Chetwynd Recreation Centre

Heat Recovery and Gas Conservation Study

Final Report 2023-12-22

Report Author

[redacted]

December 22, 2023

Kashmira Kaushik, Jr. Engineer
kashmira@polareng.ca , 778-700-1086 ext. 6

Engineer of Record

Steffen Trangeled, P.Eng., Sr. Engineer
steffen@polareng.ca, 778-700-1086 ext. 4

PROFESSIONAL
PROVINCE OF
S. L. TRANGELED
50517

[redacted]

EGBC Permit to Practice # 1003657

Disclaimer

This document entitled "Chetwynd Recreation Centre: Heat Recovery and Gas Conservation Study" was prepared by Polar Engineering to investigate efficiency measures at the Chetwynd Recreation Centre on behalf of the District of Chetwynd.

This report is intended solely for the District of Chetwynd. Any use of the report, reliance on the report, or decisions based upon the report, by a third party are the responsibility of those third parties unless authorized in writing by Polar Engineering. In no event will Polar Engineering be liable for any indirect, special incidental, consequential or other similar damages or losses, related to the contents of this report being used for purposes beyond the specific scope and limitations of this report.

Executive Summary

This section has been prepared to provide a high-level summary of the Energy Study findings and engineering analysis performed for the Chetwynd Recreation Centre. The information presented below is described in further detail throughout the Report.

The Chetwynd Recreation Centre (CRC) is located in Chetwynd, BC and is owned by the Peace River Regional District and operated by the District of Chetwynd. The facility has one NHL sized ice surface, a six-lane curling sheet, aquatic centre, fitness area, running / walking track, various courts, and a bistro. The District of Chetwynd hired Polar Engineering to conduct a detailed engineering analysis at the CRC to identify energy conservation measures (ECMs) that will achieve utility cost savings and reduce greenhouse gas (GHG) emissions of the facility. This will be achieved through recovering excess heat produced by the refrigeration plant, which is currently released into the atmosphere through using the outdoor condenser.

The following energy saving opportunities were identified and analyzed:

1. **Desuperheater Integration w/ DHW Systems:** Install a desuperheater in the ammonia refrigeration plant which will capture waste energy from the superheated ammonia compressor discharge. This high-temp heat recovered by the desuperheater will be used to preheat the potable, domestic hot water (DHW) on the arena side of the facility. This will significantly reduce the DHW natural gas load of the facility.
2. **Dehumidifier Setpoint Optimization:** Implementation of a floating dewpoint setpoint for the gas-fired dehumidifier which resets based on ambient conditions. This will reduce the natural gas load of the system while ensuring patron & skater comfort year-round.
3. **Heat Recovery using Site-Specific Heat Pump:** Replace the aging Multistack heat pump serving the pool with an industrial grade, low-GWP site-specific heat pump of increased capacity and efficiency. This new system will also be integrated with the ice plant to recover additional free heat, further offsetting the load of natural gas boilers on site.
4. **Low Flow Showerhead Retrofit:** Replace all existing showerheads with low-flow fixtures, therefore reducing the DHW heating load and facility water consumption.

The analyzed ECM outcomes are summarized as follow:

Table 1: ECM Progression Summary of Benefit and Cost

ECM	Description	Natural Gas (GJ/year)	(CUSUM)	Capital Cost ($)	(CUSUM)	GHG (tCO2e)	(CUSUM)
#1	Desuperheater	317	3%	$ 66,200	$ 66,200	16	3%
#2	Dehum Control	137	4%	$ 15,000	$ 81,200	7	4%
#3	Heat Pump	1,919	21%	$ 498,000	$ 579,200	95	20%
#4	Showerheads	265	23%	$ 9,000	$ 588,200	13	22%
	BUNDLE	2,638		$ 588,200		225	

Estimated capital costs of the ECMs are shown below. It is important to note that an "effective payback" period has been presented which accounts for known and expected escalation of energy rates and carbon taxes. The base case cost for ECM#3 is to replace the existing Multistack unit with an identical unit with no additional integrations.

Table 2: ECM Financial Summary

ECM	Description	Total Capital Cost	Base Case Cost	First Year Savings	Effective Payback (years)
#1	Desuperheater	$ 66,200	$ -	$ 4,164	3
#2	Dehum Control	$ 15,000	$ -	$ 1,615	2
#3	Heat Pump	$ 498,000	$ 159,000	$ 18,121	5
#4	Showerheads	$ 9,000	$ -	$ 4,592	<1
ECM 1 - 4	BUNDLE	$ 579,200	$ 159,000	$ 28,492	4

Implementing these mechanical and control measures will reduce natural gas consumption by 23%, GHG emissions by 22%, and save ~$28,000 annually. Other benefits include water savings of ~2,000,000 L annually, reduced equipment runtime, increased system redundancy, and improved reliability.

Implementing these ECMs will make the Chetwynd Recreation Centre one of the most energy efficient recreational facilities in BC and ensure sustainable recreation for the residents of Chetwynd and surrounding areas for years to come.

Table of Contents

APPENDIX	DESCRIPTION
A	Financial and Carbon Lifecycle Analysis
B	Heat Pump Schematic

1. Introduction

1.1 Client Contact

Steve McLain
Chief Administrative Officer
smclain@gochetwynd.com , 250-401-4100 ext. 104
4512 N Access Rd, Chetwynd, BC V0C 1J0

1.2 Consultant Info

Polar Engineering Ltd. is a comprehensive design, project management, commissioning, and consulting engineering firm which specializes in obtaining grant funding to install site-specific heat recovery systems at refrigeration plants.

At Polar, we focus on engineering state-of-the-art refrigeration and HVAC systems. This combination has allowed us to become world leaders at recovering waste heat from cooling plants to offset 30% - 100% of a facility's GHG emissions, and substantially reduce utility bills at the same time.

Our primary clients are ice arenas, recreation centers, and industrial applications, though we are also active with other sectors.

To ensure that our clients spend the least to realize the most, Polar has formed strong partnerships with various grant funding programs. This process allows our clients to realize the largest GHG and utility-cost reductions for the smallest capital investments, thereby maximizing financial return on investment.

Legal Name:	Polar Engineering LTD.
Principal:	Ian Welle, P.Eng. – ian@polareng.ca
Address:	300-722 Cormorant St. Victoria, BC V8W 1P8
Phone Number:	778-700-1086
Work Safe BC #:	794442533BW0001

1.3 Project Objectives

The purpose of this report is to outline how the District of Chetwynd is a prime candidate for the FortisBC Custom Efficiency Program funding for the implementation of gas conservation measures.

These energy savings will be beneficial to the District of Chetwynd and British Columbia as a whole through the aligned targets of energy conservation and GHG reduction.

Polar met with The City staff on October 4th, 2023, to kick-off this Energy Study project. The following objectives and win conditions were noted:

Primary Objectives:

- Reduce natural gas consumption.
- Reduce operating costs.
- Investigate the use of heat pumps and waste heat technologies at Chetwynd.

1.4 Methodology Overview

Throughout this study, Polar has analyzed the past, present, and future energy demands of the facility and outlined how the proposed energy conservation measures (ECMs) will result in energy savings and greenhouse gas reductions.

Polar has developed proprietary excel-based energy models to estimate the energy consumption of the base case and proposed system at the facility, as well as relevant key performance indicators for the proposed system. A copy of the site-specific energy model for this study is available as a separate Workbook to accompany this report.

Polar staff visited the facility in-person on October 4th, 2023, to gather the following site information.

- Equipment specifications and age
- Overall operations of the site
- Operator feedback on existing systems
- Ice plant compressor runtimes
- DDC screenshots

This study meets the ASHRAE Level 3 grade study quality with Class C cost estimates including major equipment costs estimated by local vendors or contractors.

1.5 Grant Program

The FortisBC Custom Efficiency Program (CEP) is designed to help commercial and industrial customers achieve energy-efficiency improvements in their buildings, facilities, or processes. The CEP program helps customers invest in high-efficiency equipment to save energy, costs, and greenhouse gas emissions.

The program will cover 75% of the cost of an energy study, with the remaining 25% covered upon successful completion of at least one recommended energy conservation measure. The implementation incentive offered is the lesser of the following:

- $6/GJ saved over the measure life.
- 75% of the invoiced project costs.
- $500,000 per project.

1.6 Acknowledgment

Polar Engineering would like to thank Stephen McLain, Robin Langille, and the rest of the staff at the Chetwynd Recreation Centre, for their support and assistance throughout the completion of this project.

Additionally, Polar would like to thank our industry collaborators at Fraser Valley Refrigeration, ClimaChange Solutions, Mayekawa and Bitzer for their technical and budget-costing support to our work.

Finally, we thank FortisBC and the CEP program team for their continued support with these projects.

2. Facility Description

2.1 Overview and Schedule

Location: 4552 North Access Road, Chetwynd, BC V0C 1J0

The Chetwynd Recreation Centre provides recreational, leisure and social activities to the residents of Chetwynd and the entire Peace River Regional District. The facility is operated by the District of Chetwynd and consists of one NHL sized ice sheet, a 6-lane curling sheet, a fitness studio, running/walking tracks, various sporting courts, and a bistro.

The CRC's operational hours are stated below and were obtained from the CRC website and through working with facility staff:

Arena Weekdays (Monday – Friday): 6:30am – 9:00pm
Pool Weekdays (Monday – Friday): 6:30am-9:30pm
Weekends (Saturday, Sunday): 10:00am-5:00pm

The ice rink is operational from September – the last week in March. The pool is operational year-round, shutting down only for three weeks each August.

Figure 1: Arena at Chetwynd Recreation Centre

Figure 2: Aquatic Centre at Chetwynd Recreation Centre

Figure 3: Curling Sheet at Chetwynd Recreation Centre

2.2 Utility Rates

The Chetwynd Recreation Centre has one natural gas meter and one electrical meter that tracks the energy consumption for the entire facility.

FortisBC Account #: 4417763

The utility rates used in this energy study are in line with the standard rate structures from the respective supplier of each utility. Known carbon tax increases and estimated utility escalation rates are applied to the project lifecycle analysis. Notable values are shown in the table below and an attached appendix shows the lifecycle rates in annual detail.

Table 3: Utility Rates

Discount Rate		6%					
Today Gas Rate	$	7.030	per GJ	**with annual escalation at**		3%	
Today Elec Rate	$	0.0614	per kWh	**with annual escalation at**		3%	
Today Power Rate	$	12.50	per kW	**with annual escalation at**		3%	
Today Water Rate	$	0.0013	per L	**with annual escalation at**		3%	
Today Sewer Rate	$	0.0017	per L	**with annual escalation at**		3%	
First Year of Savings		2024	including Carbon Tax of	$	80		$/tonne

2.3 Mechanical Systems

There are five distinct mechanical heating systems on site pertaining to the heating/hot water (HW), domestic hot water (DHW) and facility energy recovery loop (ER) as presented in the table below.

Table 4: Oak Bay Recreation Centre Heating Loops

System	Description
Arena-DHW	The Arena-DHW loop is heated by one gas-fired boiler. This system provides DHW for all the fixtures on the arena side of the facility as well as providing heated Zamboni water.
Arena – HW	The Arena-HW loop is heated by one gas-fired boiler. This system provides hot water to five heat recovery units (HRV's) and multiple fan coil units.

Pool-HW	The Pool-HW loop is heated by two gas-fired boilers. The system provides hot water to AHU-1, AHU-2, leisure pool, swirl pool and unit heaters on the pool side.
Pool - DHW	The Pool-DHW loop is heated by one gas-fired water heater. This system provides DHW for all the fixtures on the pool side of the facility.
Facility-ER Loop	The CHW loop from AHU-1 and AHU-2 feed into the existing Multistack heat pump and are used to offset the natural gas usage of the pool-HW loop.

The following table provides a summary of the relevant gas-fired heating equipment at the facility which was considered in this analysis.

Table 5: Relevant Gas-Fired Heating Equipment

Equipment	Description	Heating Output
Modulex Boiler	This is the main boiler on the arena side of the facility. It provides heating to the arena-HW and arena-DHW loop.	1,000 MBH
A.O. Smith Water Heater (x2)	Provides secondary heating to the arena-DHW loop.	400 MBH each
Advanced Thermal Hydronics Boiler	This is the lead boiler on the pool side of the facility. It provides heating to the pool-HW loop.	1,799 MBH
Advanced Thermal Hydronics Boiler	This is the lag boiler on the pool side of the facility. It provides heating to the pool-HW loop.	900 MBH
GSW Water Heater	Provides heating to the pool-DHW loop.	340 MBH
AHU-1	Rooftop gas fired unit which serves the running track and mezzanine.	120MBH
AHU-2	Rooftop gas fired unit which serves the boardroom multipurpose rooms.	84 MBH
AHU-3	Rooftop gas fired unit which serves the squash court.	120 MBH
AHU-4	Rooftop make up air unit which serves the main foyer kitchen makeup.	405 MBH
AHU-5	Rooftop gas fired unit which serves the fitness centre.	123 MBH

2.4 Refrigeration Plant

The cooling requirements for the one NHL sized rink and curling sheet are provided by an ammonia refrigeration plant. A detailed list of the existing key components in the refrigeration plant are shown in the table below.

Table 6: Existing Key Refrigeration Equipment

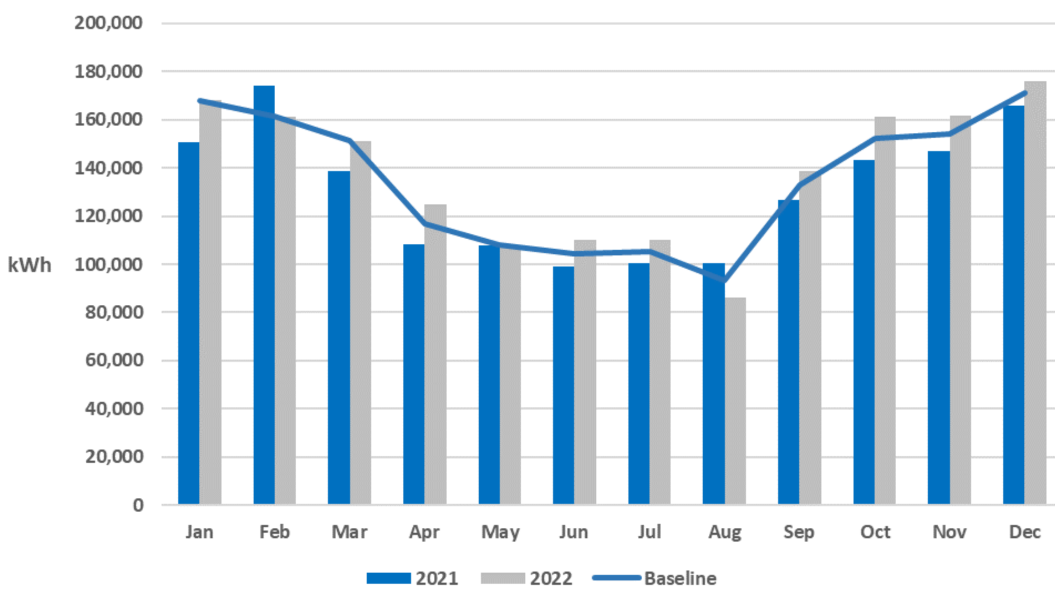
Equipment Name	Description	Important Specifications
C-1	Ammonia Compressor	Model: Mycom N6WB Capacity: 83 TR Motor: 100 HP
C-2	Ammonia Compressor	Model: Mycom N6WB Capacity: 83 TR Motor: 100 HP
EC-1	Evaporative Condenser	Model: BAC VC1-N230 Capacity: 2,213 MBH
HX-1	Chiller	Model: MK15BW-FD Capacity: 900 MBH Warm Side Fluid: Brine Cold Side Fluid: Ammonia
HX2	Underfloor Heat Exchanger	Model: MK15BW-FD Capacity: 130 MBH Warm Side Fluid: Ammonia Cold Side Fluid: Brine

3. Baseline Energy Analysis

3.1 Electricity Consumption

The Chetwynd Recreation Centre has one electric meter. The electrical consumption baseline is based on historical data from Jan-2021 through December-2022, with the exclusion of the period January-2021 through March-2021 due to the irregular operations resulting from COVID-19 public health restrictions. The annual baseline electrical consumption is ~1,600,00 kWh.

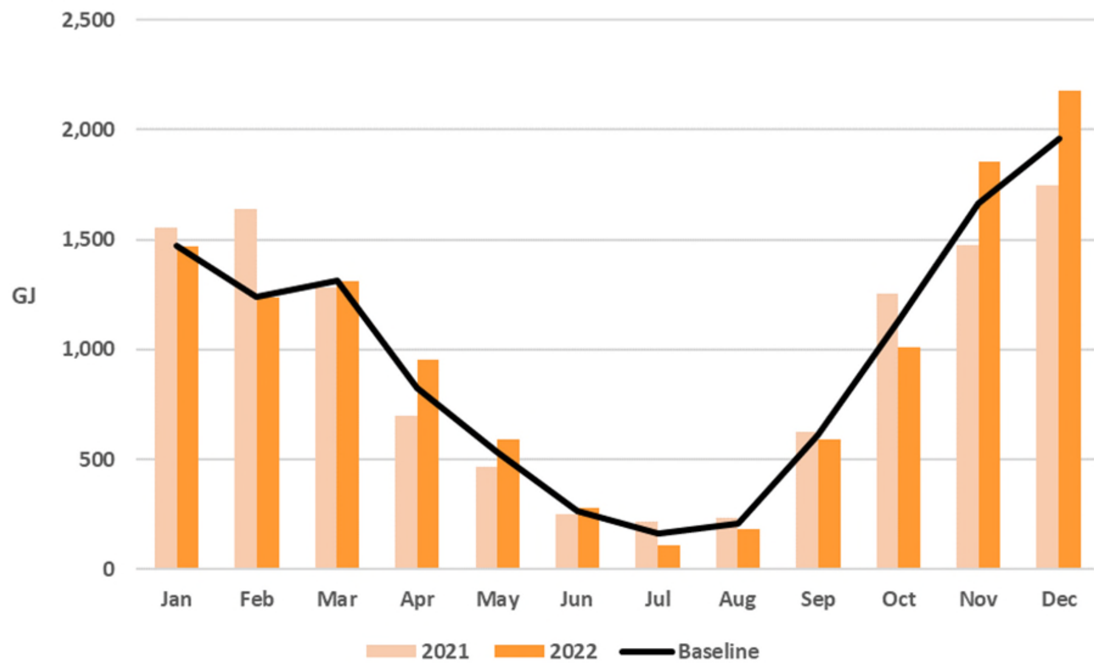
Figure 4: Historical Electrical Consumption



3.2 Natural Gas Consumption

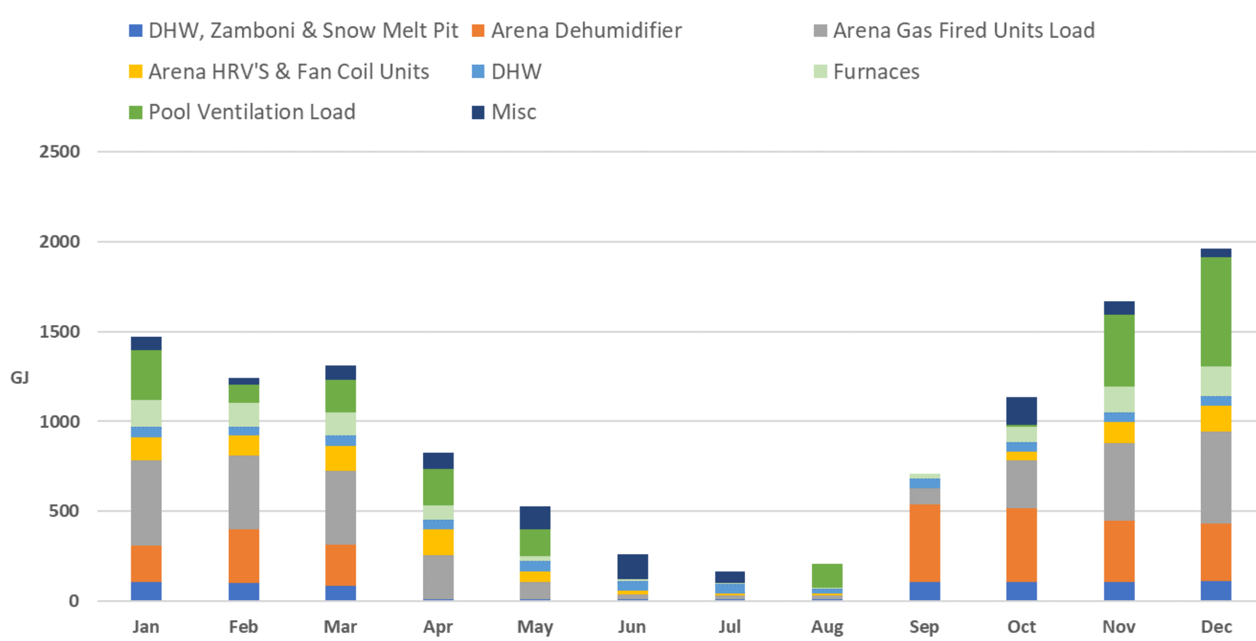
The Chetwynd Recreation Centre has one gas meter. The natural gas consumption baseline is based on historical data from January-2021 through December-2022, with the exclusion of the period January-2021 through March-2021 due to the irregular operations resulting from COVID-19 public health restrictions. The annual baseline natural gas consumption is ~11,300 GJ/year.

Figure 5: Historical Natural Gas Consumption



The annual natural gas consumption is broken down by end uses in the graph below.

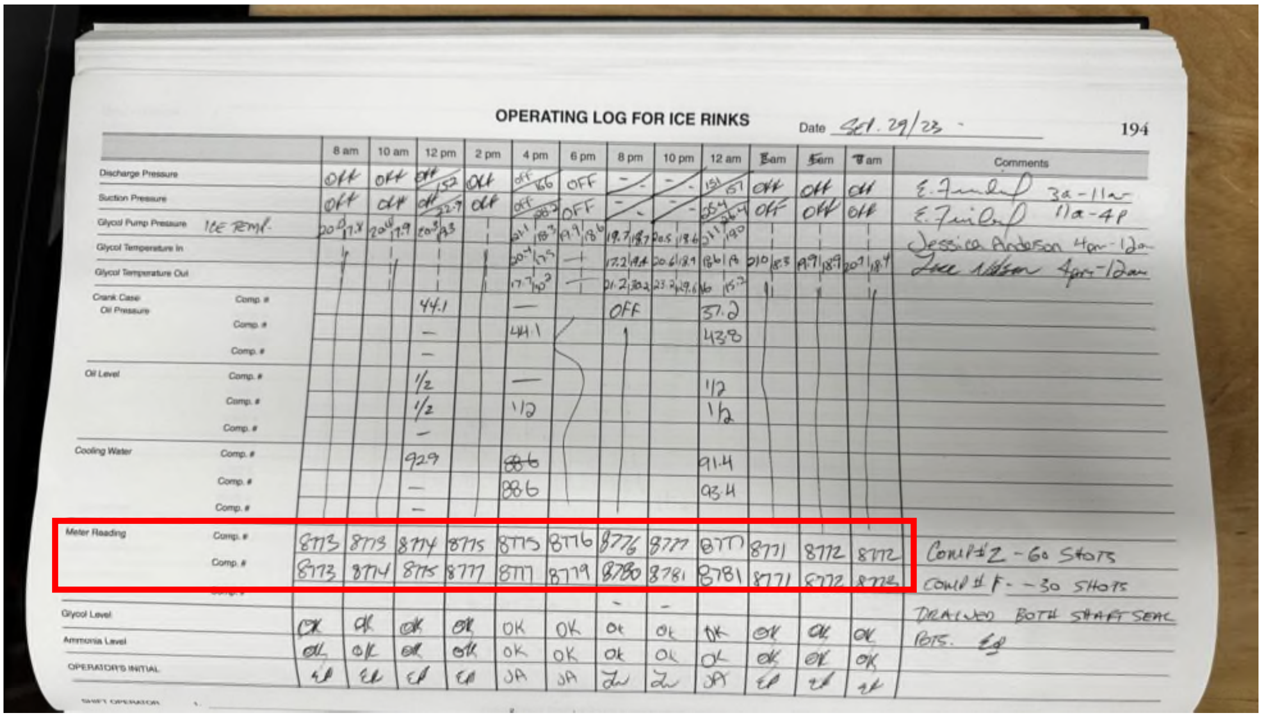
Figure 6: Natural Gas End Use



3.3 Heat Available from the Ice Plant

The Chetwynd Recreation Centre has one ammonia refrigeration plant, with two compressors. Compressor runtimes used in this analysis were determined through the refrigeration logbooks.

Figure 7: Refrigeration Logbook



The heat of rejection is determined based on actual operating conditions of the plant including the exact compressor model, the system commissioning parameters, cooling jacket design, and the observed monthly runtime gathered from the compressor logbooks on site. It accounts for the heat extracted from the ice surfaces as well as the direct heat from compressor work. The heat produced by the ammonia refrigeration system can be utilized to offset the natural gas usage of various amenities on site. Based on our analysis there is currently ~3,700 GJ of heat which can be recovered from the refrigeration plant.

3.4 Existing Heat Recovery

The Chetwynd Recreation Centre ice plant has multiple existing heat recovery systems which have been summarized in the table below.

Table 7: Existing Heat Recovery

Heat Recovery System	Description
Underfloor Heat Exchanger (HX-2)	Heat is extracted from the ammonia and is transferred into a brine loop. Based on our site visit and speaking to operators this condenser is not currently operational.
Multistack Heat Pump	The CHW loop from AHU-1 and AHU-2, which provides dehumidification and space cooling to the natatorium (pool deck) feeds into the evaporator of the Multistack unit. This recovered heat is used to offset the natural gas usage of the pool-HW loop. Amenities on this loop include: - AHU-1 OA Preheat Coil - AHU-1 Heating Coil - AHU-2 OA Preheat Coil - AHU-2 Heating Coil - Leisure Pool Heat Exchanger - Swirl Pool Heat Exchanger - One small unit heater

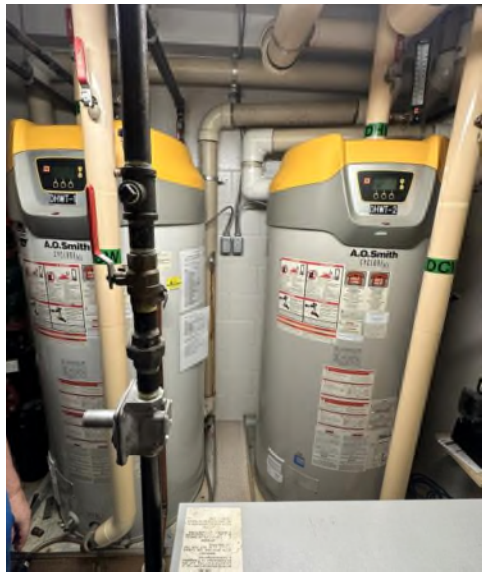
4. Energy Conservation Measures

4.1 ECM 1: Desuperheater Integration w/ DHW Systems

4.1.1 Existing Conditions

Domestic hot water for the arena plumbing fixtures system is provided by one Modulex natural gas boiler. This system also provides DHW to the Zamboni system on site. There are two A.O. Smith water heaters that provide downstream secondary heating for the DHW system. There are currently no energy recovery measures implemented to reduce the arena-DHW natural gas load.

Figure 8: A.O. Smith Water Heaters for Arena-DHW Heating



4.1.2 Base-Case

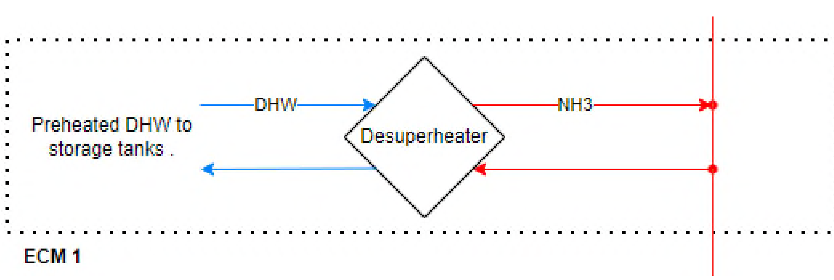
The base case for this system is business as usual.

4.1.3 Proposed System

The ammonia refrigeration plant at Chetwynd Recreation Centre generates a significant amount of heat each month while providing adequate cooling for the facility's two ice surfaces. The only refrigeration plant energy recovery measure installed at the facility is an underfloor heat exchanger (HX2), which is currently not operational.

Polar is proposing the installation of an ammonia desuperheater that can recover high-grade heat from the refrigeration plant and send it to the arena DHW system. Please refer to the figure below for a schematic of the desuperheater integration.

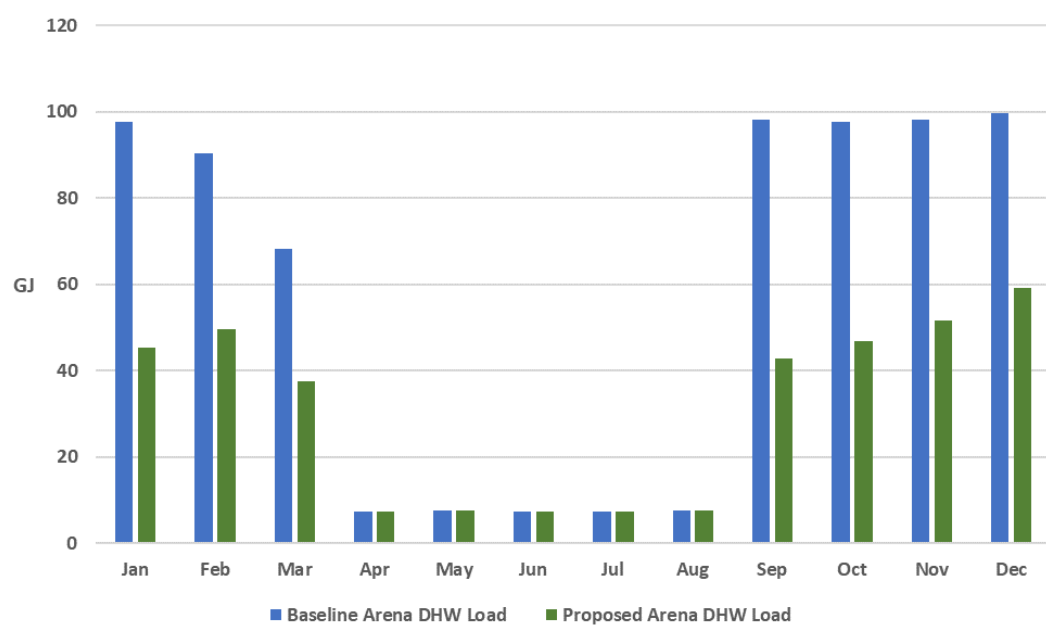
Figure 9: ECM#1 Integration Schematic



The desuperheater will extract energy from the superheated ammonia at the compressor discharge, cooling but not condensing it before it reaches the existing evaporative condenser. The recovered heat will be used to preheat the domestic cold water, therefore reducing the load on the existing evaporative condenser as well as the natural gas boiler which provides DHW to the arena and Zamboni system on site.

The graph below shows the baseline vs. proposed DHW natural gas consumption on the arena side of the facility. The baseline values (blue) will be reduced to the proposed values (green) shown, saving roughly half of the system's natural gas consumption.

Figure 10: Baseline vs. Proposed Arena DHW Gas Consumption



4.1.4 Energy Savings Estimate

The energy savings for this measure are summarized in the table below. The water and electrical savings come from the evaporative condenser on site operating less because energy will be recovered through the desuperheater.

Table 8: ECM#1 Energy Savings Estimate

Subcomponent	Gas Savings (GJ)	Elec Savings (kWh)	Water Savings (L)
Arena DHW	317	3,147	170,056
SUM	**317**	**3,147**	**170,056**

4.1.5 Capital Cost Budgeting

The cost estimate for ECM#1 comes from Polar Engineering's previous experiences installing desuperheaters at refrigeration plants across Western Canada. The key capital cost metrics are shown in the table below. Please note that professional fees and contingency are not included in this estimate.

Table 9: ECM#1 Costing Summary

Item	Cost	Estimate Source
Desuperheater	$ 28,152	Doucette List Price
Ammonia Side Work	$ 15,000	Polar Estimate
Storage Tanks	$ 11,000	Polar Estimate
Mechanical Installation	$ 12,000	Polar Estimate
ECM Subtotal	**$ 66,200**	

4.2 ECM 2: Dehumidifier Setpoint Optimization

4.2.1 Existing Conditions

One Munters A30 desiccant dehumidification unit serves the arena, maintaining temperature and humidity setpoints within the arena. Doing this ensures that the arena has great ice conditions while also being comfortable for patrons. The dehumidifier heating requirements are met through a direct fired gas burner.

Figure 11: Munters Dehumidification Unit

4.2.2 Proposed System

ECM #2 pertains to optimizing the control logic of the desiccant dehumidifier serving the arena controlling to a dynamic dewpoint (DP) differential rather than the static relative humidity (RH) setpoint as existing. The control setpoint will have a minimum and maximum range. The DP will float in this range based on outdoor conditions in order to optimize the energy consumption while maintaining optimal ice conditions for skaters & spectators. The table below provides key system parameters:

Parameter	Baseline	Proposed	Comment
Dew Point Range	0.4°C (32.8°F)	3.1 – 5.2°C (36.7 – 40.6°F)	Controlled reset of the dew point setpoint based on NHL-acceptable ice conditions and fog avoidance.
Relative Humidity Range	45%, static.	53 – 61%, floating	Allows the RH to float up to a defined maximum.

4.2.3 Energy Savings Estimate

Please refer to the table below for a summary of the measure's energy savings.

Table 10: ECM#2 Energy Savings Estimate

Subcomponent	Gas Savings (GJ)
Arena Dehumidifier	137
SUM	**137**

Currently the dehumidifier is only serving the arena, but it was sized to provide dehumidification to the curling sheet as well. The facility is planning on expanding the existing dehumidifier ducting to the curling rink. Since the dehumidifier setpoints will be optimized and the unit will be operating more efficiently further energy savings will be noticed in the future.

4.2.4 Capital Cost Budgeting

The cost estimate for ECM#2 comes from Polar Engineering's previous experiences completing similar control optimizations on arena dehumidifiers across British Columbia. The key capital cost metrics are shown in the table below. Please note that professional fees and contingency are not included in this estimate.

Table 11: ECM#2 Costing Summary

Item	Cost	Estimate Source
Control Optimization	$ 15,000	Polar Estimate
ECM Subtotal	**$ 15,000**	

4.1 ECM 3: Site-Specific Heat Pump

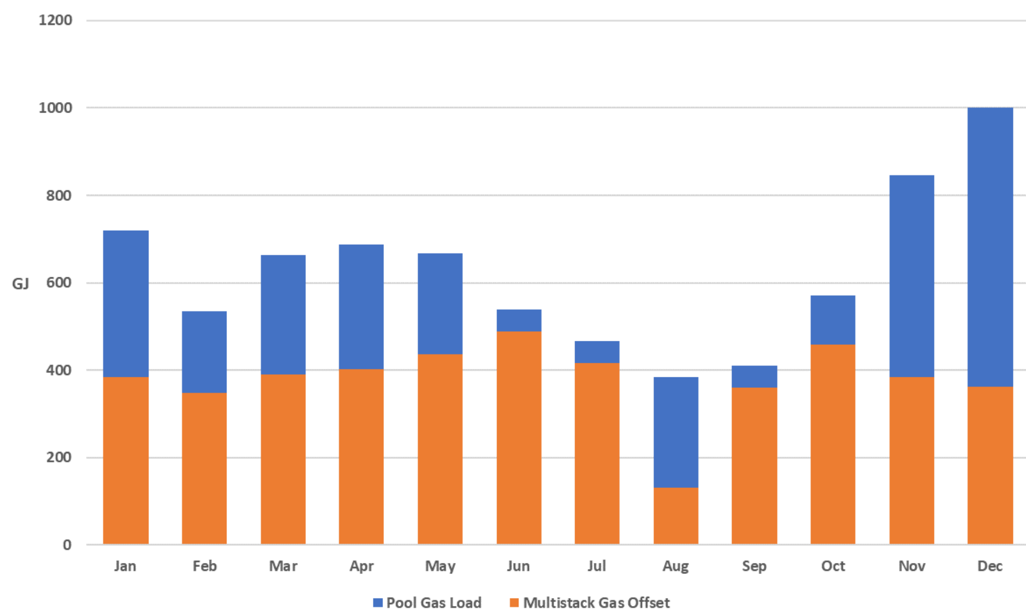
4.1.1 Existing Conditions

The natural gas load of the pool-HW loop is met through two Advanced Thermal Hydronics gas fired boilers, described in section 2.3 of this report. The CHW loop from AHU-1 and AHU-2, which provide dehumidification and space cooling to the natatorium (pool deck) feeds into the evaporator of an existing Multistack unit and offsets the pool-HW loop load. The existing Multistack unit is shown in the figure below.

Figure 12: Existing Multistack Unit

The baseline natural gas offset through the Multistack unit is shown in the graph below.

Figure 13: Baseline Gas Offset due to Multistack Unit



Since there is a substantial amount of heat available from the refrigeration plant annually, ~3,700 GJ, this excess heat can be recovered to further offset the natural gas requirements of the pool-HW loop which serves various amenities described in section 2.4 of this report.

4.1.2 Base-Case

The base-case for this measure is replacing the existing Multistack unit with an identical unit which has the same capacity. The refrigerant used in the existing Multistack heat pump is R-410A which has a GWP of 1,890. Based on new refrigerant regulations and laws coming into effect there is a mandate to use refrigerants which have a GWP of 750 or less. Therefore, the replacement Multistack unit would use R-454B as a refrigerant which has a GWP of 467. The cost for the base case is $159,000 and was obtained through working with ClimaChange Solutions.

4.1.3 Proposed System

The proposed system for this measure includes replacing the existing Multistack unit with a site-specific heat pump (SSHP) which operates using a low-GWP refrigerant at condensing temperatures high enough to meet the boiler loop setpoint at the facility.

This new unit will have increased capacity and efficiency compared to the Multistack unit.

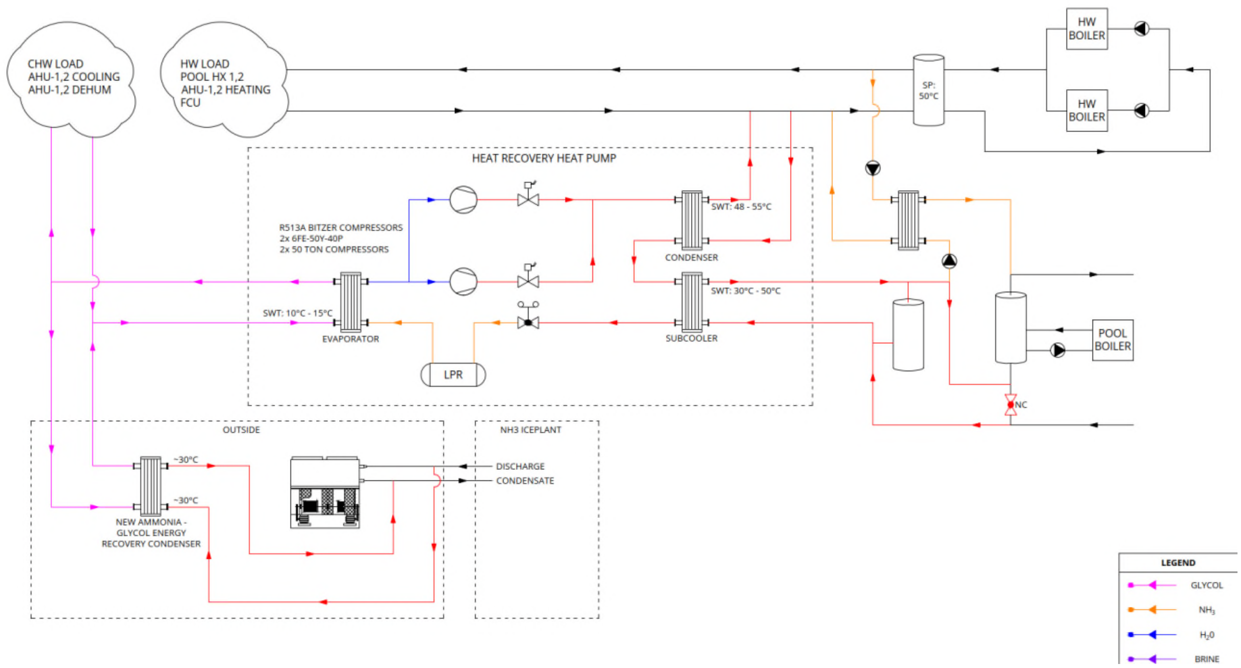
The heat pump will recover heat from the CHW loop from AHU-1 & AHU-2 as well as recovering heat from the refrigeration plant. Preliminary unit specifications and performance are described below:

Table 12: SSHP Specifications

Item	Description
Compressor	2 x Bitzer 6FEH-50Y-40P
Condenser	370 kW
Subcooler	72 kW
Refrigerant	R513A
Coefficient of Performance (COP)	5.4

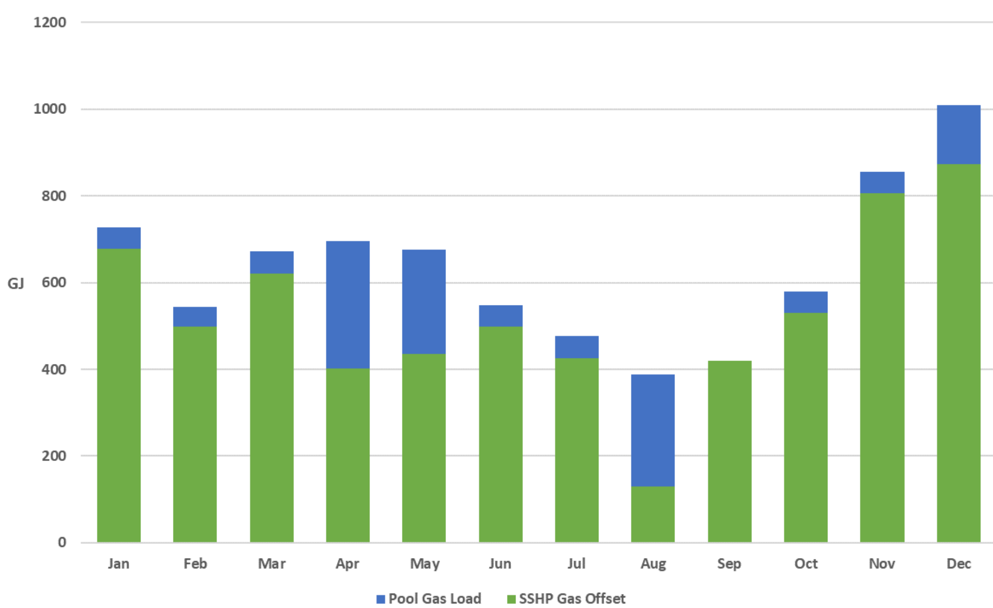
Approx 85% of the heat available from the heat pump will be provided by the condenser, with temperatures ranging between 48-55°C. The condenser of the heat pump will offset the pool-HW loop requirements. The remaining 15% of the heat is provided by the subcooler with temperatures ranging between 30-50°C. The subcooler will offset the pool-DHW requirements by providing DHW preheat. An integration schematic is shown below.

Table 13: ECM Integration Schematic



The proposed natural gas offset through the proposed SSHP is shown in the graph below. We expect the vast majority of the pool heating and pool ventilation load to be offset by the new system.

Figure 14: Proposed Gas Offset due to Proposed SSHP



Polar Engineering designs SSHPs in-house. This is an entirely custom and industrial approach to heat pump design using industrial equipment and practices. As the design engineers, we provide detailed engineering drawings and specifications for the heat pump and associated integration work; refrigeration and mechanical, which can then be tendered or direct awarded to a local refrigeration contractor to be built and supplied. An example of a site-specific heat pump is shown below.

Figure 15: Example of Site-Specific Heat Pump designed by Polar

4.1.4 Refrigerant Selection

As part of this energy study, careful consideration was placed on the ideal refrigerant for the facility's load profile and performance requirements.

Based on the load profiles of the facility and the operational requirements of the site, **we recommend a low-GWP synthetic refrigerant such as R513A**. This specific refrigerant product is new to the Canadian market and offers performance advantages aligned with this application. R513A has an A1 classification, thus requiring no special conditions beyond familiar alternatives. This refrigerant is not flammable, has a low toxicity.

4.1.5 Energy Savings Estimate

The energy savings and electricity savings for this measure are summarized in the table below. The increased electrical load to power the heat pump compressor is partially offset by the reduced runtime of the evaporative condenser, as less energy will be rejected to the atmosphere. The water savings come from the evaporative condenser operating less since a substantial amount of energy will be recovered from the refrigeration plant.

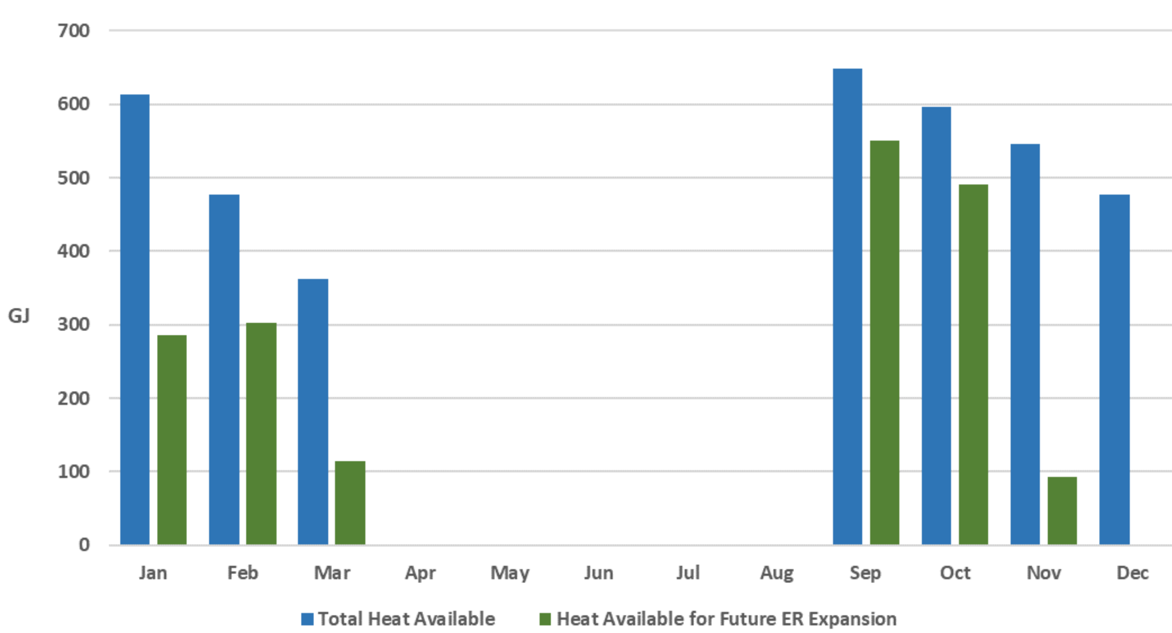
Table 14: ECM#3 Energy Savings Estimate

Subcomponent	Gas Savings (GJ)	Elec Savings (kWh)	Water Savings (L)
Pool HW Load	1,482		
Pool DHW Load	437		
Site-Specific Heat Pump		- 105,634	
Evaporative Condenser		19,063	1,030,077
SUM	**1,919**	**- 86,571**	**1,030,077**

4.1.6 Co-Benefits

The SSHP adds redundancy to the heating systems, as the existing boilers and water heaters will remain in place for backup heating. The SSHP will also allow the facility to expand upon the energy recovery loop in the future. There will still be ~1,800 GJ of energy left annually to recover from the refrigeration plant to further offset loads on the pool-HW loop. The graph below shows the monthly amount of heat still available.

Figure 16: Future Heat Recovery Potential



4.1.7 Capital Cost Budgeting

The cost estimate for ECM#3 comes from Fraser Valley Refrigeration. The key capital cost metrics are shown in the table below. Please note that professional fees and contingency are not included in this estimate.

Table 15: ECM#3 Costing Summary

Item	Cost	Note
Heat Pump Costing	$ 290,000	Fraser Valley Estimate
Heat Pump Installation	$ 48,000	Polar Estimate
Evaporator Hydronic Integration	$ 75,000	Polar Estimate
Condenser Hydronic Integration	$ 15,000	Polar Estimate
Subcooler Hydronic Integration	$ 35,000	Polar Estimate
Electrical	$ 20,000	Polar Estimate
Controls	$ 15,000	Polar Estimate
ECM Subtotal	**$ 498,000**	
Base Case Subtotal	$ 159,000	
Incremental Costs	**$ 339,000**	

4.1 ECM 4: Install Low Flow Shower Head Fixtures

4.1.1 Existing Conditions

All the showerheads at the Chetwynd Recreation Centre have a shower fixture specification of 2.5 GPM.

4.1.2 Base-Case

The base-case for this measure is business as usual.

4.1.3 Proposed System

Polar proposes to replace all the high-flow showerheads (2.5GPM) with low-flow fixtures which are rated at 1.5 GPM. This will lead to a reduction in water consumption as well as a reduction in the DHW heating load. The measurement and adjustment of water pressure, along with quality showerhead selection, will yield good occupant experience.

4.1.4 Energy Savings Estimate

The energy savings for this measure are summarized in the table below:

Table 16: ECM#4 Energy Savings Estimate

Subcomponent	Gas Savings (GJ)	Water Savings (L)
Arena DHW	105	401,866
Pool DHW	159	684,651
SUM	**265**	**1,086,517**

4.1.5 Co-Benefits

Implementing this energy conservation measure will not only lead to natural gas savings but will also substantially reduce water consumption. This is especially important for the District of Chetwynd since they are currently in a severe drought.

4.1.6 Capital Cost Budgeting

The cost estimate for ECM#4 stems from Polar Engineering's previous experience completing showerhead replacements at various facilities across British Columbia. The key capital cost metrics are shown in the table below. Please note that professional fees and contingency are not included in this estimate.

Table 17: ECM#4 Costing Summary

Item	Qty/Rate	Cost	Estimate Source
Low-Flow Showerheads - 1.5 GPM	**18**	$ 9,000	Polar Estimate
ECM Subtotal		**$ 9,000**	

5. Measure Summary and Recommendations

Polar Engineering recommends that the Chetwynd Recreation Centre implement all of the evaluated ECMs in this report. The recommended order of implementation is shown in the table below. This strategy will first prioritize demand load reductions followed by waste heat recovery.

Table 18: Recommended Order of Implementation

ECM	Description
#4	Ice Plant Desuperheater
#2	Dehumidifier Setpoint Optimization
#1	Heat Pump Upgrade
#3	Low Flow Showerheads

As a bundle, these measures will have a major impact on the natural gas consumption and GHG emissions at the CRC, while having a slight impact on the electrical consumption. The measures will also result in significant water savings for the facility. These energy results are summarized below.

Table 19: ECM Bundled Energy Savings

ECM	Description	Natural Gas (GJ/year)	Electricity (kWh/year)	Water (L/year)	Measure Life (years)	Lifetime GHG Reductions (tCO2e)
#4	Showerheads	265	0	1,086,517	10	119
#2	Dehum Control	137	0	0	15	96
#1	Desuperheater	317	3,147	170,056	25	379
#3	Heat Pump	1,919	-86,571	1,030,077	20	1,818
ECM 1 - 4	BUNDLE	2,638	-83,424	2,286,650	18	2,412

The detailed financial metrics for each measure can be seen in the table below.

Table 20: Financial Performance Summary

ECM	Description	Total Capital Cost	Base Case Cost	First Year Savings	Effective Payback (years)
#4	Showerheads	$ 9,000	$ -	$ 4,592	<1
#2	Dehum Control	$ 15,000	$ -	$ 1,615	2
#1	Desuperheater	$ 66,200	$ -	$ 4,164	3
#3	Heat Pump	$ 498,000	$ 159,000	$ 18,121	5
ECM 1-4	BUNDLE	$ 588,200	$ 159,000	$ 28,492	4

Please note that the capital cost values shown above are Class C (+/-30%) and do not include professional fees or budget contingency. For budgetary purposes, it is recommended that the following financial factors are applied to the capital costs shown above:

- 10% annual escalation of all equipment costs from the date of this report.
- 10% of capital costs for engineering fees.
- 5% of capital costs for construction management
- 15-30% of capital costs for contingency

Additionally, the effective payback periods shown account for the estimated CEP incentive from FortisBC, as well as relevant utility costs, utility rate escalations, escalating carbon tax, and carbon purchasing throughout the lifetime of the measures. The detailed annual breakout of these factors is appended.

The cumulative-sum table below shows the progression of costs and key savings in the recommended order of implementation.

Table 21: Gas, GHG, and Cost Progression

		Natural Gas		Capital Cost		GHG	
ECM	Description	(GJ/year)	(CUSUM)	($)	(CUSUM)	(tCO2e)	(CUSUM)
#4	Showerheads	265	2%	$ 9,000	$ 9,000	13	2%
#2	Dehum Control	137	4%	$ 15,000	$ 24,000	7	3%
#1	Desuperheater	317	6%	$ 66,200	$ 90,200	16	6%
#3	Heat Pump	1,919	23%	$ 498,000	$ 588,200	95	22%
	BUNDLE	**2,638**		**$ 588,200**		**131**	

6. Conclusion

Polar Engineering recommends the implementation of all ECMs described in this report. These measures will help reduce the overall energy demand of the Chetwynd Recreation Centre and improve the efficiency of the mechanical systems on site without compromising optimal indoor conditions for facility longevity and patron comfort. Implementing these energy projects will **reduce the facility's annual natural gas consumption by 23%** and GHG emissions by 22%.

Polar Engineering would like to thank the District of Chetwynd and the FortisBC team for the opportunity to provide this Energy Study Report. If you have any questions or require further information presented in this report, please don't hesitate to contact us. We are happy to help.

Appendix A: Financial and Carbon Lifecyle Analysis

Rate Summary				
Discount Rate	6%			
Today Gas Rate	$ 7.030	per GJ	with annual escalation at	3%
Today Elec Rate	$ 0.0614	per kWh	with annual escalation at	3%
Today Power Rate	$ 12.50	per kW	with annual escalation at	3%
Today Water Rate	$ 0.0013	per L	with annual escalation at	3%
Today Sewer Rate	$ 0.0017	per L	with annual escalation at	3%
First Year of Savings	2024	including Carbon Tax of	$ 80	$/tonne

Natural Gas	
Utility:	FortisBC
Schedule:	Rate 3
GST	0%
PST	7%
ICE	0.40%
Net	7.4%

Electricity	
Utility:	BC Hydro
Schedule	LGS
GST	5%
PST	0%
Net	5.0%

Water and Sewer

Project Year	Calendar Year	Carbon Tax $/tonne	Carbon Purchase $/tonne	Carbon Cost $/tonne	Gas Carbon tonne/GJ	Elec Carbon tonne/kWh	RNG Carbon tonne/kWh	Escalation Rate	Gas Cost $/GJ	Carbon Tax $/GJ	Carbon Purchase $/GJ	Total w PST+ICE $/GJ	Escalation Rate	Elec Cost $/kWh	Carbon Cost $/kWh	Total w tax + levi $/kWh	Demand Rate $/kW	Escalation Rate	Water Rate $/L	Sewer Rate $/L
1	2024	80	0	80	0.04987	0.00001	0.00029	3%	$ 7.24	$ 3.99	$ -	$ 11.77	3%	$ 0.0632	$ 0.0009	$ 0.0673	$ 12.88	3%	$0.0013	$0.0018
2	2025	95	0	95	0.04987	0.00001	0.00029	3%	$ 7.46	$ 4.74	$ -	$ 12.75	3%	$ 0.0651	$ 0.0010	$ 0.0694	$ 13.26	3%	$0.0014	$0.0018
3	2026	110	0	110	0.04987	0.00001	0.00029	3%	$ 7.68	$ 5.49	$ -	$ 13.74	3%	$ 0.0671	$ 0.0012	$ 0.0716	$ 13.66	3%	$0.0014	$0.0019
4	2027	125	0	125	0.04987	0.00001	0.00029	3%	$ 7.91	$ 6.23	$ -	$ 14.73	3%	$ 0.0691	$ 0.0013	$ 0.0739	$ 14.07	3%	$0.0014	$0.0019
5	2028	140	0	140	0.04987	0.00001	0.00029	3%	$ 8.15	$ 6.98	$ -	$ 15.73	3%	$ 0.0712	$ 0.0015	$ 0.0762	$ 14.49	3%	$0.0015	$0.0020
6	2029	155	0	155	0.04987	0.00001	0.00029	3%	$ 8.39	$ 7.73	$ -	$ 16.75	3%	$ 0.0733	$ 0.0017	$ 0.0786	$ 14.93	3%	$0.0015	$0.0020
7	2030	170	0	170	0.04987	0.00001	0.00029	3%	$ 8.65	$ 8.48	$ -	$ 17.76	3%	$ 0.0755	$ 0.0018	$ 0.0811	$ 15.37	3%	$0.0016	$0.0021
8	2031	170	0	170	0.04987	0.00001	0.00029	3%	$ 8.91	$ 8.48	$ -	$ 18.04	3%	$ 0.0778	$ 0.0018	$ 0.0835	$ 15.83	3%	$0.0016	$0.0022
9	2032	170	0	170	0.04987	0.00001	0.00029	3%	$ 9.17	$ 8.48	$ -	$ 18.33	3%	$ 0.0801	$ 0.0018	$ 0.0859	$ 16.31	3%	$0.0017	$0.0022
10	2033	170	0	170	0.04987	0.00001	0.00029	3%	$ 9.45	$ 8.48	$ -	$ 18.62	3%	$ 0.0825	$ 0.0018	$ 0.0885	$ 16.80	3%	$0.0017	$0.0023
11	2034	170	0	170	0.04987	0.00001	0.00029	3%	$ 9.73	$ 8.48	$ -	$ 18.93	3%	$ 0.0850	$ 0.0018	$ 0.0911	$ 17.30	3%	$0.0018	$0.0024
12	2035	170	0	170	0.04987	0.00001	0.00029	3%	$ 10.02	$ 8.48	$ -	$ 19.24	3%	$ 0.0875	$ 0.0018	$ 0.0937	$ 17.82	3%	$0.0018	$0.0024
13	2036	170	0	170	0.04987	0.00001	0.00029	3%	$ 10.32	$ 8.48	$ -	$ 19.57	3%	$ 0.0902	$ 0.0018	$ 0.0965	$ 18.36	3%	$0.0019	$0.0025
14	2037	170	0	170	0.04987	0.00001	0.00029	3%	$ 10.63	$ 8.48	$ -	$ 19.90	3%	$ 0.0929	$ 0.0018	$ 0.0993	$ 18.91	3%	$0.0019	$0.0026
15	2038	170	0	170	0.04987	0.00001	0.00029	3%	$ 10.95	$ 8.48	$ -	$ 20.24	3%	$ 0.0957	$ 0.0018	$ 0.1023	$ 19.47	3%	$0.0020	$0.0027
16	2039	170	0	170	0.04987	0.00001	0.00029	3%	$ 11.28	$ 8.48	$ -	$ 20.59	3%	$ 0.0985	$ 0.0018	$ 0.1053	$ 20.06	3%	$0.0021	$0.0027
17	2040	170	0	170	0.04987	0.00001	0.00029	3%	$ 11.62	$ 8.48	$ -	$ 20.96	3%	$ 0.1015	$ 0.0018	$ 0.1084	$ 20.66	3%	$0.0021	$0.0028
18	2041	170	0	170	0.04987	0.00001	0.00029	3%	$ 11.97	$ 8.48	$ -	$ 21.33	3%	$ 0.1045	$ 0.0018	$ 0.1116	$ 21.28	3%	$0.0022	$0.0029
19	2042	170	0	170	0.04987	0.00001	0.00029	3%	$ 12.33	$ 8.48	$ -	$ 21.72	3%	$ 0.1077	$ 0.0018	$ 0.1149	$ 21.92	3%	$0.0023	$0.0030
20	2043	170	0	170	0.04987	0.00001	0.00029	3%	$ 12.70	$ 8.48	$ -	$ 22.11	3%	$ 0.1109	$ 0.0018	$ 0.1183	$ 22.58	3%	$0.0023	$0.0031
21	2044	170	0	170	0.04987	0.00001	0.00029	3%	$ 13.08	$ 8.48	$ -	$ 22.52	3%	$ 0.1142	$ 0.0018	$ 0.1217	$ 23.25	3%	$0.0024	$0.0032
22	2045	170	0	170	0.04987	0.00001	0.00029	3%	$ 13.47	$ 8.48	$ -	$ 22.94	3%	$ 0.1176	$ 0.0018	$ 0.1253	$ 23.95	3%	$0.0025	$0.0033
23	2046	170	0	170	0.04987	0.00001	0.00029	3%	$ 13.87	$ 8.48	$ -	$ 23.38	3%	$ 0.1212	$ 0.0018	$ 0.1291	$ 24.67	3%	$0.0025	$0.0034
24	2047	170	0	170	0.04987	0.00001	0.00029	3%	$ 14.29	$ 8.48	$ -	$ 23.83	3%	$ 0.1248	$ 0.0018	$ 0.1329	$ 25.41	3%	$0.0026	$0.0035
25	2048	170	0	170	0.04987	0.00001	0.00029	3%	$ 14.72	$ 8.48	$ -	$ 24.29	3%	$ 0.1286	$ 0.0018	$ 0.1368	$ 26.17	3%	$0.0027	$0.0036
26	2049	170	0	170	0.04987	0.00001	0.00029	3%	$ 15.16	$ 8.48	$ -	$ 24.76	3%	$ 0.1324	$ 0.0018	$ 0.1408	$ 26.96	3%	$0.0028	$0.0037
27	2050	170	0	170	0.04987	0.00001	0.00029	3%	$ 15.62	$ 8.48	$ -	$ 25.25	3%	$ 0.1364	$ 0.0018	$ 0.1450	$ 27.77	3%	$0.0029	$0.0038
28	2051	170	0	170	0.04987	0.00001	0.00029	3%	$ 16.08	$ 8.48	$ -	$ 25.75	3%	$ 0.1405	$ 0.0018	$ 0.1493	$ 28.60	3%	$0.0029	$0.0039
29	2052	170	0	170	0.04987	0.00001	0.00029	3%	$ 16.57	$ 8.48	$ -	$ 26.27	3%	$ 0.1447	$ 0.0018	$ 0.1537	$ 29.46	3%	$0.0030	$0.0040
30	2053	170	0	170	0.04987	0.00001	0.00029	3%	$ 17.06	$ 8.48	$ -	$ 26.80	3%	$ 0.1490	$ 0.0018	$ 0.1583	$ 30.34	3%	$0.0031	$0.0041

Appendix B: Heat Pump Schematic

SITE:	CITY OF CHETWYND - CHETWYND REC CENTRE
PROJECT:	FORTIS ENERGY STUDY (Polar P#2332)
SKETCH:	SK-1 , HEAT PUMP SCHEMATIC
BY:	Steffen Trangeled, P. Eng., 2023-12-19

THIS SKETCH REPRESENTS A HIGHLY SIMPLIFIED SYSTEM SCHEMATIC INTENDED ONLY TO COMMUNICATE PROJECT CONCEPTS. MANY EXISTING AND PROPOSED SYSTEM DETAILS ARE EXCLUDED.
NOT FOR CONSTRUCTION. NOT FOR RELIANCE BY OTHERS.

POLAR ENGINEERING