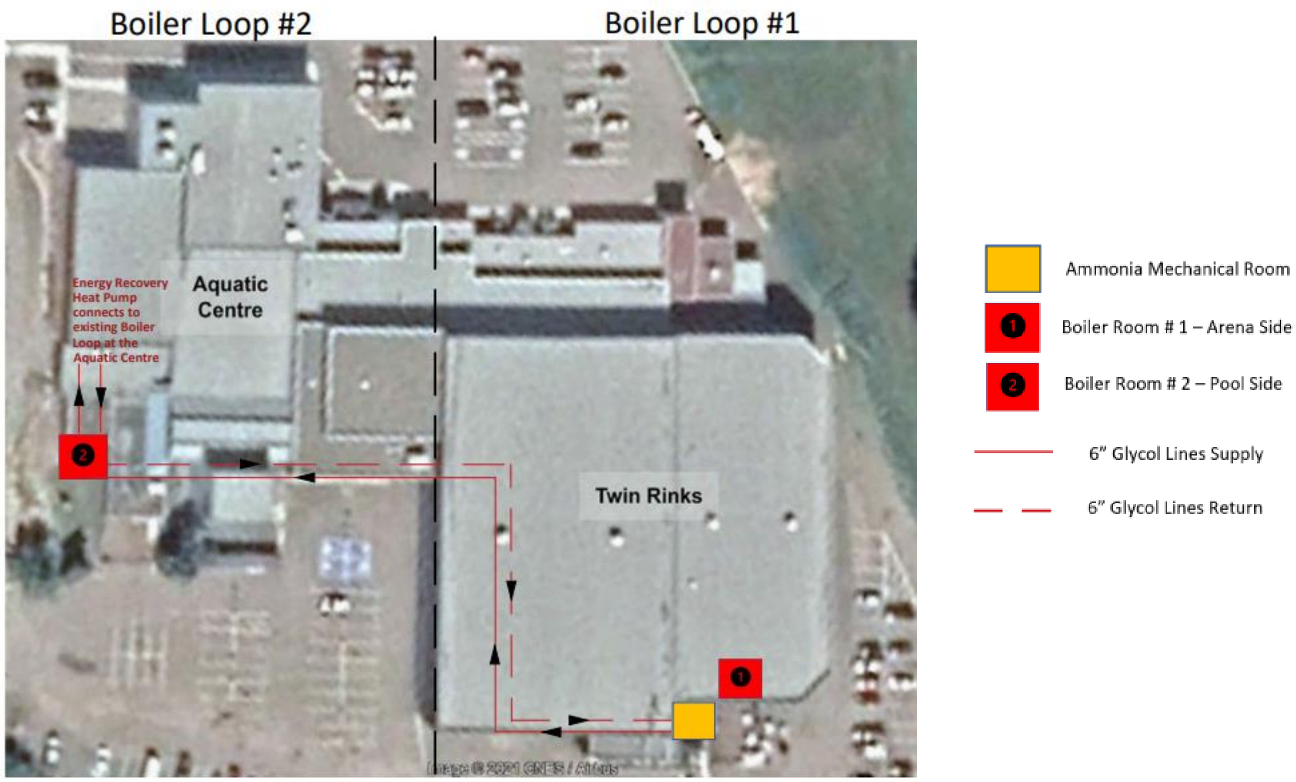

Figure 5: Proposed LCE System

The evaporator of the heat pump will be supplied with heated propylene glycol from the refrigeration plant using the heat recovery loop shown in Figure 7. The evaporator will then be responsible for transferring heat from the propylene glycol into the R513 refrigerant contained within the heat pump. From the heat pump evaporator, the vaporized refrigerant is first sent to the accumulator. The purpose of the accumulator is to separate out any liquid refrigerant from the flow to avoid compressor damage.

After leaving the accumulator, the vapor is then sent to the compressor of the heat pump. Inside the compressor the temperature and pressure of the refrigerant is increased, leaving the vapor in a super-heated state. The motor of the compressor will be controlled using a variable frequency drive (VFD) which allows the compressor to change speeds depending on the fluctuating heating requirements of the facility. This allows for a more efficient system and reduces the amount of electrical power required from the motor of the compressor. From the compressor, the superheated vapor refrigerant is sent to the condenser of the heat pump where it will transfer its thermal energy to provide heating for the boiler loop. At the Cariboo Memorial Recreation Complex, the boiler loop provides heating to AHU 201 and AHU 202 which both serve the pool hall at the facility. These AHUs act as a natatorium dehumidifier since they are not trying to heat the pool but are aiming to keep it at optimal humidity levels throughout the year. The condenser, shown in Figure 8, will also be providing heat to three pool heat exchangers: lap pool, leisure pool and the swirl pool.

Once the R513 Refrigerant has passed through the condenser it's in a saturated liquid state. This liquid is then sent to a receiver tank, whose purpose is to store excess refrigerant that is not being used within the heat pump loop at the given time. This is another important component which allows the system to function efficiently under varying heating loads.

After the receiver, the saturated liquid refrigerant is sent to the subcooler of the heat pump, shown in Figure 9. Since Polar will work with contractors to build a site-specific heat pump, Polar can install an additional component, called the subcooler. This component sub-cools the liquid ammonia and prevents it from turning into a liquid/vapor mixture before reaching the evaporator. The subcooler will preheat the domestic cold water (DCW) coming into the facility to approximately 120F. The condenser of the heat pump will boost the temperature of the water to the desired 140F, the setpoint of the pool boiler loop at the CMRC.

After leaving the subcooler, the liquid R513 Refrigerant is passed back to the heat pump's evaporator where it will repeat the process highlighted in the paragraphs above. R513 refrigerant is used in Polar's heat pump designs for several reasons. R513 is non-flammable, non-ozone depleting, and has a low global warming potential. This makes the refrigerant much safter for both humans the environment in cause of a leak.

Figure 8: Condenser of Heat Pump

Figure 9: Subcooler of Heat Pump

4.0 Engineering Analysis

The study results in this document were calculated using industry standard techniques. For detailed engineering calculations please reference accompanying Excel document.

4.1 Baseline Natural Gas Usage at the CMRC

The current natural gas consumption at the CMRC was determined using data provided to us by Ian James, the former Director of Leisure Services. The CMRC has two separate natural gas meters, one for the pool and the other for the arena side. The average natural gas consumption of the entire facility is 14,336 GJ and a monthly breakdown can be seen in Table 1. Since the LCE system Polar is proposing will only be integrating with the pool side boiler loop for the purpose of this project, we will be focusing on the pool side natural gas usage, which is 9,912 GJ/year. For the pool side we were only provided with natural gas bills from 2020. Since 2020 was the year of Covid-19, the facility pool was closed from April – August. Due to this, Polar averaged the natural gas values from September and March for those months to provide a more realistic natural gas value for the facility.

Table 1: Natural Gas Consumption at the Pool and Arena at the CMRC

Month	Arena Side	Pool Side	CMRC
	Consumption (GJ)	Consumption (GJ)	Consumption (GJ)
January	528.15	1124.60	1,652.75
February	719.00	1011.20	1,730.20
March	739.60	736.80	1,476.40
April	355.50	697.30	1,052.80
May	144.15	697.30	841.45
June	74.65	697.30	771.95
July	81.50	697.30	778.80
August	82.20	697.30	779.50
September	191.15	657.80	848.95
October	388.90	932.60	1,321.50
November	460.70	933.60	1,394.30
December	658.25	1028.90	1,687.15
Total (GJ/year)	**4,424**	**9,912**	**14,336**

To get an accurate natural gas rate for the facility Polar used the total gas consumption at the CMRC annually, 14,336 GJ, and divided it by the total natural gas cost of the facility, which was $128,163. This yielded an average natural gas rate of $8.94. A summary of these results are shown in Table 2.

Table 2: Natural Gas Consumption Summary at CMRC

Natural Gas Consumption at CMRC	
Average Natural Gas Consumption (GJ/year)	14,336
Average Yearly Cost ($/year)	$128,163
Average Rate ($/GJ)	$8.94

4.2 Baseline Electricity Consumption at the CMRC

The baseline electrical consumption of the CMRC was determined by data provided to us by Ian James, the former Director of Leisure Services. There is one combined meter at the facility that tracks the pool and arena usage. The electricity usage was determined using the average of the 2018 and 2019 data for the facility. Averaging values from these two years gave us an annual electricity consumption of 1,014,632 kWh/year. The baseline annual peak demand for the facility is 298 kW and the monthly average demand is 215 kW. A monthly breakdown of the electricity consumption at the CMRC can be seen below in Table 3.

Table 3: Electricity Consumption at the CMRC

Month	Electricity Usage at the CMRC 2018 + 2019 Average Electricity (kWh)	 Demand (kW)
Jan	102,063.5	269.0
Feb	95,020.5	246.5
Mar	43,460.0	98.1
Apr	36,969.6	116.1
May	34,796.6	101.9
Jun	31,075.4	73.0
Jul	70,077.7	218.7
Aug	114,979.7	287.6
Sep	128,275.5	294.0
Oct	125,878.4	297.8
Nov	124,803.0	295.8
Dec	107,232.0	276.5
Total	**1,014,632**	**Annual Peak (kW)**
		298
		Monthly Average Demand (kW)
		215

To get an accurate demand charge and energy charge for the facility, Polar referred to the LGS rates on the BC Hydro website. The average demand charge is $12.26/kW, and the average energy charge is $0.0602/kWh. A summary of these results are shown in Table 4.

Table 4: Electricity Consumption Summary at CMRC

Electrical Consumption at CMRC	
Average Electricity Consumption (kWh/year)	1,014,632
Average Peak Demand (kW)	215
Yearly Peak Demand (kW)	298
Energy Charge ($/year)	0.0602
Demand Charge ($/kW)	12.26

4.3 Proposed Natural Gas Usage at the CMRC

Using data provided by the City of Williams Lake it was determined that the average annual natural gas usage on the pool side of the CMRC is 9,912 GJ. As stated previously, the facility has recently installed various natural gas Trane rooftop units which have energy recovery built in, and Polar's heat recovery system will not be integrating with them. These AHUs include AHU 001 (change-room), AHU 003 (offices), AHU 204 (fitness room), and AHU 205 (fitness room). These units account for 11% of the natural gas usage at the facility. The remainder of the natural gas usage at the facility is for the DHW preheat, pool heat exchangers, and the two natatorium dehumidifiers (AHU 201 + AHU 202).

To accurately determine the natural gas consumption of the facility's boilers Polar thoroughly studied the heating schematics of the facility and used standard industry practices to determine the amount of energy required for the three different functions of the boiler loop, which will be further explained in this section of the report. The two natural gas boilers at the CMRC have a combined efficiency of 90% and this was taken into account when calculating the natural gas usage per amenity.

The first function of the boiler loop is to provide heating to the facility's lane pool, leisure pool and wave pool. Using formulas highlighted in the ASHRAE Application Section 5.7 Polar was able to calculate water evaporation rates for the various pools, which were then multiplied by the latent heat of evaporation (970 BTU/lb) to obtain the amount of heat required for the pools. The amount of heat being consumed by the multiple pools was calculated to be 3,273 GJ/year. This natural gas usage will be offset using the condenser of the proposed high-temperature heat pump.

The second function of the boiler loop is to provide heating to the facility's natatorium dehumidifiers. Polar calculated this using the previously determined evaporation rates of the facility's pool. The heating load of the natatorium dehumidifiers was determined using an AHU energy model. ASHRAE dehumidification design conditions for the City of Williams Lake were used for the climate conditions when performing these calculations. On average, the smaller natatorium dehumidifier, AHU 201, requires 492 GJ of heat annually while AHU 202, the bigger natatorium dehumidifier, requires 2,726 GJ of heat per year. AHU 202 is the primary dehumidifier used for the majority of the day, while AHU 201 is only turned on during the night for a couple hours, therefore the natural gas usage of AHU 202 is significantly higher. The natural gas usage of both these dehumidifiers will be offset using the condenser of the proposed high-temperature heat pump.

The third function of the boiler loop is to provide thermal energy to the existing DHW heat exchanger on the pool side of the facility. Polar calculated this using average monthly water consumption rates for each of the facility's pool side 21 showers, 18 sinks and 4 utility sinks. The heating demand for the DHW was calculated to be 2,330 GJ/year. The natural gas usage of the DHW heat exchanger will be offset using the subcooler and condenser of the heat pump. The subcooler will preheat the DCW coming into the facility to approximately 120°F, and then the condenser of the heat pump will be able to provide it with higher grade heat, therefore boosting the temperature to 140°F, the DHW setpoint at the facility.

The results of the heat required calculations at the CMRC are stated below:

- 2,330 GJ/year for the domestic hot water being used on the pool side of the facility
- 3,273 GJ/year for the pool heat exchangers
- 492 GJ/year for AHU 201 – Natatorium Dehumidifier
- 2,726 GJ/year for AHU 202 – Natatorium Dehumidifier

For a monthly breakdown of the energy required by each amenity on the pool side of the facility, please refer to Table 5 below. Figure 7 also provides a visual depiction of the data provided in this section of the report.

Table 5: Heat Required by Natural Gas Boilers at CMRC

Heat Required by CMRC				
Month	**Pool Heat Required (GJ/month)**	**AHU 201 – Pool Dehumidifier (GJ/month)**	**AHU 202 – Pool Dehumidifier (GJ/month)**	**DHW – Pool Side (GJ/month)**
January	242.00	58	315	174.76
February	242.00	58	315	174.76
March	242.00	38	188	174.76
April	242.00	38	188	174.76
May	252.31	22	77	174.76
June	252.31	12	77	174.76
July	252.31	12	77	174.76
August	252.31	12	77	174.76
September	242.00	38	255	174.76
October	242.00	38	255	174.76
November	242.00	58	315	174.76
December	242.00	58	315	174.76
Totals (GJ/year)	**2,945**	**443**	**2,453**	**2,097**
Boiler Natural Gas Usage (GJ/year)	**3,273**	**492**	**2,726**	**2,330**

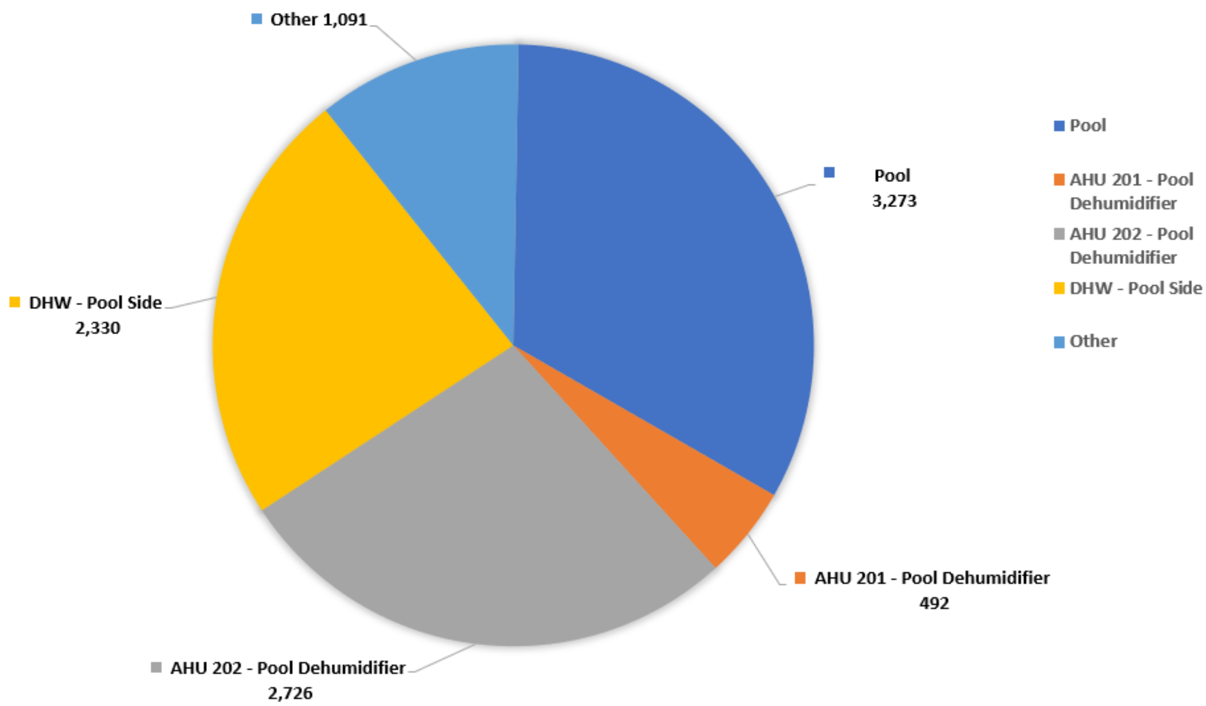

Figure 6: Natural Gas Breakdown on the Pool Side of the CMRC

Once the heating requirements of the facility's amenities were determined, calculations were carried out to determine the amount of energy that can be recovered from the Cariboo Memorial Recreation Complex's ammonia refrigeration plant. To accomplish this, Polar used Mycom compressor analysis software to determine the total heat of rejection (THR) at the outlet of the compressors. This heat rejection accounts for the thermal energy present at the inlet of the compressor (heat extracted from the cooling floor of each arena), as well as the increase in thermal energy due to the compression process within the Mycom N4M compressors. Multiplying this heat of rejection by the compressor runtime yielded the total available heat present within the refrigeration system. Since the ammonia refrigeration plant currently has a desuperheater which uses some of the energy available from the refrigeration plant, it was therefore subtracted from the total heat available. Table 6 provides a monthly breakdown of the heat available from the refrigeration plant.

Table 6: Heat Available from Refrigeration Plant at CMRC

Heat Available from Refrigeration Plant at the CMRC						
Month	Comp 2 Runtime (hours)	Comp 4 Runtime (hours)	Heat Available (kBTU/month)	Heating Available (GJ/month)	Heat Used - Desuperheater (GJ/month)	Total Heat Available (GJ/month)
January	16	10	779,598	822.52	85.27	737.25
February	16	10	779,598	822.52	85.27	737.25
March	16	10	779,598	822.52	85.27	737.25
April	16	10	779,598	822.52	85.27	737.25
May	0	0	0	0.00	0.00	0.00
June	0	0	0	0.00	0.00	0.00
July	0	0	0	0.00	0.00	0.00
August	16	10	779,598	822.52	85.27	737.25
September	16	10	779,598	822.52	85.27	737.25
October	16	10	779,598	822.52	85.27	737.25
November	16	10	779,598	822.52	85.27	737.25
December	16	10	779,598	822.52	85.27	737.25
					Total Heat Available (GJ/year)	6,635

Due to the large amount of heat available from the refrigeration system at the CMRC (6,635 GJ/year), a significant portion of the heating load of the natural gas boilers can be met using the proposed high temperature heat pump. From May-July the heat pump will not be able to offset any natural gas usage since the refrigeration plant does not operate. Figure 11 compares the energy available from the heat pump with the total heat required by the Cariboo Memorial Recreation Complex – Pool Side.

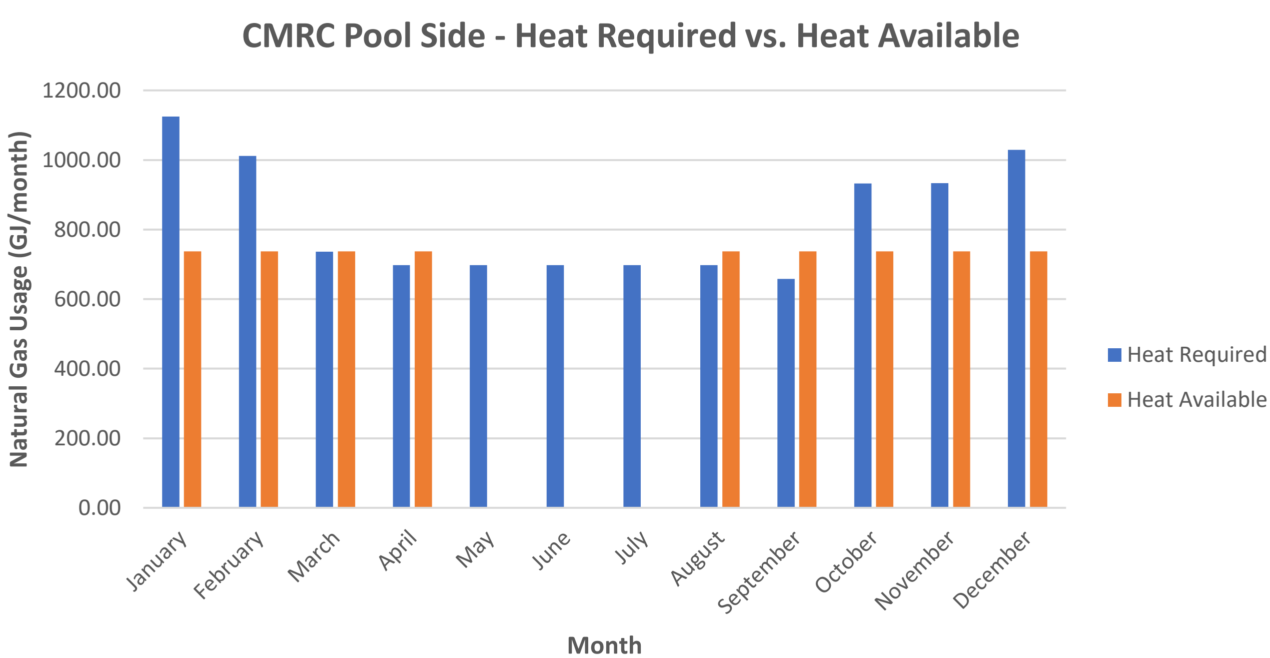

Figure 7: Heat Required vs. Heat Available at CMRC

The expected natural gas consumption of the CMRC following the installation of the high-temperature heat pump can be found below:

- 3,055 GJ/year proposed natural gas usage
- 6,857 GJ/year of natural gas savings
- 69% reduction in proposed natural gas usage

The Excel document included with the submission of this report contains additional information regarding the detailed engineering analysis performed. Also, please do not hesitate to contact Polar Engineering if you have any questions or require any additional information.

4.3 Proposed Electricity Consumption at the CMRC

The proposed LCE system, a high temperature heat pump, will increase the electrical usage at the facility since the compressors in these units require electricity to operate. The coefficient of performance (COP) of the proposed high temperature heat pump is 5.93. Building a custom unit allows Polar to choose every specific component in the unit, therefore allowing for a higher COP when compared to off the shelf heat pumps in the market. Based on Polar's calculations, the heat pump will lead to an increase in electricity consumption by 289,062 kWh/year. Due to the significant reduction in natural gas usage from the proposed LCE system, the CMRC will still save money on combined energy costs.

Since the heat pump will be recovering energy from the ammonia refrigeration plant during operating months the BAC evaporative condenser used to release excess heat into the atmosphere will have to operate significantly less. The condenser fan will consume 15 HP less per hour not running, and the condenser pump will consume 3 HP less per hour not running. This will reduce the electrical usage of the heat pump and leads to electrical savings of 53,927 kWh/year.

The expected electricity consumption of the CMRC following the installation of the heat recovery system can be found below:

- 1,249,766 kWh/year proposed electricity consumption
- 235,134 kWh of increase in electricity consumption
- 19% increase in proposed electricity consumption

4.4 GHG Emissions at the CMRC

The baseline greenhouse gas emissions at the CMRC were calculated using natural gas data provided by Ian James, the former Director of Leisure Services at the CMRC. The average natural gas consumed on the pool side of the facility is 9,912 GJ/year. This translates to greenhouse gas emissions of 491 tonnesCO2/year. The proposed natural gas usage on the pool side of the facility is 3,055 GJ/year which translates to GHG emissions of 151 tonnesCO2/year. Therefore, the installation of this low carbon emission system would lead to a decrease of GHG emissions by 340 tonnesCO2 for the facility annually. To calculate the amount of reduced GHG emissions, Polar used the same methodology as the 2016 BC Best Practices Methodology for Quantifying Greenhouse Gas Emissions. See the calculation below as an example:

$$3{,}055\frac{GJ\ NG}{year} * 49.58\frac{kg\ CO_2}{GJ\ NG} * 0.001\ \frac{tonne}{kg} = 151\frac{tonne\ CO_2}{year}$$

4.5 Capital Cost

A ROM cost breakdown was completed to determine the equipment and labor costs that would be associated with the installation of the proposed heat recovery system. The price below has been calculated for the proposed high-temperature heat pump option available to the CMRC:

High-Temperature Heat Pump: $600,000

This value has a +/-30% contingency. Please note that this total does not include engineering costs or any unforeseen building upgrades, such as structural.

4.6 Operation and Maintenance

Polar Engineering recommends that an inspection of the system should be conducted twice annually, with each test typically costing $500. With the additional maintenance required for the pumps and compressor of the heat pump, the City of Williams Lake should expect annual operation and maintenance costs of approximately $2,000 a year.

4.7 Additional Benefits for Proposed LCE Measures

Additional benefits for this LCE system are that the CMRC will be spending less money on their overall natural gas usage. Since they pay a high rate for their natural gas at $8.94/GJ, these measures of reducing natural gas usage will lead to significant facility savings, allowing for more room in the budget for additional programs, inclusive community gatherings and any building upgrades the CMRC might be required to do in the future.

4.8 Recommendations

Polar Engineering recommends that CleanBC approves the installation of the proposed LCE heat recovery system because it would lead to a decrease in the facility's natural gas usage, and ultimately a 69% reduction in greenhouse gas emissions.

5.0 Study Results

The results below mirror the CleanBC application workbook:

Baseline conditions at the CMRC:

- HVAC Fuel Usage: 7,582 GJ/year
- DHW Fuel usage: 2,330 GJ/year
- HVAC Electricity Usage: 1,014,632 kWh/year
- DHW Electricity Usage: 0 kWh/year
- Annual Peak Demand: 298 kW
- Average Monthly Peak Demand: 215 kW

Implementing the LCE measure of installating a high temperature at the CMRC will lead to the proposed values below:

- HVAC Fuel Usage: 2,472 GJ/year
- DHW Fuel usage: 583 GJ/year
- HVAC Electricity Usage: 929,779 kWh/year
- DHW Electricity Usage: 319,987 kWh/year
- Annual Peak Demand: 369 kW
- Average Monthly Peak Demand: 264 kW

6.0 Energy Tracking

Along with providing state-of-the-art engineering design and analysis, Polar Engineering can also provide an energy savings display that track, in real time, the amount of CO2 saved by installing the proposed LCE measures throughout the facility. The tonneCO2 is not a common unit for the public, and therefore the GHG savings are converted into more easily understood units, such as an equivalent number of trees planted, cars taken off the road, and houses heated in a year. This provides a visual depiction to the public which often resonates within them deeper. Please see below for an example of this energy savings dashboard. This example shows the equivalent number of trees planted for a similar heat recovery system which was previously installed by Polar.

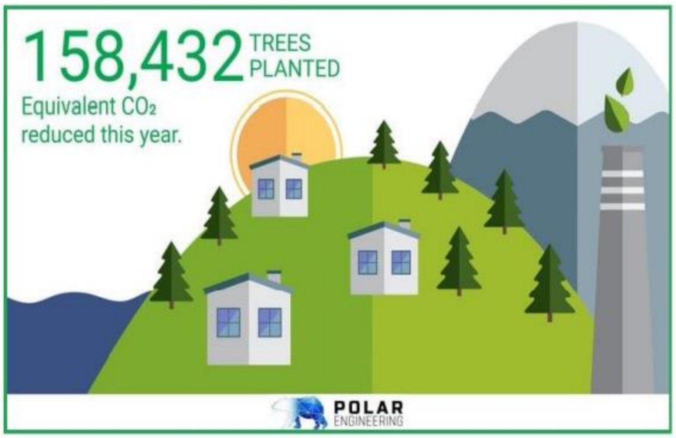

Figure 8: Polar Engineering Energy Dashboard

7.0 Assumptions

The following assumptions were made regarding the Cariboo Memorial Recreation Complex. These assumptions are based off industry standards and extensive engineering experience:

Compressor Runtimes: The Cariboo Memorial Recreation Complex does not have paper copies of their compressor runtimes; therefore, operating hours for compressor 1 was assumed to be 16 hours a day during the operating months of the facility, and 10 hours for the 2nd compressor.

Shower Usage: Shower run times were assumed to be approximately 8 min/hour. The usage was calculated using operational hours of the pool / dressing room on weekdays (14) and weekends (10). These values were obtained using data provided to us by Ian James, former Director of Leisure Services at the CMRC.

Tap Usage: The bathroom sinks were assumed to be running for 8 min/hour on weekdays for 14 hours and weekends for 10 hours. The utility sink was said to be running for only 4 min/hour for 14 hours on weekdays and 10 hours on weekends since it is not a commonly used fixture.

8.0 Conclusion

Polar would like to thank you for giving us the opportunity to provide CleanBC with this energy analysis report. The energy recovery system outlined in this report has been designed using state-of-the-art technology and will make the Cariboo Memorial Recreation Complex one of the most energy efficient facilities of its kind in North America.

To conclude, the Cariboo Memorial Recreation Facility would greatly benefit by installing the proposed LCE system, a high-temperature heat pump, at their facility due to the reduction in natural gas usage, greenhouse gas emissions and decrease in overall combined energy costs.

The recommended high-temperature heat pump will lead to 6,857 GJ/year of natural gas savings at the facility, setting the annual natural gas usage to 3,055 GJ/year. This will lead to an offset of natural gas usage on the pool side of the facility by 69% when compared to the baseline natural gas consumption value of 9,912 GJ/year. This results in $61,297 of natural gas savings annually for the facility based on their current natural gas rate of 8.94/GJ. This reduction of natural gas usage translates to a reduction of greenhouse gas emissions by 340 tonnesCO2/year. This will offset greenhouse gas emissions on the pool side by 69% compared to the baseline greenhouse gas emission of 491 tonnesCO2/year. The electricity usage will increase by 235,134 kWh/year which includes the increase in electrical consumption of the heat pump and the decrease in electrical consumption of the BAC evaporative condenser. Even with the increase in electricity consumption, the CMRC would save approximately $39,880 per year in operating costs. This is substantial and will allow the facility to introduce new programs, perform necessary building upgrades, and look into further energy recovery systems in the future. Table 6 provides a summary of the overall energy study results

Cariboo Memorial Recreational Complex - Savings		
Item	**Baseline**	**Proposed**
Natural Gas Consumed (GJ/year)	9,912	3,055
Natural Gas Cost (GJ/year)	$88,613	$27,316
CO2 Emissions (tonnesCO2/year)	491	151
Electricity Consumed (GJ/year)	1,014,632	1,249,766
Annual Monthly Peak Demand (kW)	215	264
Electricity Cost ($/year)	$92,650	$114,068
Combined Energy Cost ($/year)	$181,264	$141,383
Annual Savings ($/year)	**$39,880**	

Table 6: Savings at CMRC due to installation of heat pump

A visual depiction of the proposed natural gas usage, GHG emissions, and combined energy costs for the heat pump are shown below:

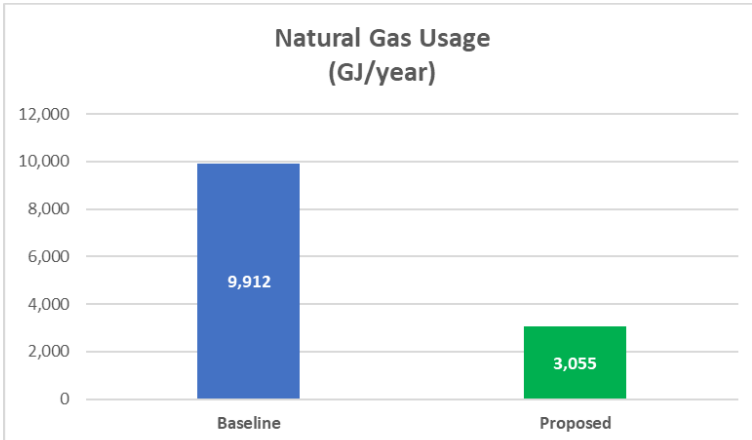

Figure 9: Proposed Natural Gas Savings at CMRC

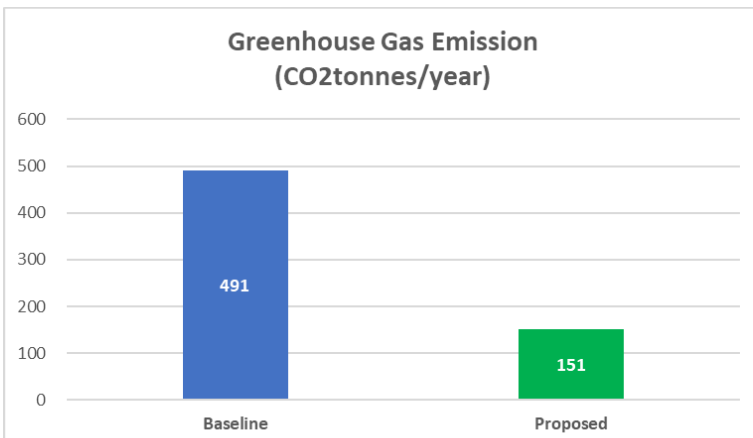

Figure 10: Proposed Reduction in GHG Emissions at the CMRC

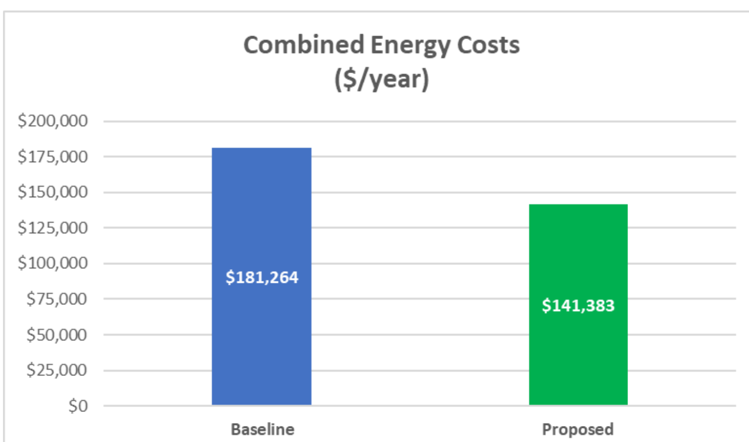

Figure 11: Proposed Combined Energy Savings at the CMRC

Thank you for your time, and please contact Polar Engineering if you have any questions or need further clarification on the information depicted in this report.